MINNESOTA

DEPARTMENT OF TRANSPORTATION

ST. PAUL, MINNESOTA

STANDARD SPECIFICATIONS FOR CONSTRUCTION

2016 EDITION

ORDER NUMBER 94858

It is hereby ordered that these Minnesota Department of Transportation Standard Specifications for Construction, 2016 Edition, be adopted for application on State and Federal Aid construction contracts awarded in Minnesota.

Upon being published and made available for distribution, these Standard Specifications shall become effective by reference in the contract plans or special provisions.

Dated June 2, 2015

Charles A. Zelle
Commissioner of Transportation

These Minnesota Department of Transportation Standard Specifications for Construction, 2016 Edition, are hereby approved for application on highway, street and related construction contracts as referenced in the contract plans or special provisions and they shall apply as noted and amended by those documents.

Dated June 2, 2015

Thomas D. Ravn
State Construction Engineer

I hereby certify that the changes contained in these Minnesota Department of Transportation Standard Specifications for Construction, 2016 Edition, were prepared by me or under my direct supervision and that I am a duly registered professional engineer under the laws of the State of Minnesota.

Dated June 2, 2015

Stephen J. Ryan
Standard Specifications Engineer
Reg. No. 21844

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DIVISION I

GENERAL REQUIREMENTS AND COVENANT

Definitions and Terms

1101 WORDING OF SPECIFICATIONS

Since the 2014 edition, the Minnesota Department of Transportation's *Standard Specification for Construction* (Standard Specifications) has emphasized the active voice. In Division 1, the Contractor's and Department's responsibilities are written in the active voice-indicative mood. In a sentence written in the active voice-indicative mood, someone acts on something. For example: "The Engineer will take a sample."

In Divisions 2 and 3, only the Department's responsibilities are written in the active voice-indicative mood.

In Divisions 2 and 3, the Contractor's responsibilities are written in active voice-imperative mood; the Department states its requirements or directions for performing the work to the Contractor. The imperative mood is used when the party issuing an instruction and the party receiving it are already understood. Such statements have the same force as if they contained the word "shall" and are considered mandatory. In an imperative sentence such as, "Pour the concrete," the Department is indicating that it requires the Contractor to pour the concrete. In the material specifications in Division 3, the subject may also be the supplier, fabricator, or manufacturer supplying the materials, products, or equipment for use on the project.

1102 ABBREVIATIONS AND MEASUREMENT UNITS

1102.1 GLOSSARY OF ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations in the Contract documents represent the full text shown in Table 1102-1.

Table 1102-1
Acronyms and Abbreviations Used

Acronym or Short Form	Full Name or Meaning
AA	Aluminum Alloy
AASHTO	American Association of State Highway and Transportation Officials
AITC	American Institute of Timber Construction
AC	Alternating Current
ACI	American Concrete Institute
ADA	American with Disabilities Act
AES	Area of Environmental Sensitivity
AGC	Associated General Contractors of America, Inc.
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ALR	Areas of Localized Roughness
AMS	Alpha Methylstyrene
ANSI	American National Standards Institute
APS	Accessible Pedestrian Signal
ARTBA	American Road & Transportation Builders Association
ASME	American Society of Mechanical Engineers
ASR	Alkali Silica Reactivity
ASTM	ASTM International; formerly American Society of Testing and Materials
ATR	Automatic Traffic Recorder
AWG	American Wire Gauge
AWPA	American Wood Protection Association
AWS	American Welding Society
BMP	Best Management Practice
CA	Corrugated Aluminum
CAS	Corrugated Aluminized Steel
CCTV	Closed Circuit Television
CIP	Cast-In-Place
CLSM	Controlled Low Strength Material
CMP	Communications Plenum Cable or Corrugated Metal Pipe

Table 1102-1 Acronyms and Abbreviations Used	
Acronym or Short Form	**Full Name or Meaning**
CMS	Changeable Message Sign
COAX	Radio Frequency Transmission Cable (Coaxial Cable)
CP	Corrugated Polyethylene
CPR	Concrete Pavement Rehabilitation
CRCP	Continually Reinforced Concrete Pavement
CRSI	Concrete Reinforcing Steel Institute
CS	Corrugated Steel
CV	Compacted Volume
DBE	Disadvantage Business Enterprise
DBR	Dowel Bar Retrofit
DCP	Dynamic Cone Penetrometer or Penetration Index Method
DFT	Dry Film Paint Thickness
DTI	Direct Tension Indicator
EEO	Equal Employment Opportunity
EIA	Electronic Industries Alliance
EV	Excavated Volume
EVP	Emergency Vehicle Pre-Emption
FAA	Fine Aggregate Angularity
FAA	Federal Aviation Administration
FDR	Full Depth Reclamation
FHWA	Federal Highway Administration, U.S. Department of Transportation
HDPE	High Density Polyethylene
HE	High Early
HH	Handhole
HMA	Hot Mix Asphalt
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineers Society
IMC	Intermediate Metal Conduit
IRI	International Roughness Index
ISO	International Organization for Standardization or formerly Insurance Services Office (depends on context)
ISSA	International Slurry Surfacing Association
ITC	Information Transmission Capacity
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
JMF	Job Mix Formula used in the Bituminous Specifications.
kVA	Kilovolt Ampere
LV	Loose Volume for Measurements, or Leveling Course for Bituminous
MAR	Maintenance Access Route
MDA	Minnesota Department of Agriculture
MDR	Mixture Design Report used in the Bituminous Specifications
MGal	1,000 Gallons
MnDOT	Minnesota Department of Transportation
MN MUTCD	Minnesota Manual on Uniform Traffic Control Devices
MN Statutes	Minnesota Statutes
MPCA	Minnesota Pollution Control Agency
MSDS	Material Safety Data Sheets
NCR	Non-compliance Report
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NMC	Non-Metallic Conduit
No.	When reference is to wire, it is the AWG gauge number.
NPDES	National Pollutant Discharge Elimination System
NRTL	National Recognized Testing Laboratory
OGAB	Open Graded Aggregate Base
OSHA	Occupational Safety and Health Administration
(P)	Planned Quantity as Defined in 1103
PAR	Pedestrian Access Route

Table 1102-1 Acronyms and Abbreviations Used	
Acronym or Short Form	**Full Name or Meaning**
PASB	Permeable Asphalt Stabilized Base
PASSRC	Permeable Asphalt Stabilized Stress Relief Course
PCC	Portland Cement Concrete
PCI	Precast/Prestressed Concrete Institute
PC-CS	Polymeric Coated-Corrugated Steel
PE	Polyethylene
PG	Performance Grade (for bituminous)
PLS	Pure Live Seed
PROWAG	Proposed Right-of-way Accessibility Guidelines
PTL	Plan Thickness Lot
PVC	Polyvinyl Chloride or Probe Verification Core
QA	Quality Assurance
QAC	Quality Acceptance Core
QAI	Quality Assurance Inspector
QC	Quality Control
QCP	Quality Control Plan or Quality Control Probing
RAP	Recycled Asphaltic Pavement
RAS	Recycled Asphalt Shingles
REA	Rural Electrification Administration
RLF	Rural Lighting and Flasher
RSC	Rigid Steel Conduit
SAE	SAE International; formerly the Society of Automotive Engineers
SAP	State-aid Project Number
SFDR	Stabilized Full Depth Reclamation
SI	International System of Units (The Modernized Metric System)
SP	State Project Number
SSPC	Society for Protective Coatings
SV	Stockpiled Volume
SWPPP	Storm Water Pollution Prevention Plan
TGB	Targeted Group Business
TH	Trunk Highway
TMS	Traffic Management System
TP	Thermoplastic
UL	Underwriters Laboratories, Inc.
USCG	United States Coast Guard
USDA	United States Department of Agriculture
UV	Ultraviolet
VAC	Volt Alternating Current (60 Hz)
VDC	Volt Direct Current
VT	Verification Test
W/C	Water/Cement Ratio
XHHW	Moisture and Heat Resistant Cross Linked Synthetic Polymer

1102.2 UNITS OF SIZE AND MEASUREMENT

The Contract documents show sizes and measurements in both inch-pound (U.S. Customary) and International System (SI or Metric) units. Inch-pound units appear first, followed by a metric counterpart inside square brackets "[ ]."

When reading the Contract documents, use the system of measurements used by the Department on the bid schedule. Do not mathematically convert the units from one system of measure to another; the Department does not intend its measurement values to be equivalent and does not consider values interchangeable.

Table 1102-2 Symbols for Metric Prefixes	
Symbol	**Prefix (Magnitude)**
M	mega (10^6)
k	kilo (10^3)
m	milli (10^{-3})
µ	micro (10^{-6})
n	nano (10^{-9})
p	pico (10^{-12})

Table 1102-3 Symbols for English Measurement Units	
Symbol	**Units (Kind of Quantity Measurement)**
A	ampere (electric current)
F	farad (electric capacitance)
oz	ounce (mass)
H	henry (inductance)
acre	acre (area)
Hz	hertz (frequency - cycles or impulses per second)
cal	calorie (energy)
MGal	1000 gallons (volume)
Mph	Miles per hour (velocity)
mi^2	square mile (area)
gal	gallon (volume)
ft/s	feet per second (velocity)
yard	yard (length)
yd^2	square yard (area)
yd^3	cubic yard (volume)
Gpm	Gallons per minute (flow rate)
lbf	Pound-force (force)
ft lbf	foot pound (torque)
Psi	Pounds per square inch (pressure, stress)
S	second (time)
S	siemens (electrical conductance)
T	ton (mass)
V	volt (electric potential)
W	watt (power)
Ω	ohm (electric resistance)
°F	degree Fahrenheit (temperature)

Table 1102-4 Symbols for Metric Measurement Units	
Symbol	**Units (Kind of Quantity Measurement)**
A	ampere (electric current)
cd	candela (luminous intensity)
F	farad (electric capacitance)
g	gram (mass)
H	henry (inductance)
ha	hectare (area)
Hz	hertz (frequency - cycles or impulses per second)
J	joule (energy)
km/h	kilometer per hour (velocity)
km^2	square kilometer (area)
L	liter (volume)
m/s	Meters per second (velocity)
m	meter (length)
m^2	square meter (area)
m^3	cubic meter (volume)
m^3/s	cubic meters per second (flow rate)
N	newton (force)
N•m	newton meter (torque)
Pa	pascal (pressure, stress)
s	second (time)
S	siemens (electrical conductance)
t	metric ton (mass)
V	volt (electric potential)
W	watt (power)
Ω	ohm (electric resistance)
°C	degree Celsius (temperature)

1103 DEFINITIONS

Unless another intention clearly appears, words and phrases (including technical words and phrases and such others as have acquired a special meaning) shall be construed according to rules of grammar and according to general usage.

Wherever the following terms, or pronouns in place of them, are used in the contract documents, the intent and meaning shall be interpreted as follows:

ADDENDUM. A supplement to the **Proposal Package** covering additions, corrections, or changes in the bidding conditions for the advertised **Work** that is issued by the **Department** to prospective **Bidders** before the date and time for opening **Proposals**.

ADVERTISEMENT FOR BIDS. The public announcement, as required by law, inviting **Proposals** for the **Work** to be performed or **Materials** to be furnished.

AGGREGATE. Natural materials such as sand, **Gravel**, crushed rock, or taconite tailings, and crushed concrete or salvaged bituminous mixtures, usually with a specified particle size, for use in base course construction, paving mixtures, and other applications.

APPROVED/QUALIFIED PRODUCTS LIST. A list of products that the **Department** has pre-approved or pre-qualified for use on a **project**. The Department uses this list to verify the acceptability of products used in the performance of the **work.** Products on an Approved Products Lists have been approved for a specific use as defined in the relevant technical section of the specifications; whereas, products on a Qualified Products List are qualified as having met specific minimum requirements as defined in the relevant technical section of the specifications, but the specifications may require further sampling, testing, and inspection specific to the product use.

AREA OF ENVIRONMENTAL SENSITIVTY. An area on the **project** that the **contract** has identified to need special protection during construction, including, but not limited to areas needing protection of habitat, wildlife, recreational or cultural resources/properties, ecological significance, geological features, visual quality, or its sensitivity to disturbance.

AUXILIARY LANE. The portion of the **Roadway** adjoining the **Traveled way** for parking, speed-change, or other purposes supplementary to through traffic movement.

AWARD. The **Department's** selection of a **Bidder's Proposal**, subject to execution and approval of the **Contract**.

BASELINE SCHEDULE. The first **Progress Schedule** for the entire **Project** submitted by the **Contractor** and accepted by the **Department**.

BEST MANAGEMENT PRACTICES (BMP). Management practices for erosion prevention, sediment control, and water quality that are the most effective and practicable means of controlling, preventing, and minimizing degradation of surface water, including avoidance of impacts, construction-phasing, minimizing the length of time soil areas are exposed, prohibitions, and other management practices published by state or designated area-wide planning agencies.

BID SCHEDULE. A listing of **Contract Items** in the **Proposal Form** showing quantities and units of measurement that provides for the **Bidder** to insert **Bid Unit Prices**.

BIDDER. An individual, firm, or corporation submitting a **Proposal** for the advertised **Work**.

BITUMINOUS ENGINEER. The **Department** engineer responsible for statewide guidance on bituminous mixtures and pavements. This individual has responsibilities delegated from the Materials Engineer.

BITUMINOUS MANUAL. A **Department** manual that contains the requirements governing quality and use of materials related to bituminous applications, the fundamental principles involved in bituminous surfacing, descriptions of procedures for practical application, and information on bituminous mixtures, equipment and calibrations, and sampling and testing methods. References to the **Bituminous Manual** from the **contract** are to the edition in effect on the letting date.

BRIDGE. Per MN Rule Subpart 2, a "Bridge" is defined as a **structure**, including supports, erected over a depression or an obstruction, such as water, **Highway**, or railway, and having a track or passageway for carrying traffic or other moving loads and having an opening measured horizontally along the center of the roadway of ten feet or more between undercopings of abutments, between spring line of arches, or between extreme ends of openings for multiple boxes. Bridge also includes multiple pipes where the clear distance between openings is less than half of the smaller contiguous opening.

BRIDGE CONSTRUCTION MANUAL. A **Department** manual that promotes uniform inspection and interpretation of the specifications related to bridge construction. The **Bridge Construction Manual** contains information on surveying and staking, preparation of foundations and backfill, pile driving, false work and forms, reinforcement, concrete bridge construction, steel construction, timber construction, surface preparation, painting of structural steel, construction on railroad right of way, and conduit systems. References to the Bridge Construction Manual from the **contract** are to the edition in effect on the letting date.

BRIDGE ENGINEER. The Director of the **Department**'s Office of Bridges and Structures, acting directly or through an authorized representative within the scope of the particular duties or functional unit referenced in the **Contract**.

BRUSH. Shrubs, trees, and other plant life having a diameter of 4 inches [100 mm] or less at a point 24 inches [600 mm] above the ground surface, as well as fallen trees and branches.

BUILDING AND BRIDGE DEMOLITION/RELOCATION WEBSITE. A **Department** website that provides assistance on building demolition/relocation and bridge demolition/rehabilitation projects to ensure proper identification and management of regulated materials.

BUSINESS DAY. Every day on the calendar, except Saturday, Sunday, and **Holidays**.

CALENDAR DAY. Every day on the calendar.

CARBONATE. Sedimentary rock composed primarily of carbonate minerals, including dolostone (dolomite, $CaMg(CO_3)_2$), **limestone** (calcite, $CaCO_3$) and mixtures of dolostone and limestone.

CERTIFICATE OF COMPLIANCE. A certificate obtained by the **Contractor** from the manufacturer, producer, or supplier of a product and submitted to the **Department** that certifies that the product, as provided to the Contractor, complies with the relevant **Contract** requirements in accordance with 1603, "Materials: Specifications, Samples, Tests, and Acceptance."

CERTIFIED CCTV TECHNICIAN. An individual certified by the **Contractor** and approved by the **Engineer** to perform all **work** associated with a CCTV system.

CERTIFIED TEST REPORT. A test report obtained by the **Contractor** from the manufacturer, producer, or supplier of a product and submitted to the **Department** that indicates actual results of tests or analyses, covering elements of the **Contract** documents for the product or workmanship, and includes validated certification.

CHANGE ORDER. A written order issued by the **Engineer** to the **Contractor** covering permissible adjustments, minor changes or corrections to the **Plans**, and rulings with respect to defects, omissions, discrepancies, and intent of the **Contract**. Change orders do not include any **Extra Work** or other alterations that are required to be covered by **Supplemental Agreement**.

CITY, COUNTY, OR TOWNSHIP. A political subdivision of the **State** used to designate or identify the location of the proposed **Work**.

COMMISSIONER. The Commissioner of the **Department**, or the chief executive of the political subdivision, governmental body, board, commission, office, department, division, or agency constituted for administration of the **Contract** within its jurisdiction.

CONCRETE ENGINEER. The **Department** engineer responsible for statewide guidance on concrete mixtures and pavements. This individual has responsibilities delegated from the Materials Engineer.

CONCRETE MANUAL. A **Department** manual that establishes fundamental principles of concrete construction, provides test methods and inspection procedures for control of concrete production and placement, and includes materials and materials testing, properties and mix designations, mix design, batching and mixing placement operations, reports and work sheets, charts and other data. References to the **Concrete Manual** from the **Contract** are to the edition in effect on the letting date.

CONSTRAINT (CPM only). A restriction placed on an activity that may override logic or restrict or distribute **Float** for a network or sub-network of logic.

CONTRACT. The written agreement between the **Department** and the **Contractor** setting forth their obligations, including, but not limited to, the performance of the **work**, the furnishing of labor and **materials**, the basis of payment, and other requirements contained in the **contract** documents. The contract documents include the **advertisement for bids**, **proposal**, contract form, **contract bonds**, **standard specifications**, **supplemental specifications**, **special provisions**, **plans**, **notice to proceed**, **work orders**, and **supplemental agreements** that are required to complete the construction of the work in an acceptable manner, including authorized extensions, all of which constitute one instrument.

CONTRACT BONDS. The approved forms of security executed by the **Contractor** and **Surety**(ies), including both of the following:

PAYMENT BOND. A bond furnished in accordance with Minnesota Statutes §574.26 and meeting the terms specified in Minnesota Statutes §574.26 subdivision 2 (2).

PERFORMANCE BOND. A bond furnished in accordance with Minnesota Statutes §574.26 and meeting the terms specified in Minnesota Statutes §574.26 subdivision 2 (1).

CONTRACT ITEM (Pay Item). A specifically described unit of **Work** for which the **Contract** defines a **Unit Price**. The sum of the scopes of work for all contract items equals the scope of work for the contract.

MAJOR CONTRACT ITEM. A **contract item** with an original value equal to or greater than 5 percent of the original **contract** amount. A **major contract item** at the time of bid will remain a major item.

MINOR CONTRACT ITEM. A **contract item** with an original value less than 5 percent of the original **contract** amount. A **minor contract item** does not become a major item through overruns, **Supplemental Agreements**, etc.

CONTRACT STARTING DATE. The latest date specified for the beginning of construction operations as set forth in the **Proposal Package**.

CONTRACT TIME. The completion date, number of **working days**, or number of **calendar days** allowed for completion of the **contract** and any intermediate milestones, including authorized extensions in accordance with 1806, "Determination and Extension of Contract Time."

CONTRACTOR. The individual, firm, or corporation contracting for and undertaking prosecution of the prescribed **Work**; the party of the second part to the **Contract**, acting directly or through a duly authorized representative.

CONTROLLING ACTIVITY. The first incomplete activity(ies) with the earliest start date that resides on the **Critical Path(s)**.

COUNTY. (See **City, County, or Township**.)

CRITICAL ACTIVITY. An activity with zero or negative **total float**.

CRITICAL PATH. The longest continuous sequence of **work** establishing the scheduled completion date of the **Project** or a **milestone**.

CULVERT. A **Structure** constructed entirely below the elevation of the **Roadway** surface and not a part of the Roadway surface, which provides an opening under the Roadway for the passage of water or traffic.

DATA DATE. The date from which a schedule is calculated and, in schedules other than the **Baseline Schedule**, the date up to which progress is reported.

DEPARTMENT. The **State** Department of Transportation, or the political subdivision, governmental body, board, commission, office, department, division, or agency constituted for administration of the **Contract** within its jurisdiction.

DETOUR. A **Road** or system of Roads, usually existing, designated as a temporary route by the **Department** to divert through traffic from a section of **Roadway** being improved.

DISTRICT MATERIALS LABORATORY. A **Department** laboratory located within a district, having responsibilities delegated from the **Materials Engineer**.

DISTRICT MATERIALS ENGINEER. A **Department** engineer, located within a district, having responsibilities delegated from the **Materials Engineer**.

DISTRICT TRAFFIC ENGINEER. A **Department** engineer, located within a district, having responsibilities delegated from the **Traffic Engineer**.

DIVIDED HIGHWAY. A **Highway** with separated **Traveled Ways** for traffic in opposite directions.

DORMANT SEEDING. Seeding allowed in the late fall when the ground temperature is too low to cause seed germination so that the seed remains in a dormant condition until spring.

DORMANT SODDING. Sodding allowed in the late fall when the ground temperature is too low so that normal rooting does not take place until spring.

EASEMENT. A right acquired by the Department to use or control property for a designated purpose.

ENGINEER. A **Department** engineer authorized as the Department's representative responsible for the engineering supervision of the **work** and delegated with those duties and authorities defined in the **contract**. The **contract** may redefine the 'Engineer' as a specific Department engineer (i.e. Concrete Engineer, Bridge Engineer, Materials Engineer, Traffic Engineer, Roadway Engineer, etc.) with jurisdiction over the engineering details of specific construction items; however, the **Engineer** is the main point of contact for the **Contractor** and should receive copies of all correspondence between the Contractor and other Department representatives.

EQUIPMENT. All machinery, tools, and apparatus, together with the necessary supplies for upkeep and maintenance, necessary for the proper construction and acceptable completion of the **work** within its intended scope.

EROSION CONTROL SCHEDULE. A written document (weekly) by the **Contractor** illustrating construction sequences and schedule of proposed methods to control erosion and manage sediment.

ERRORS AND OMISSIONS. A deficiency in the **Contract** that results in multiple interpretations of a requirement, as determined by the **Engineer**, except for those resolved by the orders of precedence in 1504, "Coordination of Contract Documents."

EXTRA WORK. Any work not required by the **Contract** as awarded but found essential to the satisfactory completion of the Contract within its intended scope. Such work shall be authorized and performed in accordance with 1402, "Contract Revisions."

FLOAT/TOTAL FLOAT. The number of days by which an activity may be delayed without delaying the **Project** or a **Milestone**.

FREE FLOAT. The number of days by which an activity may be delayed from its early dates without delaying the early start date of a successor activity. Free Float is a unique attribute of an activity.

FRONTAGE ROAD (or STREET). A local **Road** or **Street** auxiliary to and located on the side of a **Highway** for service to abutting property and adjacent areas and for control of access.

GRADE SEPARATION. A **Bridge** with its approaches that provides for **Highway** or pedestrian traffic to pass without interruption over or under a railway, Highway, **Road**, or **Street**.

GRADING AND BASE ENGINEER. A **Department** engineer responsible for statewide guidance on grading and base. This individual has responsibilities delegated from the **Materials Engineer**.

GRADING AND BASE MANUAL. A **Department** manual that serves as a tool to assist Department personnel in measuring the quality of materials and evaluate the work as construction progresses. References to the **Grading and Base Manual** from the **contract** are to the edition in effect on the letting date.

GRAVEL. Naturally occurring rock or mineral particles produced by glacial and water action. Particle size ranges from 3 inches [76 mm] diameter to the size retained on a No. 10 [2.0 mm] sieve.

HIGHWAY, ROAD, ROADWAY, OR STREET. General terms denoting a public way for purposes of vehicular travel, including the entire area within the **right of way**.

HOLIDAYS. The days of each year set aside by legal authority for public commemoration of special events, and on which no public business shall be transacted except as specifically provided in cases of necessity. Unless otherwise noted, holidays shall be as established in MS 645.44.

IMPACT SCHEDULE. A schedule prepared to demonstrate the impact of a proposed change. When accepted by the **Department**, an **Impact Schedule** becomes the **Progress Schedule**.

INCIDENTAL. Whenever the word "incidental" is used in the **Contract** it shall mean no direct compensation will be made.

INDUSTRY STANDARD. An acknowledged and acceptable measure of quantitative or qualitative value or an established procedure to be followed for a given operation within the given industry. This will generally be in the form of a written code, standard, or specification by a creditable association valid on the date of the **Advertisement for Bids**.

INSPECTION AND CONTRACT ADMINISTRATION MANUAL FOR MnDOT LANDSCAPE PROJECTS (ICAMMLP). A **Department** manual that provides clear, objective, and measurable criteria on decision-making and payment criteria for those responsible for plant installation and establishment design, or inspection. References to the **ICAMMLP** from the **Contract** are to the edition in effect on the letting date.

INSPECTOR. The **Engineer's** authorized representative assigned to make detailed inspections of **Contract work**.

INTERCHANGE. A grade-separated **Intersection** with one or more turning **Roadways** for travel between intersection legs.

INTERSECTION. The general area where two or more **Highways** join or cross, within which are included the **Roadway** and roadside facilities for traffic movements in the area.

LABORATORY MANUAL. A **Department** manual that outlines laboratory test procedures for **materials** testing. References to the **Laboratory Manual** from the **Contract** are to the edition in effect on the letting date.

LAYER. The total embankment thickness for each material type, composed of a single or multiple **lifts**.

LIFT. A unit of material within a **layer** that is placed for compaction.

LIGHTING ENGINEER. A **Department** engineer responsible for statewide guidance on lighting. This individual has responsibilities delegated from the Traffic Engineer.

LIMESTONE. (See **Carbonate**.)

LOOP. A one-way turning **Roadway** that curves about 270 degrees to the right, primarily to accommodate a left-turning movement, but which may also include provisions for another turning movement.

MAJOR CONTRACT ITEM. (See **Contract Item**.)

MATERIALS. Any substances specified for use in the performance of the **work**.

MATERIALS ENGINEER. The Director of the **Department's** Office of Materials and Road Research acting directly or through an authorized representative within the scope of the particular duties or functional unit referenced in the **Contract**.

MATERIALS LABORATORY. The **Department's** Central Materials Laboratory.

MAXIMUM DENSITY. The maximum density of a particular soil as determined by the method prescribed in the **Grading and Base Manual**.

MILESTONE. A dated specified in the **Contract**, such as the date that the **Contract Time** expires.

MINNESOTA MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MN MUTCD). A **Department** manual that establishes the standards for traffic control devices that regulate, warn, and guide road users along all **roadways** within the **State**. References to the **MN MUTCD** from the **contract** are to the edition in effect on the letting date.

MINNESOTA SEAL COAT HANDBOOK. A manual published by the Minnesota Local Road Research Board's Research Implementation Committee that provides tools for roadway designers and technicians to design and implement seal coat operations.

MINOR CONTRACT ITEM. (See **Contract Item**.)

NARRATIVE REPORT. A descriptive report submitted with each schedule. The required contents of this report are specified in 1803.2.C.1 "Narrative Reports," for Bar Chart schedules, and 1803.3.C.1, "Narrative Reports," for CPM schedules.

NEAR-CRITICAL ACTIVITIES. Activities with Total Float equal to or less than 10 working days.

NOMINAL. The intended, named, or stated value, as opposed to the actual value. The nominal value of something is the value that it is supposed or intended to have, or the value by which it is commonly known.

NONCONFORMANCE REPORT (NCR). A report the **Contractor** submits to the **Engineer** that documents any deviation from the Quality Control Plan (QCP), approved shop drawings, or **Contract** requirements.

NOTICE TO PROCEED. Written notice to the **Contractor** to proceed with the **work** including, if applicable, the date of beginning of **contract time**. Notice to Proceed 1 (NTP1) occurs upon the Department's acceptance of the Contractor's first Preliminary Schedule. Notice to Proceed 2 (NTP2) occurs upon the Department's acceptance of the Contractor's Baseline Schedule.

NPDES PERMIT. The general permit issued by the MPCA that authorizes the discharge of storm water associated with construction activity under the National Pollutant Discharge Elimination System Program.

OPTIMUM MOISTURE. The moisture content of a particular soil at maximum dry density as determined by the method prescribed in the **Grading and Base Manual**.

(P). A designation in the summary of quantities on the **plans** meaning that the **plan quantity** will be the quantity for payment. The Department will not measure or recalculate plan quantities, except as provided in 1901, "Measurement of Quantities."

PAVEMENT STRUCTURE. The combination of layers placed on a **subgrade** to support the traffic load and distribute it to the **roadbed**.

PAY ITEM. (See **Contract Item**.)

PAYMENT BOND. (See **Contract Bonds**.)

PERFORMANCE BOND. (See **Contract Bonds**.)

PERMANENT EROSION CONTROL MEASURES. Soil-erosion control measures such as curbing, **culvert** aprons, riprap, flumes, sodding, erosion mats, and other means to minimize erosion on the completed **project** while establishing permanent perennial vegetation.

PLANS. The **plans**, profiles, typical cross-sections, and **Standard Plans and Standard Plates** that show the locations, character, dimensions, and details of the **work**.

PLAN QUANTITY. The quantity listed in the summary of quantities on the **plans**. The summary of quantities will usually be titled "Statement of Estimated Quantities," "Schedule of Quantities for Entire Bridge," or "Schedule of Quantities."

PREDECESSOR. An activity that is defined by schedule logic to precede another activity. A predecessor may control the start or finish date of its **Successor**.

PRELIMINARY SCHEDULE(S). All schedules submitted before acceptance of the **Baseline Schedule**.

PROFESSIONAL ENGINEER. A person registered and licensed by the **State** of Minnesota to practice one or more branches of engineering. The **Contract** may require that the **Contractor** provide a **Professional Engineer**, registered and licensed in a specific branch of engineering, to perform certain responsibilities.

PROFILE GRADE. The trace of a vertical plane intersecting the top surface of the **roadbed** or **pavement structure**, usually along the longitudinal centerline of the **traveled way**. Profile grade means either elevation or gradient of such trace according to the context.

PROGRESS SCHEDULE. The schedule submitted by the **Contractor** and accepted by the **Department** for managing the **Project**. For example, the **Baseline Schedule** is the **Progress Schedule** from the **Data Date** of the Baseline Schedule to the Data Date of the first **Update Schedule**. The first Update Schedule is the Progress Schedule from its Data Date to the Data Date of the next accepted Update Schedule, and so on.

PROJECT. The specific section of the **highway**, the location, or the permanent construction improvements as defined by the **contract**.

PROJECT SITE. The area available to the **Contractor** for use in performing the **work**, as defined on the **plans** by the **right-of-way** and the end and beginning of the **project**.

PROPOSAL. The offer of a **bidder** on the prescribed **proposal form** to perform the **work** and furnish the labor and **materials** at the bid **unit prices**.

PROPOSAL FORM. The approved form on which the **Department** requires **proposals** to be prepared and submitted for the **work**, in accordance with 1206, "Preparation of Proposal."

PROPOSAL PACKAGE. All documents and information provided by the **Department** to prospective **bidders** in accordance with 1202, "Contents of Proposal Package."

PROPOSAL GUARANTY. The security furnished with a **proposal** to guarantee that the **bidder** will enter into the **contract** if the **Department** awards the contract to the bidder.

PURE LIVE SEED (PLS). A percentage calculated by multiplying the percent of viable seed ("total germination and hard seed or dormant seed when applicable") by the percent of pure seed and dividing the product by 100.

QUALIFIED LABORATORY. A laboratory accredited by the AASHTO Materials Reference Laboratory (AMRL), or a comparable accreditation program approved by MnDOT and the FHWA for all test procedures performed.

QUALITY ASSURANCE (QA). The activities performed by the **Department** that have to do with making sure the quality of a product or process meets the relevant **contract** requirements.

QUALITY COMPACTION. A compaction method as defined in 2105.3.F.2, "Quality Compaction."

QUALITY CONTROL (QC). The activities performed by the **Contractor** that have to do with making the quality of a product or process meets the relevant **contract** requirements.

QUESTIONNAIRE. The specified forms on which a **bidder** may be required to furnish information as to ability to perform and finance the **work**.

RAMP. A connecting **roadway** for travel between **intersection** legs at or leading to an **interchange**.

RELATIONSHIP. The interdependencies among activities. Relationships link an activity to its **Predecessors** and **Successors**. A schedule's relationships are sometimes referred to as the logic of the schedule. Examples of relationships are finish-to-start, start-to-start, and finish-to-finish. Relationships are implied in bar chart schedules and explicit in CPM schedules.

REVISED SCHEDULE. A schedule prepared and submitted by the **Contractor** and accepted by the **Department** that includes a significant modification to the schedule logic, activity durations, or other significant attributes of a schedule. The **Revised Schedule** is usually prepared for the purpose of depicting a significant change in the Contractor's plan. Once accepted by the Department, the Revised Schedule becomes the **Progress Schedule**.

RIGHT OF WAY. A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a **highway**.

ROAD. (See **Highway, Road, Roadway, or Street**.)

ROADBED. The graded portion of a **highway** within top and side slopes, prepared as a foundation for the **pavement structure** and **shoulders**.

ROADWAY. (See **Highway, Road, Roadway, or Street**.)

ROAD DESIGN MANUAL. A **Department** manual that establishes uniform design policies and procedures in preparation of road plans. References to the **Road Design Manual** from the **contract** are to the edition in effect on the letting date.

SCALE. A device used to measure the mass or the proportion of a liquid or solid. This definition includes metering devices.

SCHEDULE OF MATERIALS CONTROL. A **Department** schedule that outlines the minimum sampling and testing requirements for most materials used in **highway** construction. References to the **Schedule of Materials Control** from the **contract** are to the edition in effect on the letting date.

SEEDING MANUAL. A Department manual that provides guidance on seed mixtures specified by the **Department** and methods for their installation and establishment. References to the **Seeding Manual** from the **contract** are to the edition in effect on the letting date.

SHOULDER. The portion of the **roadway** contiguous with the **traveled way** for accommodation of stopped vehicles, for emergency use, and for lateral support of the **pavement structure**.

SIDEWALK. That portion of the **roadway** primarily constructed for the use of pedestrians.

SIEVE. A woven wire screen meeting the requirements of AASHTO M-92 for the size required by the **contract**.

SIGNING ENGINEER. A **Department** engineer responsible for statewide guidance on signing. This individual has responsibilities delegated from the **Traffic Engineer**.

SITE MANAGEMENT PLAN. A **Contractor**-provided written amendment to the **Department**'s **SWPPP** that indicates the means and methods the Contractor will use for performing work in or adjacent to waters of the **State**. The **Contractor** must obtain the **Engineer**'s approval of the Site Management Plan before beginning the work, and the Site Management Plans shall include timing, narratives, details, and locations of the work.

SPECIAL PROVISIONS. Additions and revisions to the **standard specifications** and **supplemental specifications** that cover conditions specific to a **contract**.

SPECIFICATIONS. The **Standard Specifications**, the **Supplemental Specifications**, the **Special Provisions**, and any Department-approved changes to these **Contract** documents.

SPECIFIED COMPLETION DATE. The date on which the **work** is specified to be completed.

SPECIMEN TREE. A tree indicated in the **contract** or identified by the **Engineer** that is notable and valued because of its species, size, condition, age, longevity, durability, crown development, function, visual quality, and public or private prominence or benefit.

STANDARD PLANS and STANDARD PLATES. Department provided drawings consisting of sheets or details of design and construction for various structures and products.

STANDARD SIGNS MANUAL. A **Department** manual that establishes, determines, and communicates standards and specifications concerning standard dimensions, colors, and other requirements of the various types of highway signs and pavement messages. References to the **Standard Signs Manual** from the **contract** are to the edition in effect on the letting date.

STANDARD SPECIFICATIONS. The current edition of this book. **Standard Specifications** are approved for general, repeated use.

STATE. The State of Minnesota acting through its elected officials and their authorized representatives.

STORMWATER POLUTION PREVENTION PLAN (SWPPP). A comprehensive plan required by the **NPDES Permit** to identify sources of pollution and describe **BMPs** to reduce pollution from stormwater runoff at a construction site. The construction plan sheets and contract documents are a part of the SWPPP that includes both temporary and permanent **BMPs** during construction.

STREET. (See **Highway, Road, Roadway, or Street**.)

STRUCTURAL METALS ENGINEER. A **Department** engineer responsible for the overall direction, supervision, and management of the Structural Metals Inspection Unit. This individual has responsibilities delegated from the **Bridge Engineer.**

STRUCTURES. **Bridges**, **culverts**, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, foundation drains, and other man-made features.

SUBCONTRACTOR. An individual, firm, or corporation to whom the **Contractor** sublets part of the **contract**.

SUBGRADE. The top surface of a **roadbed** upon which the **pavement structure** and **shoulders** are constructed. Also, a general term denoting the foundation upon which a base course, surface course, or other construction is to be placed, in which case reference to subgrade operations may imply depth as well as top surface.

SUBSTRUCTURE. The part of a **bridge** below the bearings of simple and continuous spans, skewbacks, or arches and tops of footings for rigid frames, together with the backwalls, wingwalls, and wing protection railings.

SUCCESSOR. An activity that is defined by schedule logic to succeed another activity. The start or finish date of a **Successor** may be controlled by its **Predecessor**.

SUPERINTENDENT. The **Contractor's** authorized representative in responsible charge of the **work**.

SUPERSTRUCTURE. The entire **bridge** except the **substructure**.

SUPPLEMENTAL AGREEMENT. A written agreement between the **Department** and the **Contractor**, executed on the prescribed form and approved as required by law, covering the performance of **extra work** or other alterations or adjustments as provided for within the general scope of the **contract**, but for which extra work or **change order** constitutes a modification of the contract as originally executed and approved.

SUPPLEMENTAL SPECIFICATIONS. Additions and revisions to the **standard specifications** that are formally approved and printed subsequent to issuance of the printed book of standard specifications.

SURETY. The corporation, partnership, or individual, other than the **Contractor**, executing a bond furnished by the Contractor.

TEMPORARY BY-PASS. A section of **roadway**, usually within existing **right of way**, provided to temporarily carry all traffic around a specific work site.

TEMPORARY EROSION CONTROL MEASURES. Soil-erosion control measures to temporarily protect the **project** from erosion before and during the installation of **permanent erosion control measures**.

TEMPORARY SEDIMENT CONTROL MEASURES. Sediment trapping and filtering devices such as sediment control logs, silt fence, sediment basins, inlet protection, and other means to temporarily control sediment until installation of **permanent erosion control measures**.

TEMPORARY TRAFFIC CONTROL ZONE LAYOUTS FIELD MANUAL. A **Department** manual that contains typical traffic control layouts. References to the **Temporary Traffic Control Zone Layouts Field Manual** from the **contract** are to the edition in effect on the letting date.

TOWNSHIP. (See **City, County, or Township**.)

TRAFFIC ELECTRICAL SYSTEMS ENGINEER. A **Department** engineer responsible for statewide guidance on traffic electrical systems. This individual has responsibilities delegated from the **Traffic Engineer**.

TRAFFIC ENGINEER. The Director of the **Department's** Office of Traffic Engineering acting directly or through an authorized representative within the scope of the particular duties or functional unit referenced in the **Contract** documents.

TRAFFIC LANE. The portion of a **traveled way** for the movement of a single line of vehicles.

TRAFFIC ENGINEERING MANUAL. A **Department** manual that establishes uniform guidelines and procedures to aid road users in recognizing and understanding various traffic control devices. References to the **Traffic Engineering Manual** from the **contract** are to the edition in effect on the letting date.

TRAVELED WAY. The portion of the **roadway** for the movement of vehicles, exclusive of **shoulders** and **auxiliary lanes**.

TURN LANE. An **auxiliary lane** for left or right turning vehicles.

TWO-WEEK LOOK-AHEAD SCHEDULE. Schedule that spans a forward looking, rolling period of at least 14 calendar days.

UNIT PRICE. The price per unit of a **contract item**.

UPDATE SCHEDULE. A schedule prepared at least monthly by incorporating the actual progress of the previous month into the **Progress Schedule**.

VERIFICATION TESTING. Sampling and testing performed by the **Department** to validate the quality of the product per Title 23 – Highways, Code of Federal Regulation 637.203

WORK. The furnishing of all labor, **materials**, **equipment**, and other incidentals necessary or convenient to the successful completion of the **project** and the performance of all duties and obligations imposed on the Contractor by the **contract**. Also used to indicate the construction required or completed by the Contractor.

WORKING DAY. A calendar day, exclusive of Saturdays, Sundays, and **Holidays**, on which weather and other conditions not under the control of the **Contractor** will permit construction operations to proceed for at least 4 hours, with the normal working force engaged in performing the progress-controlling operations.

WORKING DRAWINGS. Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data that the **Contractor** is required to furnish and submit to the **Engineer**.

WORK ORDER. A written order signed by the **Engineer** of a contractual status requiring performance or other action by the **Contractor** without negotiation of any sort.

Bidding Requirements and Conditions

1201 PREQUALIFICATION OF BIDDERS

The Department will not require prequalification of the Bidders before submission of Proposals, but the Department may require a written statement from the apparent low Bidder before Award. If the Department requires a written statement, the statement shall include the following:

(1) Bidder experience,
(2) Bidder certifications,
(3) Bidder licenses, and
(4) The amount of capital and equipment available for performance of the proposed Work.

1202 CONTENTS OF PROPOSAL PACKAGE

The Proposal Package will include the following:

(1) The location and description of the proposed construction;
(2) The Bid Schedule;
(3) The Contract Time;
(4) The amount and nature of the required Proposal Guaranty;
(5) The basis for comparison of proposals, if other than by total cost;
(6) The date, time, and place for opening Proposals (also defined in the Advertisement for Bids);
(7) Any Special Provisions and other supplementary requirements; and
(8) The Plans, Specifications, and other documents included in the Proposal Package.

The bidder shall not alter the contents of the Proposal Package, unless authorized in writing by the Department. The Department considers alterations to include any unauthorized additions, deletions, or changes.

1203 ACCESS TO PROPOSAL PACKAGE

The Department will provide Bidders with access to the Proposal Package through the online E-Plan Room. The Department may require a fee for Bidders to purchase and download copies of the Proposal Package.

1204 INTERPRETATION OF QUANTITIES IN BID SCHEDULE

The quantities in the Bid Schedule are estimates only. The Department will use these quantities to compare Proposals in accordance with 1301, "Consideration of Proposals."

During the Project, the Department may increase, decrease, or eliminate quantities of Contract Items in accordance with 1402, "Contract Revisions;" and will measure and pay for accepted quantities of Contract Items in accordance with 1901, "Measurement of Quantities."

1205 EXAMINATION OF PROPOSAL PACKAGE AND SITE OF WORK

1205.1 PROPOSAL PACKAGE AND SITE OF WORK

Before submitting a Proposal, the Bidders shall carefully examine the Proposal Package and perform a reasonable investigation of the site of Work. Submitting a Proposal is considered an affirmative statement that the Bidder has examined the Proposal Package and performed a reasonable investigation of the site of Work, and is satisfied as to the character, quality, quantities, and conditions to be encountered in performing the Work. A reasonable site investigation includes investigating or reviewing the following:

(1) Project Site;
(2) Borrow sites;
(3) Haul routes;
(4) Utility property in accordance with 1507, "Utility Property and Service;"
(5) All other locations related to the performance of the Work, and
(6) Any additional information the Department makes available in accordance with 1205.2, "Additional Information."

The Bidder shall immediately notify the Department of any apparent defect in the Proposal Package. The Department will determine if a defect exists and, if necessary, will issue an Addendum to all prospective Bidders to address the correction.

1205.2 ADDITIONAL INFORMATION

When available, the Department may make the following additional information available to Bidders:

(1) All Department boring logs and other records of subsurface investigation,
(2) Record drawings,
(3) Results of other preliminary investigations, and
(4) Other documents.

A review of this additional information is not a substitute for a Bidder's own evaluation, interpretation, or judgment in preparing a Proposal. Bidders shall understand that this additional information is not part of the Proposal Package and will not become part of the Contract. The Department makes this additional information available for the Bidders' information only and warns the Bidders not to rely on any included estimates or quantities. If not included in the Proposal Package, the additional information may be available upon request, and Bidders shall be deemed to have knowledge of the availability of this additional information. Bidders are solely responsible for all assumptions, deductions, and conclusions that they may reach. The Department does not make or imply a warranty as to the accuracy, sufficiency, or reliability of this additional information.

If the Department has taken test borings on the Project, the Department may or may not include the test boring information on the Plans. If the Department includes test boring information on the Plans, the Bidders shall understand the following with regard to the test boring information:

(1) The Department takes borings by ordinary and conventional methods and with care deemed adequate for the Department's design purposes.
(2) The logs of the borings may have been edited or abridged and may not reveal all information that might be useful or of interest to the Contractor.
(3) The Department will make any field logs and laboratory logs relating to the borings available to the Bidders, or Contractor.
(4) The Department may have taken some borings to gather information for purposes other than those related to the construction of the Project.
(5) The Department does not warrant that the information is complete, but believes that the information as to the conditions and materials reported within each test hole was accurate at the time the boring was taken.
(6) The Department does not warrant that conditions adjacent to test borings will necessarily be the same as shown on the logs because subsurface conditions outside of each individual test hole are unknown to the Department, and soil, rock, and water conditions cannot be relied upon to be consistent and uniform.
(7) The Department will not be responsible for any interpretations made by the Contractor.
(8) The absence of notations on the logs regarding water does not necessarily mean that the borings were dry or that the Contractor will not encounter subsurface water during the course of construction.

1206 PREPARATION AND DELIVERY OF PROPOSAL

1206.1 PREPARATION AND DELIVERY

The Bidder shall use the electronic submittal process. The Bidder shall submit the electronic Proposal in accordance with AASHTO "Expedite Bid" software and the "Bid Express" website (www.bidx.com).

The Bidder shall submit its Proposal by the date and time for opening Proposals. Bid Express will not accept Proposals past the date and time of the opening of proposals.

The Bidder shall submit the Proposal Guaranty electronically or file a hard copy of the Proposal Guaranty with the Department by the same date and time.

If a Bidder fails to provide a Unit Price for any Pay Item on the Bid Schedule, except for "Lump Sum" Pay Items, the Department will reject the Proposal.

If a Pay Item in the Proposal requires the Bidder to choose an alternate Pay Item, the Bidder shall indicate its choice in accordance with the Specifications for that Pay Item.

1206.2 ALLOWABLE SUBSTITUTIONS

When directed by the Department, the Bidder shall submit a disk Proposal using AASHTO "Expedite Bid" and EBS files. The Bidder shall label the disk with the company name and the project number.

The Bidder shall deliver the Proposal and the Proposal Guaranty in a sealed envelope. The Bidder shall mark the sealed envelope with the name of the Bidder, the Project number, and the letting date. The Bidder shall deliver the sealed envelope to the Department as specified in the Advertisement for Bids as follows:

(1) To the address specified,
(2) In care of the official receiving the Proposals, and
(3) By the date and time for opening Proposals.

If the Department receives a Proposal after the date and time for opening Proposals, the Department will return the Proposal to the Bidder unopened.

1207 IRREGULAR PROPOSALS

The Department may reject irregular Proposals. The Department will consider a Proposal to be irregular for any of the following reasons:

(1) The Bidder submits its Proposal on a form other than the Proposal Form;
(2) The Bidder alters the contents of the Proposal Package, as defined in 1202, "Contents of Proposal Package;"
(3) The Proposal is incomplete, indefinite, or ambiguous as to the meaning;
(4) The Proposal contains unauthorized alternate bids;
(5) The Proposal is a conditional Proposal that reserves the Bidder's right to enter into the Contract pursuant to an Award, except for that allowed in 1211, "Conditional Proposals;" or
(6) Any Unit Prices in the Proposal are unbalanced in excess of or below the reasonable cost analysis values.

In accordance with 1206, "Preparation and Delivery of Proposal," the Department will reject any Proposal in which the Bidder fails to provide a Unit Price for any Pay Item or work on the Proposal Form, except for "Lump Sum" Pay Items.

1208 PROPOSAL GUARANTY

The Bidder shall include with its Proposal a Proposal Guaranty that meets the following requirements:

(1) Equal to 5 percent of the total amount of the Proposal;
(2) Made payable to the Department; and
(3) In the form of a certified check, a cashier's check, or a bond.

If providing a Proposal Guaranty in the form of a bond, the bond must meet the following requirements:

(1) Issued by a corporation authorized by the Minnesota Department of Commerce to contract as a surety in the State of Minnesota; and
(2) Conditioned on execution of the Contract in accordance with 1306, "Execution and Approval of Contract."

1209 BLANK

1210 REVISION OF PROPOSAL PACKAGE OR WITHDRAWAL OF PROPOSALS

If submitting a Proposal electronically, the Bidder may revise its Proposal an unlimited number of times and may withdraw its Proposal before the date and time for opening Proposals.

If submitting a Proposal in accordance with 1206.2, "Allowable Substitutions," the Bidder may revise or withdraw its Proposal after delivery to the Department if the Department receives the Bidder's written request for withdrawal or revision before the date and time for opening Proposals.

The Department reserves the right to revise the Proposal Package at any time before the date and time for opening Proposals. The Department will issue a numbered and dated Addendum for any revision of the Proposal Package. The Department will electronically post each Addendum as announced in an e-mail notification to each Bidder on the Department's list of Bidders. The Department will include each Addendum with all Proposal Forms issued to the Bidder after the date of the Addendum.

If revisions made by an Addendum require change to Proposals or reconsideration by the Bidder, the Department may postpone opening Proposals. If the Department postpones opening Proposals, the Department will specify the new date and time for opening Proposals in the Addendum.

The Bidder shall acknowledge receipt of each Addendum in the electronic proposal.

1211 CONDITIONAL PROPOSALS

The Department will accept conditional Proposals only as authorized by the Department in this section. The Department will award the Contract to a Bidder with a conditional Proposal if doing so is in the best interest of the Department.

If the Bidder submits Proposals on multiple Projects and the amount of the Proposals for the multiple Projects is more than the Bidder is able to perform, the Bidder may complete and include the following statement with each Proposal to limit the amount of Projects awarded:

"This Bidder can only enter into a contract or contracts totaling no more than $_____, and hereby authorizes the Department to determine which Proposal or Proposals to award and which to reject."

With each statement, the Bidder shall provide all Project numbers for which the statement applies.

1212 OPENING OF PROPOSALS

The Department will open Proposals at the time, date, and place defined in the Proposal Package and the Advertisement for Bids. The Department will electronically post Proposal results after the opening.

1213 DISQUALIFICATION OF BIDDERS

The Department may disqualify a Bidder and reject the Bidder's Proposal for any of the following reasons:

(1) If an individual, firm, or corporation, either under the same or different name, submits more than one Proposal for the same Project;
(2) The Department finds evidence of collusion among Bidders; or
(3) The Bidder failed to perform on a previous contract with the State.

Bidding Requirements and Covenants

1301 CONSIDERATION OF PROPOSALS

After opening Proposals, the Department will compare the Proposals based on the correct summation of the products of the scheduled quantities and unit bid prices. If the lowest responsible Bidder has submitted prices on more than one alternate item, the Department reserves the right to determine which alternate to accept. If the extended bid item price, obtained by multiplying the unit bid price by the bid item quantity, is incorrectly calculated, the Department will use the unit bid price to recalculate the extended bid item price.

The Department will not consider Proposals that do not include a Proposal Guaranty in accordance with 1208, "Proposal Guaranty."

The Department reserves the right to:

(1) Reject any or all Proposals,
(2) Waive defects and technicalities in a Proposal, or
(3) Advertise for new Proposals.

1302 AWARD OF CONTRACT

Within 30 calendar days after opening Proposals, the Department will Award the Contract to the lowest responsible Bidder provided that the lowest responsible Bidder complies with the Proposal requirements. The Department may also decide not to make a Contract Award. The Department will notify the lowest responsible Bidder electronically, in writing, or by other means that the Department has accepted the Proposal subject to execution and approval of the Contract as required by law.

The Department and the lowest responsible Bidder may mutually agree to extend the time within which the Department makes the Award.

1303 CANCELLATION OF AWARD

Before Contract execution, the Department reserves the right to cancel the Award of the Contract without liability.

1304 RETURN OF PROPOSAL GUARANTY

After opening and auditing the Proposals, the Department will immediately return Proposal Guaranties to all Bidders, except for the two lowest Bidders. The Department will retain the Proposal Guaranties of the two lowest Bidders until execution and approval of the Contract as required by law. After execution and approval of the Contract, the Department will return the Proposal Guaranties of the two lowest Bidders, except in the case of forfeiture as specified in 1307, "Failure to Execute Contract." The Department will only return Proposal Guaranties that the Bidders submit as checks (certified or cashier's).

1305 REQUIREMENT OF CONTRACT BOND

The lowest responsible Bidder shall submit with the signed Contract a Payment Bond and a Performance Bond each equal to the Contract Amount as required by MN Statute § 574.26. The Department will review the Surety and form of the Contract Bonds and provide approval if acceptable.

1306 EXECUTION AND APPROVAL OF CONTRACT

The lowest responsible Bidder shall return the Contract to the Department with the required Payment and Performance Bonds within 10 business days after Award.

If the Contract specifies the Contract Time as working days and the lowest responsible Bidder fails to return the signed Contract documents within 10 business days, the Department may reduce the Contract Time to reflect the delay caused by the Contractor.

If the Contract specifies the Contract Time as a completion date, the lowest responsible Bidder's delay in returning the signed Contract documents is non-excusable delay under 1806.3.A, "Non-Excusable Delays," and the Contractor is not entitled to an extension of the Contract Time.

If the lowest responsible Bidder is unable to return the signed Contract documents within the specified time due to the absence of one or more of the required signers, the Department may grant an extension of time provided the Contractor submits satisfactory evidence that the Contract documents will be signed.

A foreign or nonresident corporation that is awarded a Contract shall provide proof that it has met all legal requirements for transacting business in the State of Minnesota, as a condition precedent to Contract approval.

The Department will provide the lowest responsible Bidder with a notice of approval or disapproval of the Contract and Contract Bonds within 10 business days after the lowest responsible Bidder properly signs and returns the Contract documents to the Department. The Award is not binding and the Contract is not effective until both parties fully execute the Contract and the Department approves the Contract, as required by law.

1307 FAILURE TO EXECUTE CONTRACT

The Department will retain the Proposal Guaranty as liquidated damages sustained, not as a penalty, if the lowest responsible Bidder fails to perform any of the following within the time specified in the Proposal Package:

(1) Sign the Contract documents,
(2) Provide the required Contract Bonds, or
(3) Comply with any other requirements imposed as a condition precedent to the Contract approval.

If the Department cancels the Award, the Department may choose any of the following actions:

(1) Award the Contract to the next lowest responsible Bidder,
(2) Advertise for new Proposals, or
(3) Otherwise perform the Work as decided by the Department.

Scope of Work

1401 INTENT OF CONTRACT

The intent of the Contract is to provide for construction of the Project and compensation for the Work in accordance with the Contract documents.

The titles and headings of the various sections and subsections of the Contract are intended for convenience of reference.

The Contractor shall construct and complete the Project in every detail as described in the Contract. The Department will require the Contractor to perform the Work diligently and vigorously to completion. The Contractor shall consider the public interests and the obligations and rights of all other parties concerned. The Contractor shall assume full responsibility for performance of the Work and shall furnish all labor, materials, equipment, tools, supplies, transportation, and other incidentals necessary or convenient for successful completion of the Project.

The Contract may not fully describe every detail or make specific allowances for all probable exceptions and contingencies. When the Contract is silent or omits a detailed description, the Contractor shall perform in accordance with the best general practice and provide materials and workmanship meeting the quality specified in the Contract. The Department's failure to itemize every allowable exception or condition in the Contract does not mean that the Contract provisions will be enforced equally under all conditions or on all parts of the Work.

In the interest of avoiding repetitious wording in the Specifications, certain words and phrases have been omitted where reference is clearly related by expressions of authority or intention. Where certain words and terms appear, they are to be construed with reference to the definitions, abbreviations, heading, titles, item names, and other pertinent provisions of the Contract documents, as may be implied.

1402 CONTRACT REVISIONS

1402.1 GENERAL

The Engineer reserves the right to make, in writing, at any time during the progress of the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project or for reasons of the Department's interest. Revisions to the Contract will not add Work beyond the limitations imposed by law or beyond the termini of the proposed construction except as may be necessary to satisfactorily complete the Project. Revisions to the Contract neither invalidate the Contract nor release the surety, and the Contractor agrees to perform the Work as revised. Either party to the Contract may assert that a Contract revision has occurred.

If the Contractor believes it has encountered a Contract revision as set forth in 1402.2, "Differing Site Conditions," 1402.3, "Significant Changes to the Character of Work," 1402.4, "Suspensions of Work Ordered by the Engineer," 1402.5, "Extra Work," or 1402.6, "Eliminated Items," the Contractor shall provide notice as required by these clauses and as required by 1403, "Notification for Contract Revisions." Failure to provide notice as specified in 1403, "Notification for Contract Revisions" constitutes a waiver of the Contractor's entitlement to compensation or a time extension and releases the Department from responsibility for providing compensation or a time extension.

If the Engineer concludes that a Contract revision is necessary, the Department will compensate the Contractor for the revision in accordance with 1904, "Compensation for Contract Revisions," 1905, "Compensation for Eliminated Items," and 1907, "Payment for Surplus Material." No allowance, except as specifically provided by the payment provisions of the Contract, will be made for any increased expenses, loss of expected reimbursement, or loss of anticipated profits suffered or asserted by the Contractor, whether resulting directly from revisions in the Work or indirectly from unbalanced allocation of expenses among the Contract Items, for any variation between the quantities in the Bid Schedule and the actual quantities ordered and performed, or from any other cause. If necessary, a time extension may be granted in accordance with 1806, "Determination and Extension of Contract Time."

In 1402.2, "Differing Site Conditions," 1402.3, "Significant Changes to the Character of the Work," and 1402.4, "Suspensions of Work Ordered by the Engineer," the term "adjustment" means compensation in accordance with 1904, "Compensation for Contract Revisions," 1905, "Compensation for Eliminated Items," and 1907, "Payment for Surplus Material," and the granting of a time extension in accordance with 1806, "Determination and Extension of Contract Time."

1402.2 DIFFERING SITE CONDITIONS

During the progress of the work, if one of the following subsurface or latent physical conditions is encountered at the site, the party encountering such conditions shall promptly notify the other party in writing of the specific differing conditions before they are disturbed and before the affected work is performed:

(1) Differ materially from those indicated in the Contract, or
(2) If unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the Work provided for in the Contract.

Upon written notification, the Engineer will investigate the conditions. If the Engineer determines that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any Work under the Contract, the Engineer will make an adjustment, excluding loss of anticipated profits, and will modify the Contract in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted.

The Department will not allow a Contract adjustment that results in a benefit to the Contractor, unless the Contractor has provided the required written notice.

1402.3 SIGNIFICANT CHANGES TO THE CHARACTER OF WORK

The Engineer reserves the right to make, in writing, at any time during the progress of the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the contract nor release the Surety, and the Contractor agrees to perform the work as altered.

If the alterations or changes in quantities significantly change the character of the work under contract, whether those alterations or changes are in themselves significant changes to the character of the work or, by affecting other work, cause such other work to become significantly different in character, an adjustment, excluding loss of anticipated profits, will be made to the contract. The Contractor and Department shall agree on the basis for an adjustment in writing before the performance of the work. If the Contractor and Department cannot agree, the Engineer will make an adjustment either for or against the Contractor in such amount as the Engineer determines to be fair and equitable.

If the alterations or changes in quantities do not significantly change the character of the work under the contract, the Department will pay for the altered work as provided elsewhere in the contract.

The term "significant change" shall be construed to apply only to the following circumstances:

(1) When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction, or

(2) When a major contract item of work is increased in excess of 125 percent or decreased below 75 percent of the original Contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125 percent of the original contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed.

1402.4 SUSPENSIONS OF WORK ORDERED BY THE ENGINEER

If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation, or contract time, or both are due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment no later than 7 calendar days after receipt of notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the cost, or time required for the performance of the Contract, or both have increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors approved under 1801 "Subletting of Contract", and not caused by weather, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the contract is warranted.

The Department will not allow a contract adjustment unless the Contractor has submitted the request for adjustment within the time prescribed.

The Department will not allow a contract adjustment under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of this Contract.

1402.5 EXTRA WORK

If the Contractor believes that it has been required to perform Extra Work, the Contractor shall notify the Engineer in accordance with 1403, "Notification for Contract Revisions." Failure to provide notice as specified in 1403 constitutes a waiver of the Contractor's entitlement to compensation or a time extension and releases the Department from responsibility from providing compensation or a time extension. If the Engineer determines, in the Engineer's sole discretion, that Extra Work is required, the Department will compensate the Contractor for Extra Work in accordance with 1904, "Compensation for Contract Revisions," and determine the appropriate time extension, if any, in accordance with 1806, "Determination and Extension of Contract Time."

The Department and the Contractor shall execute a Supplemental Agreement specifying the location and nature of the work to be performed and the basis of payment before the Contractor is authorized to perform Extra Work. The Contractor shall perform Extra Work in accordance with the specifications unless otherwise specified in the Supplemental Agreement authorizing the

Extra Work. The Supplemental Agreement authorizing Extra Work shall not become effective until it has been fully executed and approved as required by law.

An executed Supplemental Agreement is not required prior to the Contractor's performance of Extra Work in the following two instances:

(1) The Engineer may order Minor Extra Work not to exceed $25,000 per individual occurrence without the execution of a Supplemental Agreement as long as the Engineer's order is in writing, specifies the location and nature of the minor extra Work, and specifies the basis of payment in accordance with 1904, "Compensation for Contract Revisions."

(2) The Engineer, with the written approval of the Construction Assistant District Engineer, may order Extra Work in excess of $25,000 but not exceeding $50,000 per individual occurrence, as long as the Engineer's order is in writing, specifies the location and nature of the Extra Work, and specifies the basis of payment in accordance with 1904.

If the Contractor performs Extra Work before a Supplemental Agreement is fully executed, the Department may consider this as unauthorized work and as having been done at the Contractor's expense. The Department will compensate the Contractor for this work only if the Engineer determines that the work is acceptable and necessary, and the Supplemental Agreement or Work Order-Minor Extra Work has been fully executed.

1402.6 ELIMINATED ITEMS

Should the Department eliminate any Contract Items from the Contract, the Department will reimburse the Contractor for all costs incurred before notification that are not the result of unauthorized Work.

The Department will compensate the Contractor in accordance with 1905, "Compensation for Eliminated Items," for approved work the Contractor performs on eliminated items.

1403 NOTIFICATION FOR CONTRACT REVISIONS

1403.1 GENERAL

The following notification requirements apply to all potential Contract revisions including those defined in 1402, "Contract Revisions." The Engineer will consider requests for Contract revisions only if the notification procedures in this section are followed. The specified time limits may only be extended through a written, jointly-signed agreement between the Contractor and the Engineer. The Engineer will address the underlying issue prompting the notification in a timely manner.

1403.2 FIRST NOTICE, BY CONTRACTOR

The Contractor shall notify the Engineer verbally as soon as a Contract revision appears necessary. The Contractor shall not start or continue with an activity or Contract Item for which a Contract revision may be necessary without authorization from the Engineer.

1403.3 WRITTEN NOTICE, BY CONTRACTOR

If the Contractor disagrees with the Engineer's response or the Engineer does not respond to the first notice, the Contractor shall provide a written notice. Provide this written notice within 5 business days of first notice if Engineer has not responded or within 5 business days of receiving the Engineer's response to the first notice. The written notice shall include the following:

(1) A description of the situation;
(2) The time and date the situation was first identified;
(3) The location of the situation, if appropriate;
(4) A clear explanation of why the situation represents a Contract revision, including appropriate references to the pertinent portions of the Contract or law;
(5) A statement of the revisions deemed necessary in the Contract Unit Price(s), delivery schedule(s), phasing, time, etc. Because of the preliminary nature of this notice, the Department recognizes that this information may rely on estimates;
(6) An estimate of the time by which the Engineer must respond to minimize cost or delay, and;
(7) Anything else that will help achieve timely resolution.

1403.4 WRITTEN ACKNOWLEDGEMENT, BY ENGINEER

The Engineer will provide a written acknowledgment of receipt of the Contractor's written notice.

1403.5 FINAL WRITTEN RESPONSE, BY ENGINEER

Within 10 business days of receiving the Contractor's written notice, the Engineer will provide a written response that includes one of the following:

(1) Confirmation of the need for a contract revision. The Contractor shall pursue time extensions in accordance with 1806, "Determination and Extension of Contract Time," and compensation in accordance with 1904, "Compensation for Contract Revisions," or
(2) Denial of the request for a contract revision, in which case the Engineer will make clear, by reference to the Contract, why the issue does not represent a revision to the contract.
(3) A request for additional information, in which case the Engineer will state clearly what is needed and by when; the Engineer will issue a final response within 10 business days of receiving the additional requested information.

1403.6 CONTRACTOR'S RECOURSE

If the Contractor disagrees with the Engineer's final written response or the Engineer's response is untimely, the Contractor may pursue a claim in accordance with 1517, "Claims for Compensation Adjustment." The Contractor shall give the Engineer written notice of the intent to pursue a claim within 5 business days of receiving the Engineer's final written response.

1404 MAINTENANCE OF TRAFFIC

1404.1 GENERAL

Unless the Contract requires otherwise, the Contractor shall keep Roads undergoing improvements open to traffic at no additional cost to the Department. The Contractor shall direct traffic over a Department-approved Detour route as required by the Contract or as directed by the Engineer.

The Contractor shall maintain the portions of the Project being used by public traffic in a condition that accommodates the public traffic at all times. The Contractor shall provide and maintain temporary approaches, crossings, and intersections with trails, Roads, Streets, businesses, parking lots, residences, garages, farms, and other abutting property in a safe and acceptable condition.

The Department will not require the Contractor to remove snow from roads open to traffic.

1404.2 PLANNED DETOURS

The Department will maintain, without any cost to the Contractor, Detour Roads established by the Commissioner for through traffic diverted from the Project, if the Plans, Special Provisions, or the Engineer directs Project Road closures.

1404.3 CONTRACTOR'S REQUEST FOR DETOUR

The Contractor may request from the Engineer a Detour for through traffic. The Contractor shall specify the Detour routes and submit justification information with the Detour request. The Department will consider and may, at its sole discretion, approve the Detour request and establish a Detour in accordance with the following:

(1) The Contractor shall design, provide, install, maintain, and remove traffic control devices on the Detour Roads at no additional cost to the Department. The Contractor shall submit the proposed Detour layout to the Engineer for approval at least 7 calendar days before the Contractor begins to use the Detour.
(2) The Contractor shall maintain and restore Detour Roads at no additional cost to the Department. The Department will remove snow from Detour Roads at the Department's expense.
(3) The Contractor shall provide, install, and maintain traffic control devices and other traffic protection measures required to maintain local traffic.

1404.4 CONTRACTOR'S REQUEST FOR TEMPORARY BY-PASSES

The Contractor shall design, construct, maintain, and remove other Temporary By-pass facilities requested by the Contractor and approved by the Engineer at no additional cost to the Department.

1404.5 MAINTENANCE DIRECTED BY THE ENGINEER

The Contractor shall perform maintenance work or provide dust control for the benefit of the public as directed by the Engineer. The Department will pay for the Engineer-directed work at Contract Unit Prices or as Extra Work in accordance with 1402, "Contract Revisions." The Department will not pay for Contractor Work performed on Contractor requested Detours and Contractor selected haul Roads.

1404.6 CONTRACTOR'S USE OF CROSSOVERS

Unless otherwise prohibited by the Engineer and in accordance with pertinent traffic laws and regulations, the Contractor may use freeway or expressway maintenance crossovers in or near the construction area to change the travel direction of the construction equipment.

1404.7 WINTER SUSPENSION

During periods of winter suspension, the Contractor shall open the Project's Roads to traffic to eliminate the need to maintain Detour Roads during the suspension period.

During periods of authorized winter suspension, the Department will perform routine maintenance on the Project's Roads at the Department's expense. The Department will maintain traffic control devices in accordance with 1710, "Traffic Control

Devices." If Contractor-owned traffic control devices are damaged or destroyed, the Department will pay the Contractor for the value of the traffic control device as determined by the Engineer.

The Contractor shall not suspend operations for the winter until meeting the requirements of 1710, "Traffic Control Devices," and 1803.6, "Temporary Suspensions."

When resuming Work after winter suspension, the Contractor shall remove and replace, or correct Work lost or damaged during the suspension, as directed by the Engineer, and shall remove, to the extent directed by the Engineer, any temporary construction or Materials used in the maintenance thereof by the Department. The Department will pay for this work at the Contract Unit Prices or as Extra Work in accordance with 1402, "Contract Revisions."

1405 USE OF MATERIALS FOUND ON THE PROJECT

The Contractor shall not destroy or use Materials found on the Right of Way or on other land acquired for the Project for any other purposes than those specified in the Contract, unless otherwise approved by the Engineer.

The Engineer may authorize the Contractor to temporarily use Materials salvaged for the Department from existing structures. The Contractor is responsible for all damage to the Materials used temporarily. The Contractor shall repair, replace, or otherwise correct by means acceptable the Engineer the Materials damaged by the temporary use, or the Department will deduct, from any moneys due or becoming due to the Contractor, an amount equivalent to the reasonable value or replacement cost of the Material.

The Engineer may authorize the Contractor to use acceptable Material found on the Project as a substitute for Material required by the Contract and provided by the Contractor from outside sources. Authorization to remove and use the substitute Material for unspecified purposes to the Contractor's advantage is at the sole discretion of the Engineer, subject to the conditions established by the Engineer and the requirements of the Contract.

The Department will make Material found on the Project available for use on the Project to the best advantage and without charge to the Contractor in the interest of providing maximum utilization of existing Materials. The Contractor shall understand that the Department will not incur additional costs resulting from the use of this Material. If Contractor needs this Material for other construction purposes on the Project, the Contractor shall provide replacement Material acceptable to the Engineer, at no additional cost to the Department.

1406 PRESERVATION OF HISTORICAL OBJECTS

Immediately upon discovery of potential historical objects of an archeological or paleontological nature within the Project Site, the Contractor shall do the following:

(1) Restrict or suspend operations in the immediate area of the discovery to preserve the potential historical objects, and
(2) Notify the Engineer of the presence of potential historical objects.

The Engineer will make arrangements for their disposition or record the desired relevant data.

The Contractor shall support the preservation and salvage effort directed by the Engineer. The Contractor shall not perform work related to the preservation and salvage efforts that the Contractor considers Extra Work without the written approval of the Engineer.

The Department may restrict or suspend the Contractor's operations in the immediate area of the historical objects for a period not to exceed 72 h, without a Contractor claim for damages. The Department will not impose restrictions over 72 h, unless agreed by the Contractor and the Department in writing.

1407 FINAL CLEANUP

Before requesting final inspection in accordance with 1516.2, "Project Acceptance," the Contractor shall remove the following from the Project Site and other locations outside of the Project Site used in performing the Work:

(1) Surplus and discarded Materials,
(2) Equipment,
(3) Rubbish,
(4) Temporary structures, and
(5) Other items not on the Project Site before execution of the Contract.

The Contractor shall also leave the Project Site, including borrow pits, in a condition acceptable to the Engineer. The cost of final cleanup is included in the Contract Unit Prices of the Contract Items.

1408 VALUE ENGINEERING INCENTIVE

Value engineering provisions provide an incentive to the Contractor to initiate, develop, and present cost reduction proposals involving changes in the Contract requirements to the Department for consideration.

Value engineering provisions only apply if the Contractor specifically submits a proposal for consideration as a value engineering proposal.

The cost reduction proposals shall produce a net savings to the Contract by providing less costly items or methods than those specified in the Contract without impairing essential functions and characteristics.

The Contractor shall submit value engineering proposals to the Engineer with the following information:

(1) A statement that the Contractor is submitting a value engineering proposal;
(2) A description of the proposal;
(3) An itemization of the proposed changes to the Contract requirements and a recommendation of how to make each change;
(4) An estimate of the reduction in performance costs that will result from adoption of the proposal;
(5) A prediction of any effects the proposed changes would have on other costs incurred by the Department;
(6) A statement of the time by which an agreement for adoption of the proposal must be executed to obtain the maximum cost reduction during the remainder of the Contract, and the reasoning for this time schedule;
(7) The dates of any previous submissions of the proposal, including Contract numbers and the actions of the Department; and
(8) A statement as to the effect the proposal would have on the time for completion of the Contract.

The Department will not assume any liability for not meeting the statement of the time described in the Contractor's value engineering proposal. The Contractor may withdraw, in whole or in part, any value engineering proposal not accepted by the Department within the period identified in the proposal. The Department's acceptance or rejection decision on a value engineering proposal shall be final and the provisions of 1517, "Claims for Compensation Adjustment," will not apply.

The Department will notify the Contractor in writing of its decision regarding each value engineering proposal. Until the Department accepts the proposal, the Contractor shall continue to perform Work in accordance with the requirements of the Contract. If the Department accepts the proposal, the Department will execute a Supplemental Agreement setting forth the terms, conditions, and costs of the proposal. If the Contractor performs any Work performed in accordance with the value engineering proposal before the execution of the Supplemental Agreement, the Department will consider that "unauthorized work" as specified in 1512, "Unacceptable and Unauthorized Work."

The Supplemental Agreement will establish the Contract modifications and the agreed net savings. The Department will calculate the net savings by subtracting the Contractor's value engineering proposal cost from the Contractor's original bid price for the work covered in the value engineering proposal.

A - Contractor's value engineering proposal cost.
B - Contractor's original bid price for the work covered in the value engineering proposal.
B - A= Net Savings.

The department reserves the right to reject any value engineering proposal that does not reflect the reasonable costs to perform the work covered in the value engineering proposal.

The Department will provide a lump sum payment of 50 percent of the net savings from the value engineering proposal to the Contractor as the Contractor's share of the value engineering incentive. The Department will not revise the lump sum payment even if the final accepted quantities vary. The Department may include conditions for consideration, approval, and implementation of the cost reduction proposal in the Supplemental Agreement.

The Contractor shall design and develop the proposal at no additional cost to the Department.

The Department will not include the costs incurred for reviewing, approving, and implementing the proposal in the net savings calculations.

After the Department accepts the cost reduction proposal, any restrictions imposed by the Contractor on its use or disclosure of the information submitted shall be void, and the Department will have the right to use, duplicate, and disclose any data necessary to use the proposal.

Control of Work

1501 AUTHORITY OF THE ENGINEER

1501.1 DECIDING QUESTIONS

The Engineer will, in the Engineer's sole discretion, decide all questions regarding:

(1) Quality and acceptability of Materials provided and Work performed,
(2) Manner of performance and rate of progress of the Work,
(3) Interpretation of the Contract,
(4) Measurement, control of quantities, and the amount of any payment deductions or adjustments, and
(5) Acceptable fulfillment of all Contract provisions on the part of the Contractor.

The Engineer's acceptance does not waive the Department's right to pursue legal remedies for defective Work or Work performed by the Contractor in an unworkmanlike manner.

1501.2 SUSPENDING WORK

The Engineer may suspend the Work if the Contractor fails to:

(1) Correct conditions unsafe for the Project personnel or the general public,
(2) Carry out the Contract provisions,
(3) Carry out any lawful orders, or
(4) Comply with the requirements of all permits for the Project.

The Engineer may also suspend work for the following:

(1) Unsuitable weather,
(2) Conditions unsuitable for prosecution of the Work, or
(3) Other conditions or reasons deemed to be in the best public, State, Department, or national interest.

1501.3 BASIS OF DECISION

The Engineer will make decisions based on engineering judgment in accordance with the following:

(1) Facts and inferences,
(2) Inherent variations of Materials and processes,
(3) Risks associated with drawing inferences from test results on small samples that may not truly represent the Material or workmanship provided,
(4) Past experiences relating to the question at issue,
(5) Regulations, instructions, and guidelines established by the Department to administer the Work, and
(6) Other factors the Engineer determines to have a bearing on the issue.

The Engineer may require additional tests to provide a statistically sound basis for judgment. The Engineer may accept satisfactory evidence of proper and adequate process control if the end result characteristics cannot be practically measured.

1502 PLANS AND WORKING DRAWINGS

The Department will provide the Plans showing details and directions to provide a comprehensive description of the construction contemplated. The Department will not provide all necessary detail drawings for structures. The Department will include the following information in the Plans:

(1) Summary of all Contract Items,
(2) General features,
(3) Typical cross sections,
(4) Alignment and grades,
(5) Structure locations and dimensions,
(6) Layout diagrams, and
(7) Special details.

The Department will provide Supplemental Drawings in the form of Standard Plates or Standard Plans. The Department may include earthwork cross sections and contours with the Plans.

Before performing the Work, the Contractor shall prepare schedules, documents, and Working Drawings necessary to complete the Work, and shall submit to the Engineer for review. The Contractor's Progress Schedule shall anticipate sufficient time, not less than 14 calendar days, for the Engineer to review and comment on the submittal and to allow the Contractor to respond to the Engineer's comment(s) before starting the Work. The Contractor shall provide additional information, including permits, detail

drawings, and calculations as necessary for the Engineer to complete the review. The Contractor shall provide submittal copies in the requested number to the Engineer for review and inspection of the work. The Contractor shall not alter the submittals without written consent from the Engineer. After completing the Work, the Contractor shall provide digitally reproducible copies to the Engineer upon request. The Contract Unit Prices for the relevant Contract Items include the cost of preparing and submitting the submittals.

The Engineer's review of the submittals does not relieve the Contractor of responsibility for the following:

(1) Accuracy of dimensions and details,
(2) Agreement and conformity with the Contract,
(3) Successful completion of the Work,
(4) Proper and safe design,
(5) Proper and safe construction of the Work, and
(6) Means and methods of performing the Work.

1503 CONFORMITY WITH CONTRACT DOCUMENTS

The Contractor shall perform all Work, including providing all Materials, in conformance with the requirements of the Contract.

Dimensions and values required by the Contract are target dimensions or values. The Department will allow deviations from these targets within the tolerances required by the Contract. It is the intent of the Contract that the Materials and workmanship shall be uniform in character and shall conform to the target or to the middle portion of the tolerance range. The purpose of the tolerance range is to accommodate occasional minor variations from the target or middle portion of the tolerance range that are unavoidable for practical reasons. If the Contract requires a maximum or minimum dimension or value, the Contractor shall control the production and processing of Material and the performance of the Work so that the Material or workmanship is not of borderline quality or dimension. If the Contract does not specify a tolerance for a requirement, the Engineer will allow an industry standard tolerance. If the Engineer determines that Materials or workmanship are consistently of borderline quality, the Engineer may direct the Contractor to suspend operations and may declare future Work of borderline quality to be unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

In constructing temporary facilities that do not become a part of the permanent improvement, the Engineer may waive requirements that the Engineer considers unnecessary in fulfilling the intended service or function of the facility. The Engineer may allow alternative designs from those required for temporary construction provided that costs to the Department do not exceed those that the Department would have incurred with the design required by the Contract.

1504 COORDINATION OF CONTRACT DOCUMENTS

A requirement appearing in one of the Contract documents is as binding as though the requirement appears in all. If discrepancies exist between the Contract documents, the following order of precedence applies:

(1) Addenda,
(2) Special Provisions,
(3) Project-Specific Plan Sheets,
(4) Supplemental Specifications,
(5) Standard Plan Sheets and Standard Plates,
(6) Standard Specifications.

If discrepancies exist between dimensions in the Contract documents, the following order of precedence applies:

(1) Plan dimensions,
(2) Calculated dimensions,
(3) Scaled dimensions.

The Department and Contractor shall inform each other as to any discrepancy or defect they discover. Neither the Contractor nor the Engineer shall take advantage of any discrepancy or defect. The Engineer will review the alleged discrepancy or defect to determine if a contract revision is necessary in accordance with 1402, "Contract Revisions." The Engineer will decide all issues concerning a discrepancy or defect.

1505 COOPERATION BY CONTRACTORS

The Department may authorize work by other contractors and agencies within the Project Site during the Contract Time. The Contractor shall cooperate with the Engineer, utility owners, and other contractors concurrently performing work on the Project.

The Contractor shall coordinate work with utility owners for the following:

(1) Allow removal and rearrangement operations to progress in a reasonable manner,

(2) Minimize duplication of Work, and
(3) Avoid unnecessarily interrupting services rendered by those parties.

When performing work of separate contracts within the limits of a project, each contractor shall avoid interfering and hindering the progress or completion of the work being performed by other contractors. Contractors working on the same Project shall cooperate with each other as required by their respective Contracts. The Contractor shall assume the risk of delay, inconvenience, or loss resulting from the presence and operations of other contractors working within the same Project Site, and shall make no claim for such delay, inconvenience, or loss.

1506 SUPERVISION BY CONTRACTOR

The Contractor is responsible for the following:

(1) Keeping a complete set of the Contract documents on the Project while Work is in progress,
(2) Assuming full responsibility for supervising the Work irrespective of the quantity of Work subcontracted, and
(3) Facilitating the Work progress and ensuring Project completion as required by the Contract.

At the Preconstruction Conference, the Contractor shall designate in writing a competent Superintendent and a competent individual (if different) for the Project. The competent Superintendent and the competent individual may be the same person, if constantly available in person on the Project and qualified in accordance with the requirements in this section.

The Contractor may change the designated competent Superintendent or designated competent individual during the Project by submitting an authorized change in writing to the Engineer. The Engineer must receive the authorized change in writing before the designated Superintendent or competent individual performs Work on the Project.

1506.1 COMPETENT SUPERINTENDENT

For the duration of the Contract, the Contractor shall act as a competent Superintendent or provide a competent Superintendent to act on the Contractor's behalf. Ensure availability of the competent Superintendent on the Project within 24 h notice to perform the following:

(1) Conduct business with the Subcontractors,
(2) Negotiate and execute Supplemental Agreements,
(3) Execute the orders and directions of the Engineer without delay, and
(4) Promptly supply the materials, equipment, tools, labor, and incidentals necessary to complete the Work.

1506.2 COMPETENT INDIVIDUAL

For the duration of the Contract, the Contractor shall provide a competent individual on the Project during the Work who is:

(1) Authorized and capable to manage, direct, and coordinate the Work in progress,
(2) Experienced in the type of Work being performed,
(3) Capable of reading and understanding the Contract, and
(4) Authorized to receive instructions from the Engineer.

If the Contractor does not employ the competent individual, the Contractor shall authorize the competent individual, in writing, to perform the functions of the competent individual specified in this subsection.

1507 UTILITY PROPERTY AND SERVICE

1507.1 GENERAL

The Contract will specify the utilities affected by the Project. The Department will direct the utility owners affected by the project to relocate or adjust their facilities and related appurtenances within the Project Site at no additional cost to the Contractor, unless the Contract makes the Contractor responsible for relocating or adjusting designated utility facilities.

The Department expects utility owners to complete utility relocations and adjustments as indicated in the Contract. The Contractor shall provide adequate notification of the scheduled Work to utility owners relocating or adjusting facilities during construction to prevent conflict with the Contractor's schedule of operations.

By submitting a Proposal for the Project as a Bidder, the Contractor has acknowledged that it has considered the following:

(1) The temporary and permanent utility facilities identified in the Contract,
(2) The existing location and the designed relocations of all utility facilities as shown on the Plans, and
(3) The precautions required to protect utility facilities in the Project site during construction activities.

If utility owners fail to relocate or adjust their facilities as required by the Department and the Contractor sustains losses that could not have been avoided by the judicious handling of forces, equipment, and plant, or by reasonable revisions to the schedule of operations, the Engineer will adjust the Contract in accordance with 1402, "Contract Revisions."

1507.2 NOTIFICATION

The Contractor shall fulfill all the obligations of an excavator in Minnesota Statutes Chapter 216D and rules adopted to implement that statute. The Contractor's obligations include but are not limited to marking the proposed excavation, contacting "Gopher State One Call" at least 48 h before starting excavation operations (excluding Saturdays, Sundays, and Holidays), and providing support and protection for underground facilities in and near the construction area.

When the Contractor works near electric power lines, the Contractor must provide for protection of personnel and the electrical power lines. The Contractor may work with the lines energized if the work can be done safely, otherwise the Contractor must:

(1) Make arrangements with the power company, at no expense to the Department, to:
  (a) temporarily shut off the power,
  (b) temporarily insulate the power line(s),
  (c) bypass the power from the work area, or
(2) Make other arrangements necessary for a safe work place.

The Department makes no promises or representation as to whether the utility will temporarily shut off power, insulate its line(s), or charge the Contractor a fee for preparing a safe work area for the Contractor.

The Contractor shall employ special equipment or construction methods, and hand labor if necessary, to accomplish the planned work adjacent to utility facilities without damaging them.

1507.3 LIABILITY

If the existence and approximate location of utility property was available to the Contractor before the damage occurred, the Contractor shall reimburse the utility owner for damage to the utility property caused by the Contractor's operations at no additional cost to the Department.

1508 CONSTRUCTION STAKES, LINES, AND GRADES

The Engineer will set construction stakes to establish lines, slopes, elevations, and continuous profile grades for grading, base, and pavement construction to establish the field control for the Project. The Engineer will also set construction stakes to establish location, line, and grade controls for drainage facilities, traffic control and protection devices, and other accessory structures and appurtenances.

For Bridge construction, the Engineer will set stakes to establish the field control and working points as shown on the Bridge layout sheet in the Plans. The Engineer will set at least one bench mark in the vicinity of each Substructure unit for the Contractor's reference when excavating these units. The Engineer will set grade points for the Substructure and Superstructure forms, and provide beam stool heights as deemed necessary for performance of the Work.

From the field control, the Contractor shall establish other necessary controls, detail dimensions, and measurements required for proper layout and performance of the Work. The Contractor shall assume full responsibility for all measurements made from the stakes and marks established by the Engineer.

The Contractor shall preserve all stakes and marks. If the Contractor carelessly or willfully destroys or disturbs any of the field control stakes or marks, the Engineer will deduct the Department's cost for replacing the damaged stakes or marks from the payment for the Work.

The Department is responsible for the accuracy of lines, slopes, grades, and other engineering work performed by the Department's personnel as specified in this section. The Contractor shall not knowingly take advantage of errors or omissions and shall report any discovered errors or omissions to the Engineer immediately upon discovery.

1509 (BLANK)

1510 AUTHORITY AND DUTIES OF THE INSPECTOR

Inspectors have the authority to do the following:

(1) Inspect the Work and the preparation, fabrication, or manufacture of Materials;
(2) Notify the Contractor of non-conforming Work;
(3) Reject non-conforming materials; and
(4) Suspend portions of the Work for the following reasons that require a decision by the Engineer:
(4.1) Interpretation of requirements in the Contract,

(4.2) Use of unapproved material, or
(4.3) Safety.

Inspectors do not have authorization to alter or waive requirements of the Contract or to issue instructions contrary to the Contract.

Inspectors do not have an obligation or have authorization to provide direction, superintendence, or guidance to the Contractor, its crews, its Subcontractors, or suppliers to accomplish the Work.

Any action or inaction of the Inspector does not waive the Department's right to pursue any and all legal remedies for defective Work or Work performed by the Contractor in an unworkmanlike manner.

1511 INSPECTION OF WORK

The Engineer may inspect Materials and the Work. The Contractor shall provide the Engineer or the Engineer's representative access to the Work, information, and assistance necessary to conduct a complete inspection. The Contractor shall notify the Engineer at least 24 h before required inspections.

The purpose of Department inspections is to determine whether the Work meets the requirements of the Contract. The Department inspections do not supplement or replace the Contractor's own quality control and do not relieve the Contractor of its responsibility to correct nonconforming Work.

If directed by the Engineer, the Contractor shall remove or uncover completed Work to allow inspection. After the Engineer's inspection, the Contractor shall restore the Work as required by the Contract. If the inspected Work meets the Contract requirements, the Department will consider the Work to uncover or remove and restore the Work as Extra Work in accordance with 1402, "Contract Revisions." If the inspected Work does not meet the Contract requirements, the Department will not pay for the Work to uncover or remove and restore the Work. The Department is not responsible for Contractor losses if the removals or uncovering of completed Work revealed nonconforming Work or Materials.

The Department will determine the level of inspection for any item of Work. The Contractor is responsible for the quality of Work and compliance with the Contract requirements regardless of the Department's level of inspection.

The Department will consider any Work performed or Materials used without the required certification, approval, or inspection by the Department as unauthorized Work in accordance with 1512.2, "Unauthorized Work."

The Engineer's failure to reject nonconforming Work or Materials, from lack of discovery of the nonconforming Work or Materials or for any other reason, will not:

(1) Prevent the Department from rejecting the nonconforming Work or Materials upon later discovery, or
(2) Obligate the Department to grant final acceptance of the Contract in accordance with 1516.4, "Final Contract Acceptance."

Inspection of Work may include inspection by representatives of other government agencies, railroad corporations, or utility owners that pay a portion of the cost of the Work. This inspection will not make these other government agencies, railroad corporations, or utility owners a party to the Contract and will not interfere with the rights of the Contractor or Department.

1512 UNACCEPTABLE AND UNAUTHORIZED WORK

1512.1 UNACCEPTABLE WORK

The Department will consider all Work and Materials that do not meet the Contract requirements to be unacceptable.

For unacceptable Work resulting from poor workmanship, use of nonconforming materials, damage through carelessness, or any other cause existing before final acceptance of the Work, the Department will take one of the following actions, at the Engineer's sole discretion:

(1) Require the Contractor to acceptably correct the Work and Materials, immediately upon receipt of written order to do so; or
(2) Allow the work to remain in place at an adjusted Contract Unit Price; or
(3) Decide the extent of acceptance for the Work to remain in place if a Contract Item fails to meet Contract requirements but is adequate to serve the design purpose, and document the basis of acceptance by change order to adjust the Contract Unit Price; the adjusted Contract Unit Price will be determined at the Engineer's sole discretion; or
(4) Require the Contractor to remove and replace the unacceptable Work at the Engineer's sole discretion.

The Department may provide notice of default in accordance with 1808, "Default of Contractor," after the Contractor has been given proper notice to acceptably correct the Work and Materials, and has failed to do so.

The Contractor shall remove and replace the unacceptable Work, or correct the work, at no additional cost to the Department if a Contract Item does not meet specified requirements and results in Work that does not serve the design purpose.

1512.2 UNAUTHORIZED WORK

The Department will consider Work performed contrary to the direction of the Engineer, or any work performed beyond that specified in the Contract or directed by the Engineer to be unauthorized.

The Department may consider the following as unauthorized Work:

(1) Work performed before the Engineer provides lines or grades or required inspections of Materials,
(2) Work performed before the Department's approval of the Contract as required by law,
(3) Extra Work performed before Engineer approval of a Supplemental Agreement, and
(4) Minor Extra Work performed before the Engineer has issued a Work Order/Minor Extra Work.

The Contractor shall remove unauthorized Work upon receipt of a written order to do so, at no additional cost to the Department.

The Department may pay for unauthorized Work only if the Engineer determines the work to be acceptable, and one of the following authorizes the Work:

(1) The Contract,
(2) A Supplemental Agreement, or
(3) Work Order/Minor Extra Work.

1512.3 NON-COMPLIANCE

If the Contractor fails to comply immediately with any order issued by the Engineer in accordance with the requirements in this section, the Engineer may direct the following and deduct the costs from moneys due or becoming due to the Contractor under the Contract or any other contract with the Department:

(1) The correction or removal and replacement of unacceptable Work and
(2) The removal of unauthorized Work.

1513 RESTRICTIONS ON MOVEMENT AND STORAGE OF HEAVY LOADS AND EQUIPMENT

The Contractor shall haul Materials and move and store equipment in accordance with the Minnesota Highway Traffic Regulation Act and applicable provisions of Minnesota Rules when using public Roads or completed Structures, base courses, and pavements within the Project that are open to traffic and becoming a part of the permanent improvement.

The Contractor shall comply with legal load restrictions and with special restrictions required by the Contract when hauling or storing Materials and moving or storing equipment on Structures, completed Subgrades, base courses, and pavements within the Project, under construction or completed but not yet open to traffic.

The Contractor shall complete and place a cab card in each vehicle used for hauling bituminous mixture, aggregate, batch concrete, or grading material (including borrow and excess), before starting work. This cab card shall identify the truck or tractor and trailer by Minnesota or prorated license number and shall contain the tare, maximum allowable legal gross mass, supporting information, and the signature of the owner. The Contractor shall make the card available to the Engineer upon request. The Contract Unit Prices include Contractor-related costs in providing, verifying, and spot checking the cab card information, including weighing empty and loaded trucks on certified commercial scales.

The Contractor shall not operate equipment mounted on crawler tracks or steel-tired wheels on or across concrete or bituminous surfaces unless otherwise approved by the Engineer. The Contract requirements may impose special restrictions on speed, load distribution, surface protection, and other precautions.

When construction operations require crossing an existing pavement, Bridges, or completed portions of the Pavement Structure with otherwise prohibited equipment or loads, the Contractor shall use Department-approved methods of load distribution or bridging at no additional cost to the Department.

The Contractor will not be relieved of liability for damages resulting from the operation and movement of construction equipment because of the issuance of a special permit, or by adherence to any other restrictions imposed.

Unless otherwise required by the Contract or approved by the Engineer, the Contractor shall temporarily store or park construction Materials and equipment on a Bridge deck during Bridge construction in accordance with the limits of this section, established to reflect typical design live loads. The Contractor shall store Materials and equipment limited as follows:

(1) No stockpiles weighing greater than 65,000 lb per 1,000 ft² [31,702 kg per 100 m²];
(2) No individual stockpiles of Materials (including pallets of products, reinforcing bar bundles, and aggregate piles) weighing greater than 25,000 lb per 100 ft² [12,200 kg per 10 m²];
(3) No single vehicle or equipment exceeding 80,000 lb [36,300 kg], and no combination of more than 200,000 lb [90,700 kg] of vehicles, Materials, and other equipment per span with lengths greater than 40 ft [12.2 m]]; and
(4) No combination of more than 200,000 lb [90,700 kg] of vehicles, Materials, and other equipment per span with lengths greater than 40 ft [12.2 m].

If loading exceeds the above defined limits, the Contractor shall submit the proposed loads and structural analysis of the deck and beams certified by a Professional Engineer to the Bridge Engineer for the Bridge Engineer's review within a minimum of 7 calendar days before placement of loads.

1514 MAINTENANCE DURING CONSTRUCTION

The Contractor shall maintain the Project and the Work in accordance with 1404.7, "Winter Suspension," 1516, "Acceptance," or 1715, "Opening Sections of the Roadway to Traffic Before Completion of the Project," until accepted by the Department. The Contractor shall maintain previously constructed Work when the Contract requires placing Materials on or the use of previously constructed Subgrade, base course, pavement, or Structure.

The Contractor shall continuously maintain Roadways and Structures during construction in a satisfactory condition. Except for compensable work as specified by the Department, the Contractor shall maintain the work during construction and until final acceptance of the Project in accordance with 1516.2, "Project Acceptance," at no additional cost to the Department.

For maintenance work directed by the Engineer, the Contractor shall perform the maintenance work or provide dust control in accordance with 1404.5, "Maintenance Directed by the Engineer". The Department will pay for the Engineer-directed work at Contract Unit Prices or by Force Account in accordance with 1402, "Contract Revisions".

The Engineer will notify the Contractor, in writing, of maintenance deficiencies. If the Contractor fails to correct the deficiencies within 24 h after receipt of written notice, the Department may immediately proceed to maintain the Work and deduct the cost of maintenance from money due or becoming due to the Contractor under the Contract or any other contract with the Department.

1515 CONTROL OF HAUL ROADS

Haul Roads are those public Roads (other than trunk Highways) that the Contractor may use for the purposes specified in 2051.2, "Maintenance and Restoration of Haul Roads, Definitions."

Haul Roads do not include a connection between a natural material source and a public Road. The Contractor must secure the Rights Of Way for, construct, and maintain such connections between a material source and a public Road, without compensation from the Department other than payment received for the Contract Items.

The Department may, but is not required to, designate haul Roads in accordance with Minnesota Statutes §161.25. If the Department has made a written designation of a haul Road, then the Department will have jurisdiction over the public Roads and Streets included in such designation. The requirements of 2051, "Maintenance and Restoration of Haul Roads," will govern the maintenance and restoration of such haul Roads.

If the Department has not made a written designation of a haul Road, then the Contractor will be responsible for the following:

(1) Arranging for the use of Roads not under the jurisdiction of the Department,
(2) Performing any maintenance and restoration as required by the applicable Road authority as a condition of use of such Road as a haul Road, and
(3) Paying any fees, charges, or damages assessed by the applicable Road authority as a condition of using such Road as a haul Road.

All actions and costs with respect to non-designated haul Roads will be without compensation from the Department, other than payment received for the Contract Items.

In preparing its Proposal, the Contractor is not entitled to assume that the Department will designate a haul Road, or that the haul Road designated will be the most convenient and direct route or not subject to reduced weight limits. The Department will not consider its decision to designate or not designate a requested haul route as a basis for a contract revision.

1516 ACCEPTANCE

1516.1 PARTIAL ACCEPTANCE

After completing a substantial and discrete portion of Work, the Contractor may request the Engineer to inspect that portion. If the Engineer determines that the portion of the Work is complete in accordance with the Contract requirements, the Engineer may accept the completed portion in writing. Partial acceptance relieves the Contractor of further responsibility for maintenance of that portion of Work, but does not invalidate or alter the terms of the Contract.

1516.2 PROJECT ACCEPTANCE

After completing the Work, the Contractor shall notify the Engineer and request a final inspection. If the Engineer determines that the Project is complete, the inspection will constitute the final inspection and the Engineer will promptly provide written notice of Project acceptance effective on the date of the final inspection. The notice of Project acceptance relieves the Contractor of further responsibility for the Work.

If the Engineer finds unacceptable or incomplete Work, the Contractor shall immediately correct the deficiencies as directed by the Engineer. After correcting the deficiencies, the Contractor shall again request a final inspection.

Acceptance of the Project does not relieve the Contractor of financial liabilities imposed on the Contractor by statute and does not constitute final acceptance of the Contract.

1516.3 COMPLETION OF THE WORK

The Department will consider the Work in all things completed when the Contractor has completed and submitted required documents, certifications, and affidavits including, but not limited to, the following:

(1) MN IC-134 Withholding Affidavit, approved by Minnesota Department of Revenue, demonstrating compliance with MN Statute § 290.92,
(2) Material certifications and warranties,
(3) Proof that known outstanding prevailing wage complaints have been resolved as approved by the Department,
(4) Final Clearance Letter for DBE participation or Veteran's participation,
(5) Payment of moneys owed to the Department, if applicable,
(6) Termination of NPDES permit, if applicable, and
(7) All other forms required by the Contract.

1516.4 FINAL CONTRACT ACCEPTANCE

The Department will make final Contract acceptance when the following occur:

(1) The Work has been in all things completed to the satisfaction of the Department, and
(2) All parties have executed the Certificate of Final Acceptance.

1517 CLAIMS FOR COMPENSATION ADJUSTMENT

The Contractor shall not file a claim until the Contractor has exhausted the requirements of 1402, "Contract Revisions," and 1403, "Notification for Contract Revisions." The Contractor is not entitled to compensation or time extensions for disputed work under this section (1517) unless the compensation or time extension is required or provided for elsewhere in the Contract.

1517.1 NOTIFICATION

The Contractor shall notify the Engineer in writing of any intent to file a claim for compensation or time extension. The Contractor shall not be entitled to compensation or a time extension if:

(1) The Contractor fails to notify the Department.
(2) The Contractor's actions or inactions prevent the Department from keeping strict account of the impacts and costs of the disputed work.
(3) The Contractor's actions or inactions prevent the Department from mitigating the impacts and costs of the disputed work.

1517.2 CLAIM SUBMITTALS

A Entitlement

The Department requires that the Contractor establish entitlement for all claims before the Department will consider impact and cost. The Contractor shall submit the following to the Engineer as a minimum to determine entitlement:

(1) A detailed factual statement of the claim providing a description of the claim issues and all relevant facts, including the events, dates, locations, and a description of what Work was affected and how this Work was affected by the claim.
(2) A narrative that identifies all of the specific Contract provisions that support the claim, why they support the claim, and how the details of the factual statement in item (1) above establish entitlement based on the referenced Contract provisions.

(3) All pertinent documents, electronic files, and the substance of any oral communications related to the information provided in item (1) and (2) above.

B Impact and Cost

If the Department determines that the Contractor has established entitlement, the Contractor shall submit the following to the Department as a minimum to determine impact and cost:

(1) If a delay is alleged, submit a narrative, all documentation (including applicable project schedules substantiating the delay), and a schedule analysis in accordance with 1806.1, "Determination and Extension of Contract Time, General."

(2) If additional costs are alleged, submit a narrative and all documentation that substantiates the claimed costs. The Contractor shall submit cost documentation for the claim submittal in a format that allows the Department to perform an audit under the authority of 1721, "Audits."

The Contractor may not submit a claim that fails to establish the causal link between the Department's responsibility and the Contractor's impacts and costs.

1517.3 REQUIRED CERTIFICATION OF CLAIMS

The Contractor shall certify the claim attesting to the following:

(1) The claim is made in good faith, based on documented fact and the value is not knowingly overstated, and
(2) Supportive data is true, accurate, and complete to the Contractor's best knowledge and belief.

In complying with this requirement, the Contractor's claim submittal shall include the following fully executed certification:

Under the penalty of law for perjury or falsification, the undersigned,

_____,
(Name)

_____ of
(Title)

_____
(Company)

hereby certifies that the claim for compensation and time, if any, made herein for work on this Contract is, to the best of the Contractor's knowledge and belief, a true statement of the costs incurred and time sought, and is fully documented and supported under the Contract between the parties.

Dated_____/s/_____

Subscribed and sworn before me this ____day of_____,20__.

Notary Public _____

My commission Expires _____

1517.4 REVIEW OF CLAIM SUBMITTALS

All claim submittals filed will be subject to review by the Department at any time following the filing of the claim submittal. The Contractor and Department shall exhaust the claim process reflected in this section (1517) before seeking compensation or extension of the Contract Time by filing an action in the courts of this State. The Contractor, Subcontractor(s), or Supplier(s) shall cooperate with the Department and shall provide the Department access to the following relevant documents, including, but not limited to:

(1) Daily time sheets and foreman's daily reports.
(2) Union agreements, if any.
(3) Subcontracts.
(4) Insurance, welfare, and benefits records.
(5) Payroll register.
(6) Earnings records.
(7) Payroll tax returns.
(8) Material invoices, purchase orders, and all material and supply requisition contracts.
(9) Material cost distribution worksheets.
(10) Equipment records (usage reports, list of company equipment, rates, etc.).
(11) Vendor rental agreements and Subcontractor invoices.

(12) Subcontractor payment certificates.
(13) Canceled checks (payroll and vendors).
(14) Job cost report.
(15) Job payroll ledger.
(16) General ledger, general journal, and all subsidiary ledgers and journals together with all supporting documentation pertinent to entries made in these ledgers and journals.
(17) Cash disbursements journal.
(18) Financial statements for all years reflecting the operations on this Project.
(19) Income tax returns whether such records are maintained by the company involved, its accountant, or others for the years reflecting operations on the Project.
(20) Depreciation records on all company equipment.
(21) All other documents used to develop costs for the Contractor's internal purposes in establishing the actual cost of owning and operating equipment.
(22) All documents that reflect the Contractor's actual profit and overhead during the time the Project was being performed and for each of the five years before the commencement of this Project.
(23) All documents related to the preparation of the Contractor's Proposal including the final calculations on which the Proposal was based, unless the documents are placed in escrow as a provision of the Contract.
(24) Worksheets used to prepare the claim submittal, establishing the cost components of the claim, including, but not limited to, labor, benefits and insurance, Materials, equipment, Subcontractors, and all documents that establish the time periods, individuals involved, the hours and the rates for the individuals.

Control of Material

1601 SOURCE OF SUPPLY AND QUALITY

The Contractor shall provide Materials for the Work from sources capable of producing and delivering uniformly acceptable Materials in accordance with 1503, "Conformity with Contract Documents," and the Progress Schedule. The Contractor shall notify the Engineer of intended sources of supply after award of the Contract and before Material delivery or use to allow the Engineer to inspect and test the Materials before delivery or use.

Unless otherwise specified, the Contractor shall provide new Materials of the specified grade and type or kind.

The Contractor shall not use multiple Material sources to provide one kind or class of Material, unless otherwise approved by the Engineer. If the Engineer approves the use of Material from more than once source, the Engineer will set the conditions for each source change.

The Contractor shall make plant alterations or provide Materials from alternative sources capable of producing uniformly acceptable Material as approved by the Engineer if, during production, the Engineer finds either of the following:

(1) Supply sources of previously approved Materials do not produce uniformly acceptable Materials, or
(2) Conditions require extraordinary inspection and testing by the Department to prevent delivery of unacceptable Material.

1602 NATURAL MATERIAL SOURCES

The Department may list possible sources of natural Materials in the Contract, but does not warrant or imply the availability of sufficient quantities of acceptable Material in those sources. The Department may also list the same sources as a possible source for other existing or future contracts. The Contractor shall acknowledge the Department's inability to ascertain from samples the limits for an entire deposit and shall consider variations as usual and expected. The Contractor shall determine the equipment and Work necessary to produce a Material meeting the Contract requirements.

The Contractor has the right to take Materials from those sources that the Contract lists as specified in the lease.

The Contractor shall notify the Engineer in writing within 15 days after Approval of the Contract if the Contractor intends to obtain Material from those sources. The Contractor may not remove Material from the source until the Engineer receives this notice.

For all sources where the Department owns the Material or where the Contractor elects to obtain Material under the terms of a Department lease or permit, the Contractor shall remove the Material in accordance with the following requirements and conditions:

(1) The Contractor shall procure Material from the portion of the source as directed by the Engineer. The Engineer may reject unacceptable portions of the source.
(2) The contractor must use the Material exclusively on the Contract Project.
(3) The Contractor will perform clearing and grubbing as necessary, in accordance with 2101, "Clearing and Grubbing," at no additional cost to the Department.
(4) If others are operating concurrently in a pit used as a source of Materials for the Project, the Contractor must cooperate in accordance with 1505, "Cooperation by Contractors."
(5) If the Contractor's operations necessitate the relocation, adjustment, rearrangement, or other Work on impacted drainage facilities or utility properties, the Contractor shall perform this Work at no additional cost to the Department.
(6) The Contractor shall blend Materials from various layers and areas within the source as directed by the Engineer, even to the extent of blending Materials from the top of the deposit with those from the bottom of the deposit.
(7) Within the areas owned or leased by the Department, the Contractor shall spread or stockpile the strippings and rejected Materials as directed by the Engineer.
(8) If the Contract includes a Material price table(s), the Contractor can only produce the Materials listed in the table(s). The Contractor shall not use Material suitable for the production of Class 5 or Class 6 base aggregate as borrow Material unless otherwise approved by the Engineer in writing.
(9) If the Contract does not contain a separate "Rock Price," the Contractor may not screen off a coarse fraction (+No. 4) of Material and blend it with Material from a different source to produce an aggregate product (the Contractor may not use rock from a source and blend it with sand from a different source to produce concrete, bituminous, or base, etc.). If the Contract contains a separate "Rock Price," the Contractor may screen off Material and will pay the indicated price for the rock fraction. In addition, the Contractor may not produce riprap, unless there is a separate "Rock Price" for riprap included in the Contract.
(10) After removing the Material and after completing the Work, the Contractor shall leave the site in a condition acceptable to the Engineer. The Contractor shall level waste piles, trim slopes and pit bottoms, replace the

stripping, and perform other cleanup work at no additional cost to the Department, unless otherwise approved by the Engineer.

The Department will provide the Contractor with statements showing the quantities of Material removed and the payment due. The Department will require full reimbursement before making final payment on the Contract.

1603 MATERIALS: SPECIFICATIONS, SAMPLES, TESTS, AND ACCEPTANCE

1603.1 SPECIFICATIONS

The Department will sample, test, and inspect all Materials in accordance with the Contract at any time before being permanently incorporated in the Work. The Department will approve or reject Materials based on the results of this sampling, testing, and inspection. The material requirements that describe material sampling, testing and inspection are normally referenced in Division II (construction details), the Plans, or the Special Provisions. In the absence of a specific material reference, the governing material specifications, in order of precedence, will be Division III (materials), AASHTO, ASTM, and the applicable industry standard.

Unless otherwise required, if the Contract cites specifications, standards, methods, tests, or practices from outside associations, societies, or governmental agencies, the Department is referring to the versions of these references that are current at the date of the Advertisement for Bids. If the Contract refers to other procedures, practices, or allowances established or approved by the Department, the Department will refer to the versions of these references that are current at the date of the Advertisement for Bids. The Department and Contractor may mutually agree to update the referenced provisions to the version current at the time of application.

1603.2 SAMPLING AND TESTING

Refer to the Schedule of Materials Control for sampling and testing of Materials on State and Federal-aid Projects. The Schedule of Materials Control sets the size of Material samples and the rate of testing. The Schedule of Materials Control does not set Contract requirements for the Material. The Schedule of Materials Control is included with the Proposal Package.

The Contractor shall provide all required samples at no additional cost to the Department and shall provide such facilities and assistance as the Engineer directs for collecting and forwarding samples. If required by the Engineer, the Contractor shall submit representative preliminary samples to the Engineer in accordance with the specified methods, for examination and testing. The Contractor shall label submitted preliminary samples with the following information:

(1) Contractor's name,
(2) Project number,
(3) The material source,
(4) Supplier's name, and
(5) Where the material fits into the Work.

For soil and aggregate samples, the Contractor shall provide the following additional information:

(1) The legal description of the property where the samples were taken, and
(2) Pit numbers for single source bituminous and concrete aggregate products.

The Department will provide special instructions for sampling upon request from the Contractor.

1603.3 CERTIFICATE OF COMPLIANCE

The Engineer may accept industry standardized products by a Certificate of Compliance in lieu of the required sampling and testing, subject to the following:

(1) The Certificate of Compliance must state that the provided Material meets the specification requirements, identify the Specification number, and include the Project number.
(2) Attach the Certificate of Compliance to the invoice, weigh bill, or other shipping document, and identify the supplier, manufacturer, product, and quantities covered.
3) Deliver a copy of the Certificate of Compliance with the shipment of the covered Material.
(4) Provide certified test reports to the Materials Engineer if requested. Keep certified test results on file with the supplier and available to the Engineer for inspection upon request.
(5) The Certificate of Compliance must be signed by a representative authorized to bind the company supplying the material covered by the certification.

The Department may require samples and test the Material for compliance regardless of prior certification by the supplier.

When the Contractor uses a Certificate of Compliance in lieu of required sampling and testing, the Engineer will withhold 100 percent of the Contract Unit Price of Work until the Contractor submits the Certificate of Compliance to the Engineer.

1603.4 ACCEPTANCE

Department approval of preliminary samples will not constitute acceptance of the Material represented.

The Department will only consider the Materials actually delivered to the Project for acceptance. The Department will base Material acceptance or rejection on the results of the tests and inspections made by the Engineer. The Engineer will make final inspection and acceptance of Material at the Project.

The Department will not allow use of Material that must meet definite Contract requirements until completion of all required acceptance inspections and tests show the Material complies with the Contract requirements.

Pending determination of test results, the Contractor may use Material having a satisfactory record of compliance with the test requirements at the Contractor's risk, with the understanding that the Department will apply the provisions of 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," if the material fails to meet the Contract requirements subsequent to placement.

1604 PLANT INSPECTION — COMMERCIAL FACILITY

1604.1 GENERAL

The Engineer may perform plant inspection and test Material at the source before delivery to determine compliance with those test requirements and process controls required by the Contract during production. The Engineer may retest Material at the site regardless of approvals given before final inspection and acceptance. The Engineer will base Material acceptance on compliance with Contract requirements at the time of incorporation in the Work.

The Engineer may retest Material after delivery and will reject Material that fails to meet the Contract requirements.

The cost of facilities and assistance provided by the Contractor required for inspection of Materials at the source will be considered as part of the production costs and are included in the Contract Unit Prices applying to the work involved.

1604.2 INSPECTION PROCEDURES

The Contractor shall meet the following conditions when the Engineer performs a plant inspection:

(1) At least 2 weeks before starting production, notify the Engineer of the date and place of production to allow for arrangements for the plant inspection;
(2) Notify the Engineer of the production schedule and other related information concerning inspection arrangements;
(3) In partnership with the producer, cooperate with and assist the Engineer in the inspection. The Department's inspectors will not handle the Materials being inspected;
(4) Arrange, store, and handle the Material as directed by the inspector;
(5) Provide the Engineer with office space as defined in 1604.3, "Requirements For Facilities," at commercial production plants and other facilities, tools deemed necessary for inspection, and free entry to the plant locations where manufacturing or production occur; and
(6) Provide and maintain safety measures as approved by the Engineer. The Engineer will terminate inspection at the source if conditions are deemed hazardous by the Engineer.

1604.3 REQUIREMENTS FOR FACILITIES

Commercial plants producing bituminous mixture, structural concrete, or graded aggregates for state Projects shall have in-plant inspection facilities meeting the following requirements:

(1) Floor area of at least 120 sq. ft [11 sq. m], with weatherproof exterior construction, adequate natural lighting, and convenient accessibility.
(2) Equipped with at least one suitable table or workbench, at least one stool and one chair, an approved fire extinguisher for use intended, and a suitable storage cabinet with lock.
(3) Provided with adequate electric lighting and electrical outlets, adequate heating system, conveniently located sanitary facilities, and convenient access to running water supply.
(4) Furnished with at least a 3-burner natural gas or electric stove for sample drying and with effective forced-air ventilation.
(5) Provided with an electrically powered mechanical sieving apparatus to determine particle size distribution of fine aggregate (less than No. 4 [4.75 mm] sieve) capable of accommodating six full height No. 200 [75 µm] round sieves with pan and cover provided by the Department. The Engineer will approve the apparatus after verifying that the sieving meets the requirements of AASHTO T 27.

The producer shall make the in-plant inspection facilities available to the Engineer before beginning production.

The producer shall maintain the in-plant inspection facilities until the termination of production, at no additional cost to the Department. If the facilities do not meet the requirements specified in this subsection, the Contractor shall provide an equivalent field laboratory unit at the plant site as directed by the Engineer and at no additional cost to the Department.

1605 SUBSTITUTE MATERIALS

When the Department classifies Material to be incorporated in the Work according to size, strength, type, or other design classification for separate units, courses, sections, or installations, the intent is to specify the acceptable level of compliance, quality, or service. The Contractor may provide Material exceeding the specified class, quality, service life, or other Contract requirements to facilitate the Work.

The Contractor may use substitutions only as approved by the Engineer, at no additional cost to the Department. The Engineer will establish the revised basis for acceptance in writing.

1606 STORAGE OF MATERIALS

The Contractor shall store Materials in a manner that preserves the quality and fitness of the Materials for the Work. The Department may inspect the stored Materials before use in the Work, even though the Department may have approved the Materials before storage. The Contractor shall store Materials to facilitate inspection.

The Contractor may use portions of the Project Site approved by the Engineer for storing Materials and for placing plant and Equipment. The Contractor shall provide needed additional space at no additional cost to the Department. The Contractor shall restore all portions of the Project Site used for storage or operations to acceptable condition, at no additional cost to the Department, before the Department will grant final acceptance of the Project.

The Contractor shall not use private property for storing Materials or Equipment without written permission of the owner or lessee. The Contractor shall provide the Engineer evidence of the written permission to use private property upon request.

The Department will only allow stockpiling of Materials within the Project Site that the Contractor will incorporate into the Work. This Specification applies to manufactured and natural Materials, including Materials stockpiled for crushing.

1607 HANDLING MATERIALS

The Contractor shall handle Materials to preserve quality and fitness for the Work. The Contractor shall transport Materials in vehicles constructed to prevent loss of Material after loading and measuring. The Contractor shall ensure the quantities of Materials as loaded are the same as the quantities received on the Project.

The Contractor shall use methods and Equipment to load and haul bulk Materials that prevent contamination or loss of Material after measurement and acceptance for the Work.

1608 UNACCEPTABLE MATERIALS

The Department considers Materials that do not meet the Contract requirements before being incorporated into the Work as unacceptable. The Engineer will reject unacceptable Material. The Contractor shall remove unacceptable Material from the Project, unless otherwise directed by the Engineer as allowed by 1603, "Materials: Specifications, Samples, Tests, and Acceptance."

If the Contractor corrects defects in Material that the Department determined was unacceptable and the Contractor brings the Materials into compliance with the Contract requirements, the Contractor may use the Material if authorized by the Engineer.

1609 DEPARTMENT-PROVIDED MATERIAL

The Department will deliver or make available Department-provided Material at the locations shown on the Plans or in the Special Provisions. The Contract Unit Price for the relevant Contract Items includes the costs of handling, transporting, and placing the Materials.

The Contractor shall take responsibility for Department-provided Material after the Department delivers or makes the Material available to the Contractor. The Department will deduct from moneys due the Contractor for shortages, deficiencies, or damage to the Material occurring after taking possession and for demurrage charges.

Legal Relations and Responsibility to the Public

1701 LAWS TO BE OBSERVED

The Contractor shall observe and comply with all of the following, relating to the conduct of Work on the Project or to individuals engaged in Work for the Project or employed on the Project:

(1) All applicable State and Federal laws and regulations;
(2) Orders and decrees of bodies and tribunals with lawful jurisdiction over the Work; and
(3) Such local ordinances as are applicable to the Work, as determined by the Department.

The Contractor shall hold harmless and indemnify the Department and its representatives against all claims and liabilities arising from or based on violations committed by the Contractor or anyone subject to the control of the Contractor.

The Contractor shall immediately report to the Engineer in writing any Contract requirements that are contrary to or inconsistent with any law, regulation, order, decree, or applicable ordinance.

The Contractor shall endeavor to comply with relevant and significant ordinances, in consultation with the Engineer. Work on the state trunk Highway system is generally not subject to regulation by political subdivisions of the State.

1701.1 DATA PRACTICES

Bidders are advised that all data created, collected, received, maintained, or disseminated by the Contractor and any subcontractors in performing the Work contained in this Contract are subject to the requirements of MN Statute Chapter 13, the Minnesota Government Data Practices Act (MGDPA). The Contractor shall comply with the requirements of the MGDPA in the same manner as the Department. The Contractor does not have a duty to provide access to public data to the public, if the public data are available from the Department, unless otherwise required by the Contract.

1701.2 WORKER CONDUCT

Bidders are hereby reminded of the Department's policy to provide a workplace free of violence, threats of violence, harassment, and discrimination. The Department has established a policy of zero tolerance for violence in the workplace. Contractors performing work on Department construction Projects, or local government entities or public agencies utilizing state funds on highway construction Projects shall maintain a workplace free of violence, harassment, and discrimination. The Contractor shall immediately remove from the Project any employee of the Contractor or a Subcontractor in violation of the Department's "Harassment Guidelines" and/or "Zero Tolerance of Violence in the Workplace" policy document until such time as the appropriate authority can complete an investigation.

1701.3 FALSE CLAIMS ACT

The provisions of the Minnesota "False Claims Against the State" Act (Minnesota Statutes Chapter 15C) apply to any claim by the Contractor under this Contract. For the purpose of this section, claim is defined in Mn Statute section 15C.01 subd. 2.

1702 PERMITS, LICENSES, AND TAXES

The Contractor shall obtain the licenses and permits required by State and Federal laws and regulations. The Contractor shall pay all charges, fees, and taxes, and give all notices necessary and incidental to the due and lawful prosecution of the Work. If requested by the Department, the Contractor shall provide the Engineer with evidence of compliance with the permit, license, notice, and tax requirements.

1703 PATENTED DEVICES, MATERIALS, AND PROCESSES

The Contract Unit Prices include the cost of all royalties and costs from patents, trademarks, and copyrights needed to the complete the Work.

If the Contractor employs any design, device, material, or process covered by letters of patent or copyright, the Contractor shall secure approval for its use from the patentee or owner. The Contractor shall indemnify and save harmless the Department and any political subdivision, department, or third party affected from all claims for infringement by reason of its use.

1704 RESTORATION OF SURFACE OPENED BY PERMIT

The Department may grant permits to individuals, firms, public utilities, or corporations wanting a surface opening, trench, or boring in the Highway. The Contractor shall only allow parties with valid permits to make openings in the Highway, as authorized by the Department.

The Department may:

(1) Allow proper authorities of a political subdivision to construct or reconstruct any utility service in the Highway at any time, and
(2) Grant permits for the construction or reconstruction of any utility service.

If the Proposal Package contained the permit and related work, the Department will not pay the Contractor for damages or delays resulting from the related work.

If the Proposal Package did not contain the permit and related work and the related work impacts the Work, the Engineer may revise the Contract in accordance with 1402, "Contract Revisions."

If the Engineer orders the Contractor to make repairs to an approved surface opening, the Department will consider the repair work to be Extra Work in accordance with 1402, "Contract Revisions."

1705 FEDERAL-AID PROVISIONS

The Contractor and all Subcontractors shall observe Federal laws, rules, and regulations if the Federal government pays for any portion of the cost of a Project. The Federal requirements of a Federal-aid Project will supersede conflicting provisions of State or local laws, rules, or regulations. The Department will inspect the Work on Projects funded by the Federal government. Inspection by the Department will not make the Federal government a party to the Contract or interfere with the rights of the parties to the Contract.

1706 EMPLOYEE HEALTH AND WELFARE

The Contractor shall provide and maintain sanitary and safety accommodations for the use and protection, and health and welfare of the Contractor's employees and suppliers in accordance with the following applicable safety and health codes and regulations:

(1) Federal,
(2) State,
(3) Local, and
(4) Other bodies and tribunals having jurisdiction.

The Contractor shall refer to the employee safety and sanitation regulations as specified in 29 CFR 1926, Occupational Safety & Health Administration (OSHA), Construction Industry Standards; MN Statute Chapter 182; and Minnesota Department of Labor & Industry, OSHA Division, Minnesota Rules Chapters 5205 to 5215 inclusive.

The Contractor shall provide, install, maintain, and remove required safety and health related Equipment and provisions, at no additional cost to the Department. The safety and health related Equipment and provisions shall comply with the applicable codes and regulations, be in operable condition, and allow Department personnel to perform required duties at the appropriate time.

The Contractor shall allow the entry of Federal, State, and local safety and health inspectors to perform inspections or investigations.

The Contractor shall perform construction operations in accordance with applicable laws, regulations and industry standards as specified this section. The Contractor is responsible for the development, implementation, and enforcement of safety requirements on the Project, regardless of any actions the Department may take to help ensure compliance with these requirements.

The Contractor shall submit a written safety program to the Engineer at the pre-construction conference addressing safety issues for all Project activities. The Contractor shall include the name(s) of the person(s), identified as the "Contractor's Designee(s)," in the safety program. Responsibilities of the "Contractor's Designee(s)" include the following:

(1) Safety requirements,
(2) Availability during performance of the Work, and
(3) Correction of violations on the Project as observed by the Engineer.

1707 PUBLIC CONVENIENCE AND SAFETY

The Contractor shall conduct operations and perform the Work in a manner that causes the least possible obstruction to traffic. The Contractor shall provide for the safety of the general public and for the residents living beside the Highway.

The Contractor shall provide temporary facilities to allow pedestrian travel over or through obstructions at public walkways and at other locations designated by the Engineer. The Contractor shall adequately fence and post conspicuous warning signs around hazardous open excavations or open excavations that contain water.

If performing Work in a municipality, the Contractor shall notify the local fire and police chiefs to allow time to rearrange routes of emergency vehicles before blockading a street. The Contractor shall keep the local fire and police chiefs informed about the status and removal of street blockades affecting emergency vehicle travel. The Contractor shall not obstruct access to fire hydrants without the approval of the local fire chief.

1708 RAILROAD HIGHWAY PROVISIONS

1708.1 GENERAL REQUIREMENTS

The Contractor shall perform Work in accordance with the Contract requirements in this section for the following:

(1) Work within the railroad right-of-way or within 25 ft [7.6 m] of the nearest track,
(2) Work adjacent to the railroad right-of-way and if Materials or Equipment may extend into the railroad right-of-way, and
(3) Work includes a Contractor crossing for the movement of Equipment and Materials across the railroad right-of-way and tracks.

The Contractor shall coordinate railroad-highway requirements with each Railway and implement the railroad requirements and the requirements in this section before beginning the Work on Railway property.

Before entering the Railway property, if required by the Railway, the Contractor shall ensure each person providing labor, material, supervision, or services connected with the Work on the Railway property attends safety orientation provided or approved by the Railway. For some Railways, this safety orientation is available on the following websites: www.contractororientation.com or https://www.e-railsafe.com

Before entering the Railway property, the Contractor shall prepare and implement a safety action plan if required by and as approved by the Railway. The Contractor shall also audit compliance with that safety action plan during the Work. The Contractor shall keep a copy of the safety action plan and audit results at the Project Site. The Contractor shall allow the Railway to inspect the safety action plan at all reasonable times.

The Contractor shall not perform Work infringing on the statutory clearances in accordance with MN Statutes §219.45 to §219.53 until the MnDOT Manager of Rail Administration approves the safety action plan. The Contractor shall submit the safety action plan and clearance variances to the MnDOT Manager of Rail Administration before commencement of Work.

Unless specifically approved by the Railway before commencement of the Work, the Contractor shall not perform Work that interferes with the constant, continuous, and uninterrupted use of the tracks, property, and facilities of the Railway, its lessees, licensees, or others. The Contractor shall not impair the safety of the tracks, property, and facilities of the Railway, its lessees, licensees or others.

When not in use, the Contractor shall keep machinery and Materials at least 50 ft [15.24 m] from the centerline of the Railway's nearest track, unless the Railway approves otherwise before commencement of the Work. The Contractor shall not allow vehicles to cross the Railway track, except for a crossing approved by the Railway before commencement of the Work, or at existing open public crossings.

The Contractor shall be responsible to the Railway, including affiliated railway companies and tenants, for damages for unscheduled delays to freight or passenger trains caused by the Contractor. The Contractor shall acknowledge the serious consequences resulting from unscheduled delays that effect the Railway's operations, especially delays of freight trains. The Contractor shall also acknowledge that delays affect the Railway's ability to fully utilize its equipment and meet customer service and contract obligations. The potential effects caused by a delay make ascertaining the amount of damages difficult.

If an emergency occurs in connection with Work on the railroad right-of-way, the Railway may perform work to maintain rail traffic. If the Contractor's operations caused the emergency, the Contractor shall reimburse the railroad for the cost of the emergency work and damages associated with delays to trains.

The Railway may inspect Work on the railroad right-of-way at any time to ensure that the Work will not adversely impact train traffic or safety.

1708.2 STRUCTURAL PLANS AND CONSTRUCTION METHODS

The Contractor shall not perform Work affecting Railway traffic, embankment, property and trainmen before the Railway approves the Contractor's construction methods and protective measures.

The Department will consider costs resulting from compliance with the requirements of this section as incidental and the Contractor shall perform this Work at no additional cost to the Department.

The Contractor shall prepare 5 sets of detailed plans indicating the foundation preparation methods intended for use adjacent to the Railway's tracks or at any Bridge Structures that are part of the Project. The detailed plans shall indicate the protective measures used to safeguard railroad property, embankment, traffic, and trainmen from damage and accident during construction operations adjacent to the Railway's track. The detailed plans shall include the following:

(1) Before excavating for pier footings adjacent to the Railway's track, the Contractor shall construct a railing, approved by the Railway before construction, between the tracks and the pier excavation and at the ends of the excavation as approved by the Railway.

(2) If using sheeting on the sides of footings adjacent to the Railway's track, the Contractor shall drive the sheeting before excavating for the footings. The Contractor shall cut off the sheeting at or slightly below the ground level immediately after driving the sheeting. The Contractor shall install and remove sheeting as approved by the Railway.

(3) The Contractor shall immediately backfill the excavation at the piers adjacent to Railway tracks after completion of pier construction. The Contractor shall keep the railing in place until the completion of the backfill.

(4) If pier construction occurs within the minimum horizontal clearance of 12 ft [3.6 m] as measured from the centerline of the Railway's nearest track, the Contractor shall construct a Railway-approved plank trainman's walk over the excavation, between the nearest track and the piers before beginning excavation. The Contractor may construct the protective installations outside of the neat lines of the footings along the track sides of the piers located within the minimum Railway horizontal clearance of 12 ft [3.6 m].

The Contractor shall submit the detailed plans to the Railway for approval. If approved, the Railway will return the plans to the Contractor. The Contractor shall submit the approved plans to the Engineer for approval. The Engineer will submit the plans to the MnDOT Office of Freight and Commercial Vehicle Operations, Rail Administration Section for approval, including approval for temporary clearance less than clearances required by statute. The MnDOT Office of Freight and Commercial Vehicle Operations, Rail Administration Section will make final distribution.

The Contractor shall indicate required agency or individual approvals on all five plan sets. For plans requiring modification for approval, the agency or individual providing the approval will note the modifications on the approved sets of plans or attachments to the plans.

The MnDOT Office of Freight and Commercial Vehicle Operations, Railroad Administration Section will distribute the final approved plans in accordance with the following:

(1) Railway – 1 set,
(2) Contractor – 2 sets,
(3) Engineer – 1 set, and
(4) MnDOT Office of Freight and Commercial Vehicle Operations, Railroad Administration Section - 1 set.

1708.3 LIABILITY INSURANCE

The Contractor shall provide liability insurance in accordance with this section, unless the Railway requires otherwise.

If performing Work on the railroad right-of-way or hauling Material across railroad tracks over a private crossing as required by the Contract, the Contractor shall provide Railroad Protective Liability Insurance in accordance with the following:

(1) Physical Damage to Property – $2,000,000 each occurrence,
(2) Bodily Injury Liability,
(3) Property Damage Liability, and
(4) Physical Damage to Property – $6,000,000 aggregate.

The Contractor shall provide an insurance certificate showing that the required insurance is in full force and effect before beginning Work. The Contractor shall not cancel the insurance until the Engineer has accepted the Work requiring the insurance. The Contractor shall submit one true and correct copy of the insurance policy to the Department and to each of the Railway companies as specified in the special provisions at least 10 calendar days before beginning Work.

1708.4 FLAGGING, PROTECTIVE SERVICES, AND DEVICES

The Contractor shall arrange for railroad flagging, unless the Railway requires and the supplemental provisions specify otherwise.

The Railway will provide flagging and other protective services and devices for Contract-required Contractor Work performed on the railroad right-of-way or for Materials hauled across railroad tracks over a private crossing to protect railway facilities, personnel, equipment, and traffic.

The Contractor shall arrange flagging and other protective services and devices with the Railway. The Contractor shall notify the Railway and the Engineer at least 30 calendar days before the need for flagging and other protective services and devices. Unless the Railway requires otherwise, the Contractor shall notify the Railway and the Engineer at least 5 business days before the date flagging and other protective services and devices will no longer be necessary to allow the Railway to remove the flagger position, as required by Railway-union agreements.

Unless the Contract requires otherwise, the Contractor shall coordinate with the Railway for flagging and protective services and devices if performing Work in accordance with the following:

(1) Over a railroad track,
(2) Under a railroad track,
(3) Within 25 ft [7.62 m] of the nearest track when measured horizontally from center line of the nearest track, and

(4) If using cranes or construction Equipment positioned outside of the 25 ft [7.62 m] horizontal zone having component parts that, if tipped or dropped, could damage the Railway facilities and equipment.

The Contractor shall coordinate flagging and protective services and devices with the Railway to protect Railway property, employees, trains, engines, and facilities as directed by the Railway Roadmaster during the following:

(1) If performing excavation below the bottom of the elevation and if the Railway Roadmaster determines that the track or other Railway facilities may move or settle,
(2) If Work interferes with the safe operation of trains at timetable speeds, and
(3) If the presence of persons, Materials, Equipment, or blasting operations present a hazards to Railway track, communications, signal, electrical, or other facilities.

The Contractor shall obtain special permission from the Railway before moving heavy or cumbersome objects or Equipment that could render the track impassable.

Unless the Contract requires otherwise, the Department will reimburse the Railway for the costs of necessary flagging, other protective services, and devices required to protect the Railway's facilities, personnel, equipment, and traffic.

1709 NAVIGABLE WATERWAYS

The Contractor shall not interfere with free navigation of waterways or impair existing navigable depths when performing Work on navigable waters, unless approved by a permit. For information regarding permits that are required for this Work, contact the MnDOT Office of Freight and Commercial Vehicle Operations.

1710 TRAFFIC CONTROL DEVICES

1710.1 GENERAL

The Contractor shall provide traffic control devices and methods meeting the requirements of the MN MUTCD, Part I and Part II of the Minnesota Standard Signs Manuals, and the applicable Material Specifications. The Contractor shall also provide traffic control devices and methods in accordance with the following:

(1) Reflectorize all signs, paddles, and other traffic control devices, including those used for daytime operations; and
(2) Signs shall meet the crash testing requirements of NCHRP 350 as specified by the MN MUTCD and the Manual for Assessing Safety Hardware (MASH).

The Project Engineer may require the Contractor to provide a Letter of Compliance stating that all of the Contractors devices are NCHRP 350 compliant and also meet the requirements of MASH. The Letter of Compliance must also include approved drawings of the different signs and devices.

1710.2 PROVIDE, MAINTAIN, AND REMOVE

The Contractor shall provide and maintain traffic control devices as required by the Department in accordance with the contract and the MN MUTCD that perform the following functions:

(1) Advise, warn, and alert the traveling public of construction in advance of the Project termini and on all Roads, Streets, and public trails approaching or crossing the Project;
(2) Control and guide traffic through the Project, which may include using flag persons and pilot vehicles as required by the Contract; and
(3) Protect, warn, and exclude traffic and protect workers at all work sites.

If the Contractor fails to properly provide, install, maintain, or remove any of the required traffic control devices, the Department reserves the right to correct the deficiency and to deduct the costs from any moneys due or becoming due to the Contractor in accordance with 1512, "Unacceptable and Unauthorized Work."

1710.3 PLANNED DETOURS

The Department, at its expense, will design traffic control devices necessary to control and guide traffic over planned Detours required by the Contract.

1710.4 (BLANK)

1710.5 TEMPORARY BY-PASSES

The Contractor shall construct, maintain, and remove traffic control devices on other temporary by-passes requested by the Contractor and approved by the Engineer at no additional cost to the Department.

1710.6 CONTRACTOR'S RESPONSIBILITY

The Engineer's approval of the traffic control devices and the Contractor's method of application of traffic control measures as specified in this section will not relieve the Contractor of responsibility for protecting the work, the workers, and the traveling public in accordance with 1511, "Inspection of Work."

The Contractor shall protect traffic signs not removed or relocated by the Department before construction in their original location for the duration of the work, except as otherwise approved by the Engineer. The Contractor may adjust or remove and reset a sign interfering with construction to a temporary location, if approved by the Engineer and if the original location is not critical and the Contractor resets the sign at the permanent location as soon as construction operations allow. The Contractor shall notify the Engineer before removing or disturbing a traffic sign.

The Department will make no direct payment for removing, protecting, and replacing traffic signs as specified in this section unless provided for elsewhere in the Contract. The Department will not provide additional compensation to the Contractor for delays, inconvenience, or damage from special construction required performing the work in the presence of traffic signs.

1710.7 ENGINEER'S AUTHORITY

In accordance with 1501, "Authority of the Engineer," the Engineer will accept or reject a traffic control device provided by the Contractor, but not incorporated in the final construction, based on acceptable day and night performance.

If requested by the Engineer, the Contractor shall provide representative samples or remove traffic control devices for testing at no additional cost to the Department.

1710.8 (BLANK)

1711 USE OF EXPLOSIVES

If using explosives to complete the Work, the Contractor shall not endanger life, property, or new Project Work. The Contractor is responsible for property damage, personal injury, and death resulting from the use of explosives.

The Contractor shall use explosives, securely store explosives, and mark explosive storage locations in accordance with applicable laws. If laws do not identify storage requirements, the Contractor shall store explosives at least 1,000 ft [300 m] away from the Road or from places of human occupancy, and as approved by the Engineer.

The Contractor shall notify property owners and public utility companies in the vicinity of the proposed detonation before using explosives to allow the property owners and public utility companies to protect property.

The Department advises the Contractor of the potential hazard of premature explosion of electric blasting caps due to propagation of radio frequency energy by transmitters of radio and related services such as television, radar, and wireless communications. The Contractor shall provide advance notification of blasting operations and any other precautions in accordance with Minnesota Rule 7500.1200.

1712 PROTECTION AND RESTORATION OF PROPERTY

1712.1 PROPERTY

The Contractor is responsible for the preservation of all public and private property of any character in performing the Work.

A Monuments

The Contractor shall preserve all land and property corner monuments, Right Of Way monuments, and vertical and horizontal control point monuments indicated in the Contract or provided in writing by the Engineer before the start of Work in the vicinity of the monument. If the Engineer determines that a monument designated for preservation was disturbed during construction activities, the Department will deduct a charge of $1,000.00 per monument from the moneys due or becoming due the Contractor. The Engineer will determine the number of monuments disturbed or destroyed by the Contractor. If the Engineer determines that a monument requires removal to allow construction, the Department will not deduct the charge of $1,000.00 per monument from moneys due or becoming due the Contractor.

B Utilities 1507

C Protection and Restoration of Vegetation 2572

D Preservation of Historical Objects 1406

1712.2 ADVANCE NOTICE

The Contractor shall give advance notice to the owners of all private property where the Contractor's operations will interfere with the property. The notice shall advise the private property owners of the nature of the interference and indicate the Contractor's intention to arrange for the protection of their property.

1712.3 (BLANK)

1712.4 GENERAL LIABILITY

The Contractor is responsible for all damages to property of any character, resulting from any act, omission, neglect, or misconduct in the execution or nonexecution of the Work. The Contractor will not be responsible for property within the Project Site if:

(1) The Contract did not specify the existence and approximate location of the underground property, and
(2) The Contractor fulfilled its obligations under Minnesota Statute Chapter 216D.

The Contractor shall restore property damaged by the Contractor's act, omission, neglect, or misconduct to a condition equal to or better than that existing before the damage occurred by repairing, rebuilding, or replacing the property, or otherwise correcting the damage to the satisfaction of the Engineer, at no additional cost to the Department, and denial of a claim by the Contractor's insurance carrier does not relieve the Contractor of its obligations in this regard.

1713 FOREST PROTECTION

If performing Work within or adjacent to State or National Forests, the Contractor shall comply with all regulations of the USDA Forest Service, State Fire Marshal, Department of Natural Resources, Division of Forestry, or other authority having jurisdiction, governing the protection of forests and the performance of Work within forests. The Contractor shall keep the areas in an orderly condition, dispose of all refuse, and obtain permits for the construction of field offices and other structures in accordance with the requirements of the Forest Supervisor.

The Contractor shall take all reasonable precautions to prevent and suppress forest fires and shall require employees and Subcontractors to take all reasonable measures within their power to prevent and suppress forest fires. The Contractor shall make every possible effort to notify a Forest official at the earliest possible moment of the location and extent of a fire.

1714 RESPONSIBILITY FOR DAMAGE CLAIMS; INSURANCE

1714.1 GENERAL

The Contractor shall indemnify, defend, and save harmless the Department, its officers, and its employees from all suits, actions, and claims of any character brought because of injuries or damages received or sustained by any person, persons, or property based on the following:

(1) On account of the operations of the Contractor;
(2) On account of or in consequence of any neglect in safeguarding the Work;
(3) Use of unacceptable Materials in constructing the Work;
(4) Any act or omission, neglect, or misconduct of the Contractor;
(6) Claims arising or amounts recovered from infringements of patent, trademark, or copyright; or
(7) Claims arising or amounts recovered under the Workers' Compensation Act, or under any other law, ordinance, order, or decree.

The Department may retain money due to the Contractor under this or any other contract with the Department that the Department deems necessary to protect its interests with respect to suits, actions, or claims arising on account of the Contractor's operations or in consequence of any act, neglect, omission, or misconduct of the Contractor. If no money is due to the Contractor, the Department may hold the Contractor's Sureties liable until the Department receives evidence that suits, actions, or claims have been settled.

The Contractor shall identify a contact person for damage complaints from the public, and shall maintain a log of such complaints and any action taken by the Contractor. The Contractor shall provide the log to the Engineer upon request.

1714.2 WORKERS' COMPENSATION INSURANCE

The Contractor shall provide workers' compensation insurance for all employees and shall require Subcontractors to provide workers' compensation insurance in accordance with the Minnesota statutory requirements and the following:

(1) Part 2, Employers' Liability including Stop Gap Liability for monopolistic states. Provide the following minimum limits unless otherwise stated in the special provisions:
  (1.1) $100,000 – Bodily Injury by disease per employee,
  (1.2) $500,000 – Bodily Injury by disease aggregate, and
  (1.3) $100,000 – Bodily Injury by accident.
(2) Coverage C: All States Coverage,
(3) If applicable, USL&H, Maritime, Voluntary, and Foreign Coverage, and
(4) Waiver of subrogation in favor of the Department.

If the Contractor is self-insured for its obligation under the Workers' Compensation Statutes in the jurisdiction where the Project is located, the Contractor shall provide the Department with a Certification of the Authority to Self-Insure.

1714.3 COMMERCIAL GENERAL LIABILITY INSURANCE

The Contractor shall maintain insurance to cover liability from operations under the Contract, whether such operations are by the Contractor, Subcontractor, or by anyone directly or indirectly employed under the Contract.

A Minimum Limits of Liability

The Contractor shall provide the following minimum limits of liability:

(1) $2,000,000 – Per occurrence,
(2) $2,000,000 – Annual aggregate,
(3) $2,000,000 – Annual aggregate applying to Products and Completed Operations,
(4) $50,000 – Fire damage, and
(5) $5,000 – Medical expense (any one person per occurrence).

The liability limits specified above are the minimum limits required, and any and all additional limits provided to the Contractor will be available on an excess, umbrella or other basis to the Additional Insured for any and all covered claims.

B Coverages

The Contractor shall provide the following types of coverage:

(1) Premises and Operations Bodily Injury and Property Damage,
(2) Personal and Advertising Injury,
(3) Products and Completed Operations Liability,
(4) Contractual Liability as provided in ISO form CG 00 01 12 04 or its equivalent,
(5) Pollution exclusion with standard exception as per ISO Commercial General Liability Coverage Form – CG 00 01 12 04 or equivalent,
(6) Explosion, Collapse, and Underground (XCU) perils,
(7) Broad Form PD,
(8) Independent Contractors – Let or Sublet Work,
(9) Waiver of subrogation in favor of the Department,
(10) Department named as an Additional Insured, by endorsement, ISO Forms CG 2010 and CG 20 37 or their equivalent for claims arising out of the Contractor's negligence or the negligence of those for whom the Contractor is responsible, and
(11) Coverage under the General Liability Policy(ies) of the Contractor will be as broadly construed for the Owner as is available to the Contractor.

1714.4 AUTOMOBILE LIABILITY INSURANCE

A Coverage

The Contractor shall maintain the following insurance coverages for liability arising out of the operations, use, or maintenance of all owned, non-owned, and hired automobiles:

(1) Owned automobiles,
(2) Non-owned automobiles,
(3) Hired automobiles, and
(4) Waiver of subrogation in favor of the Department.

B Minimum Limit of Liability

The Contractor shall provide a minimum limit of liability of at least $2,000,000 Per Occurrence Combined Single Limit for Bodily Injury and Property Damage.

1714.5 UMBRELLA OR EXCESS LIABILITY INSURANCE

The Contractor may use an umbrella or excess liability insurance policy to supplement the Contractor's policy limits to meet the full policy limits as required by the Contract.

1714.6 ADDITIONAL CONDITIONS

The Contractor shall provide primary and non-contributory insurance policies to any other valid and collectible insurance available to the Department with respect to any claim arising out of the Contract.

The Contractor shall file evidence of Subcontractor insurance.

The Contractor shall pay for Contract-related insurance premiums and deductibles.

The Contractor shall provide policies from insurance companies meeting the following requirements:

(1) AM Best rating of at least "A–",
(2) Financial Size Category of at least VII, and
(3) Authorized to do business in the State of Minnesota.

If the Contractor receives a cancellation notice from an insurance carrier affording coverage herein, the Contractor agrees to notify the Department within five business days with a copy of the cancellation notice, unless the Contractor's policy(ies) contain a provision that coverage afforded under the policy(ies) will not be cancelled without at least thirty days advance written notice to the Department.

The insurance and insurance limits required herein will not be deemed a limitation on the Contractor's liability with regard to the indemnities granted to the Department under this Contract.

1714.7 NOTICE TO THE CONTRACTOR

The failure of the Contractor to provide the Department with certificates of insurance for the policies or renewals and the failure of the insurance company to notify the Department of cancellation of policies as required by the Contract shall not constitute a waiver by the Department to the Contractor to provide insurance.

The Department reserves the right to terminate the Contract in accordance with 1808, "Default of Contractor," if the Contractor fails to meet the insurance requirements specified in this section. The Department retains all rights to pursue any legal remedies against the Contractor. In the event of a claims dispute, the Contractor shall make all insurance policies available for the Department's inspection and shall submit copies of policies to the Department's authorized agent if requested by the Department in writing.

1715 OPENING SECTIONS OF THE ROADWAY TO TRAFFIC BEFORE COMPLETION OF THE PROJECT

The requirement of this section shall not relieve the Contractor of obligations for maintenance of traffic over Roads undergoing improvements, as specified in 1404, "Maintenance of Traffic." Opening of a section of the Roadway to traffic shall not constitute acceptance of the incomplete portions of the Project, nor shall opening a section of the Roadway to traffic before the completion of the entire Contract waive any provisions of the Contract.

The Special Provisions may require, or the Engineer may direct, the Contractor to open sections of the Roadway to traffic before the completion of that section or the entire Project:

(1) On sections of the Roadway that the Department requires the Contractor to open to traffic before completion of the entire Project, the Department will relieve the Contractor of any expense entailed in maintaining the Roadway for traffic. The Department will hold the Contractor responsible for repair of damage to the Work not attributable to traffic. If the Contract does not include Contract Unit Prices for Roadway maintenance, the Department may direct the Contractor to perform the Roadway maintenance work as Extra Work in accordance with 1402, "Contract Revisions," or the Department may perform the Roadway maintenance work with the Department's forces.
(2) If a section of the Roadway is opened to traffic as directed by the Engineer, for unforeseen reasons not the fault of the Contractor, the Department will pay the Contractor for additional expenses incurred in completing the remaining Work under traffic. The Department may extend the Contract Time, if justified, with a Supplemental Agreement executed in advance of the traffic opening, describing the agreed conditions.
(3) If a section of the Roadway is opened to traffic before its completion, as a requirement of the Contract or as directed by the Engineer as a result of failure or negligence by the Contractor, the Contractor shall perform remaining construction operations with the least possible obstruction to traffic. The Department will not provide the Contractor any additional compensation or extension of time due to increased costs or changed working conditions resulting from opening the Road to traffic before its completion.

1716 CONTRACTOR'S RESPONSIBILITY FOR WORK

The Contractor is responsible for the Work until the Engineer provides final project acceptance in writing. The Contractor shall protect the Work against injury or damage from weather or other causes arising from the execution or non-execution of the Work. The Contractor shall rebuild, repair, and correct injuries or damages to the Work at no additional cost to the Department, before the Engineer will grant final acceptance of the Project unless:

(1) Otherwise specified in the Contract, or
(2) The damage to the Work was caused by unforeseeable causes beyond the control of and without the fault or negligence of the Contractor, including acts of God such as earthquake, tidal wave, flood, tornado, hurricane, other cataclysmic phenomenon of nature, or acts of a public enemy or of governmental authorities.

If the Engineer suspends the Work, the Contractor shall perform the following functions at no additional cost to the Department:

(1) Take precautions to prevent damage to the Project;

(2) Provide for normal drainage in accordance with 2573, "Storm Water Management," and 2575, "Establishing Turf and Controlling Erosion;"
(3) Erect necessary temporary structures, signs, or other facilities in accordance with 1404, "Maintenance of Traffic," and 1710, "Traffic Control Devices;" and
(4) Take precautions to protect new tree growth and other vegetative growth against injury as specified in 2571, "Plant Installation and Establishment," 2572, "Protection and Restoration of Vegetation," and 2575, "Establishing Turf and Controlling Erosion."

If the Contractor fails to comply with these provisions, the Engineer will notify the Contractor in writing of the unacceptable Work. If the Contractor fails to take action as directed by the Engineer, the Department may have the Work performed by others and will deduct the costs for this Work from moneys due the Contractor under this Contract or any other contract with the Department.

1717 AIR, LAND, AND WATER POLLUTION

1717.1 GENERAL

The Contractor shall schedule and conduct construction operations to prevent, control, minimize, or abate pollution of air, land, and water in accordance with 1701, "Laws to be Observed." The Contractor shall obtain permits in accordance with 1702, "Permits, Licenses, and Taxes."

A Discovery of Contaminated Materials and Regulated Waste

If during the course of the Project, the Contractor unexpectedly encounters any of the following conditions indicating the possible presence of contaminated soil, contaminated water, or regulated waste, the Contractor shall immediately stop Work in the vicinity, notify the Engineer, and request suspension of Work in the vicinity of the discovery area, in accordance with 1803.6, "Temporary Suspensions."

The Engineer will conduct a documented inspection and evaluation before resumption of Work. The Contractor shall not resume Work in the suspected area until approved by the Engineer.

Some indicators of contaminated soil, ground water, or surface water include the following:

(1) Odor, including gasoline, diesel, creosote as in the odor of railroad ties, mothballs, or other chemical odor;
(2) Soil stained green or black for reasons other than organic content, or soil with a dark, oily appearance, or any unusual soil color or texture; or
(3) A rainbow colored sheen on surface water or soil.

Some indicators of regulated wastes include the following:

(1) Cans, bottles, glass, scrap metal, and wood;
(2) Concrete and asphalt rubble;
(3) Roofing materials, shingles, siding, vermiculite, floor tiles, transite or fibrous material, possible indicators of demolition waste that could contain asbestos, lead, or other chemicals;
(4) Culverts or other pipes with tar-like coating, insulation or transite, possible indicators of asbestos;
(5) Ash, possibly from burning of regulated materials that may contain lead, asbestos or other chemicals;
(6) Sandblast residue that could contain lead;
(7) Treated wood including, but not limited to products referred to as green treat, brown treat, and creosote;
(8) Chemical containers such as storage tanks, drums, and filters; and
(9) Old basements with intact floor tiles or insulation that could contain asbestos, sumps that could contain chemical waste, waste traps that could contain oil wastes, and cesspools that could contain chemical or oily wastes.

B Water Protection

The Contractor shall take all precautions and actions to prevent pollution of ground water and surface water with any particulate or liquid matter that may be harmful to fish and wild life, public health or cause a public nuisance.

The Contractor shall minimize the crossings of streams and rivers with hauling equipment. The Contractor shall use temporary bridging when required by the Contract or by permit. The Contractor shall clear the crossings of temporary construction and restore to pre-disturbed conditions as soon as practical after use. The Contractor shall minimize water pollution from haul roads, work platforms, temporary earth fills, and other temporary construction used to facilitate bridge or culvert construction.

C Land Protection

The Contractor shall minimize erosion on the project. The Department will consider all areas within the grading construction limits, exclusive of roadbed areas, that grading or grubbing operations have rendered natural vegetation ineffective as being exposed to probable erosion until such time that the Contractor completes final surface finishing and turf establishment operations.

D Air Protection

The Contractor shall take actions to minimize pollution of air with particulate matter that may harm public health or may create a public nuisance.

1717.2 STORMWATER MANAGEMENT AND EROSION CONTROL

When required by Contract, the Contractor shall obtain and adhere to the NPDES Stormwater Permit for Construction Activity from the Minnesota Pollution Control Agency (MPCA). The Contractor shall not initiate work until the MPCA activates the permit.

A General Requirements

The Contractor shall schedule and conduct construction activities in a manner that will minimize soil erosion and provide water protection.

Before construction begins, the Contractor shall install temporary sediment control measures in areas that contribute flow to public waters.

The Contractor shall implement the Storm Water Pollution Prevention Plan, including the following:

(1) Schedule, install, and maintain temporary and permanent sediment and erosion control measures;
(2) Construct ponds;
(3) Construct drainage facilities;
(4) Finish earthwork operations;
(5) Place topsoil; and
(6) Establish turf.

The Contractor shall install perimeter control barriers on stockpiles.

The Contractor shall minimize vehicle tracking of sediment or soil off site at locations where vehicles exit the Project Site onto paved surfaces. The Contractor shall remove tracked sediment from paved surfaces that do not drain back into the Project Site within 24 h of discovery.

The Contractor shall retrieve sediment that has left the right-of-way unless the Project has received approval or certification for depositing fill into surface waters.

The Contractor shall remove deltas and sediment deposited in drainage ways or catch basins, and stabilize the areas where sediment removal results in exposed soil.

The Contractor shall provide and incorporate temporary or permanent stabilization on exposed slopes into the erosion and sediment control schedule.

B Quality Control

The Contractor shall maintain and implement a quality control program for erosion control and sediment prevention including the following:

(1) Adherence to permit requirements related to the Work;
(2) Conducting weekly inspections of Sediment control Best Management practices (BMPs);
(3) Developing and maintaining the inspection log with dates and times;
(4) Incorporating temporary or permanent erosion control into the work and stabilizing disturbed areas with mulch, seed ,or vegetative cover on a section by section basis;
(5) Maintaining temporary sediment control devices; and
(6) Removing temporary sediment control devices after use.

The Contractor shall provide an individual to conduct the quality control program. The Engineer may review the Contractor's quality control and inspection procedures. The Contractor shall maintain the erosion and sediment control inspection records at the Project Site and make the inspection records available to the Engineer for verification.

C Erosion and Sediment Control Schedule

The Contractor shall prepare and submit a weekly schedule of proposed erosion and sediment control activities including the following:

(1) Proposed erosion and sediment control installations and the installation time,
(2) Areas ready for permanent turf establishment and the work time frame,
(3) Grading operations and how the Contractor will incorporate the erosion control into the Work,
(4) Findings of erosion and sediment control inspections with recommended repair or maintenance required on erosion or sediment control BMPs and completion date, and
(5) Proposed erosion control measures during work suspensions.

D Site Management Plan

The Contractor shall provide a Site Management Plan as shown on the Plans, or within 10 calendar days of receipt of written notice from the Engineer, for construction operations within 1 mi [1.6 km] of surface waters or Areas of Environmental Sensitivity (AES). In the Site Management Plan, the Contractor shall detail the schedule of work, materials, and equipment along with storm water or pollutant management BMPs to complete the work and protect the surface waters or AES. The Contractor shall not start work in the affected areas until the Engineer approves the Site Management Plan document.

1718 FURNISHING RIGHT OF WAY

The Department will provide the required Right Of Way for the Project before scheduled construction Work begins, except as otherwise required by the Contract.

1719 PERSONAL LIABILITY OF PUBLIC OFFICIALS

In carrying out the provisions of the Contract, and in exercising the powers and authorities granted to them by or within the scope thereof, no personal liability shall fall upon the Commissioner, the Engineer, or their authorized representatives, it being understood that in all matters they act solely as agents and representatives of the Department.

1720 NO WAIVER OF LEGAL RIGHTS

The Department may correct measurements, estimates, or certificates made before or after completion and acceptance of Work, after final acceptance of the Contract in accordance with 1516.4, "Final Contract Acceptance." The Department may recover overpayments and damages sustained from the Contractor's failure to fulfill the obligations as required by the Contract from the Contractor or the Contractor's sureties. The Contractor shall not consider a waiver from the Department for any breach of any part of the Contract as a waiver of any other or subsequent breach.

Notwithstanding final acceptance of the Contract, the Contractor shall remain responsible for false claims, latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the Department's rights under any warranty or guaranty.

1721 AUDITS

In accordance with MN Statute § 16C.05, Subdivision 5, the Department and the Legislative Auditor or the State Auditor may examine and audit the following for at least 6 years after the end of the Contract:

(1) Books,
(2) Records,
(3) Documents,
(4) Accounting procedures, and
(5) Accounting practices of the Contractor, Subcontractors, or suppliers.

Prosecution and Progress

1801 SUBLETTING OF CONTRACT

The Contractor shall not sublet, sell, transfer, delegate, or assign the Contract or any portion of the Contract without written approval of the Engineer. If approved by the Engineer and if the Contractor performs Work amounting to at least 40 percent of the total original Contract Amount, the Contractor may sublet a portion of the Contract.

The Contractor may subcontract Contract Items designated in the Contract as "specialty items" and the Department will deduct the cost of any specialty items performed by subcontract from the total original Contract Amount before calculating the 40 percent of Work that the Contractor must perform.

On Contracts with Disadvantaged Business Enterprise (DBE) or Targeted Group Business (TGB) established goals, or both, the Contractor shall perform Work amounting to not less than 30 percent of the total original Contract Amount. The Department will deduct specialty items from the total original Contract Amount before calculating the amount of Work that the Contractor shall perform.

No Subcontractor shall further sublet its portion of the Work without the written approval of the Contractor and the Engineer. If approved by the Contractor and the Engineer, a first tier Subcontractor may sublet a portion of the Work no greater than 50 percent of the Work originally sublet. The Department will not allow second tier Subcontractors to sublet any portion of the Work.

The Contractor shall submit requests to sublet portions of the Contract to the Engineer on a "Request to Sublet" form provided by the Department, at least 10 business days before the Subcontractor intends to start Work. If requested by the Department, the Contractor shall provide one signed copy of each subcontract agreement to the Engineer. The Contractor may omit subcontract prices when the Engineer requests a copy of the subcontract under this specification.

The Department will consider Work subcontracted without the approval of the Engineer and subcontracted Work exceeding the percentages specified in this section as unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

The Contractor shall not construe the Engineer's approval as an endorsement of the subcontract, the Subcontractor, or the Subcontractor's ability to complete the Work in a satisfactory manner.

The subcontract or the Engineer's approval of the "Request to Sublet" form shall not relieve the Contractor of any responsibility to complete the Contract or relieve the Contractor of any obligations or liability under the Contract and the Contractor's Contract Bonds. The Engineer will conduct all transactions with the Contractor. The Engineer will recognize Subcontractors only in the capacity of employees or workers, subject to the Contract requirements regarding character and competence. The subcontract does not create a contractual relationship between the Department and the Subcontractor; or convey to the Subcontractor any rights against the Department.

The Contractor shall ensure that the subcontracts at least contain the following:

(1) Federal, State Special Provisions, Division A, or both,
(2) Federal, State certified prevailing wage determinations, or both, and
(3) State certified truck rental rates.

1802 QUALIFICATIONS OF WORKERS

The Contractor shall provide workers with sufficient skill and experience to perform the Work assigned to them. Upon request by the Engineer, the Contractor shall submit evidence of qualification for any person engaged in special Work requiring professional training or certification. If any Subcontractor employed by the Contractor or any person employed by the Contractor or by a Subcontractor fails to perform assigned Work in a proper and skillful manner, or becomes intemperate, disorderly, abusive, or harassing, the Contractor shall remove that Subcontractor or person from the Project as directed in writing by the Engineer. The Contractor shall not employ that Subcontractor or person again on any portion of the Project unless otherwise approved by the Engineer. If the Contractor fails to remove a Subcontractor or person as directed by the Engineer, or fails to provide suitable and sufficient personnel for the proper prosecution of the Work, the Engineer may suspend the Work until the Contractor complies with the direction from the Engineer.

1803 PROGRESS SCHEDULES

1803.1 ALL SCHEDULES

A General Requirements

The Contractor shall prepare the Progress Schedule as specified in 1803.2, "Bar Chart Schedules," or 1803.3, "CPM Schedule." If the Engineer determines that the Progress Schedule or any necessary Schedule Update does not provide the required information, then the schedule will be returned to the Contractor for correction and resubmittal.

The Contactor shall give the Engineer at least 72 hours advance notice before beginning any construction, and at least 24 hours advanced notice before beginning each major construction operation. The Contractor shall inform the Department of the number of hours the Contractor intends to be working each day; and provide 24 hours advance notice of any changes to workday hours, equipment, forces, or sequence of operations.

A.1 Acceptance

The Department allocates its resources to a Contract based on the total time allowed in the Contract. The Engineer may accept a Progress Schedule indicating an early Physical Completion Date but cannot guarantee the Department's resources will be available to meet an accelerated schedule. No additional compensation will be allowed if the Contractor is not able to meet their accelerated schedule due to the unavailability of the Department's resources or for other reasons beyond the Department's control.

Review by the Department of a portion of a schedule or an incomplete schedule submittal will not indicate acceptance of the entire schedule; the Department will return the accepted schedule to the Contractor as "Accepted-As-Noted" or "No Exceptions Taken."

The Engineer's acceptance of any schedule shall not transfer any of the Contractor's responsibilities to the Department. The Contractor alone shall remain responsible for adjusting forces, equipment, and Work schedules to ensure completion of the Work within the time(s) specified in the Contract.

A.2 Early Completion

Early Completion is defined as an initial schedule, baseline schedule or update schedule which anticipates completion of all work prior to the Completion Date established by the contract documents and the Contractor submits as an Early Completion Schedule. In the event that an Early Completion Schedule is accepted, the Engineer will initiate a Supplemental Agreement amending the Completion Date to the finish date shown on the accepted Early Completion Schedule. The amended Completion Date will be effective upon execution of that Supplemental Agreement and all contract provisions concerning the Completion Date such as incentives, disincentives, excusable delays, compensable delays, and liquidated damages will be measured against the amended Completion Date. The Contractor may elect not to execute the Supplemental Agreement amending the Completion Date; however, in so doing, the Contractor waives its rights to delay damages in meeting the projected early Completion Date.

A.3 Non-Compliance

It is the Contractor's responsibility to ensure that the Schedule submitted meets the requirements of 1803.2, "Bar Chart Schedules" or 1803.3, "Critical Path Method (CPM) Schedules" and accurately reflects the work progress. The Engineer may suspend work under 1803.6A if the schedule does not accurately reflect the actual progress of the work; the suspension may continue until accurate schedules are submitted.

The Department will withhold each monthly progress estimate for failure to submit an original or updated schedule on time and in the manner required. Payment withheld for violation of the schedule requirements will be included in the next progress estimate following the Contractor's submission of the required schedules. The Project Engineer's approval does not attest to the validity of the schedule.

1803.2 BAR CHART SCHEDULES

A General Requirements

The Contractor shall submit a bar chart progress schedule as specified in 1803.2B, "Required Schedules". The Contractor shall plan and execute the work to meet the contract-required interim completion dates and the specified contract time or completion date. The Engineer will use the schedule to monitor the progress of the work.

B Required Schedules

B.1 Initial Bar Chart Progress Schedule

At least 7 calendar days before the preconstruction meeting, the Contractor shall submit to the Engineer for review, an initial bar chart progress schedule conforming to the following minimum requirements:

(1) Include activities that describe essential features of the work and activities that might potentially delay contract completion. Identify activities that are controlling items of work.
(2) Identify the contemplated start and completion dates for each activity. Provide a duration, ranging from one to 15 working days, for each activity. Break longer activities into 2 or more activities distinguished by the addition of a location or some other description. Specify the sequencing of all activities.
(3) Provide the quantity and the estimated daily production rate for controlling items of work.
(4) Provide a Written Narrative (WN). Include in the WN:

(4.1) The proposed work process sequence describing the relationship of the work activities listed in Section 1 herein required to complete the contract, including shop drawing submittals, permits (including estimated maximum waiting periods for all required permits), fabrication and delivery activities.

(4.2) A detailed description and the progress time of each work activity listed in Section 1 herein, measured by working day or calendar day, as appropriate.

(4.3) A detailed description of the Bar Chart, including holidays, planned workdays per week, number of shifts per day, hours per shift, size of work crews and resources used.

(5) Show completing the work within interim completion dates and the specified contract time or completion date.

In addition to the required activities, the contractor is encouraged to include other activities such as:

(1) The procurement of materials, equipment, articles of special manufacture, etc.
(2) The furnishing of drawings, plans, and other data required in the contract for the engineer's review.
(3) The department's inspections of structural steel fabrication, etc.
(4) Third party activities related to the contract.

The Engineer will review the schedule and within 7 calendar days of receipt and will either accept the schedule or provide the Contractor with comments. If the contractor develops the initial schedule with scheduling software, the Contractor is encouraged to provide the Engineer an electronic file of the schedule and the name of the scheduling software used.

B.2 Weekly Look Ahead Schedule

For each week that Work will be performed, the Contractor shall submit a Weekly Look-Ahead Schedule showing the Contractor's and all Subcontractors' proposed Work activities for the next two weeks. The Weekly Look-Ahead Schedule shall include the description, duration and sequence of Work, along with the planned hours of Work. This schedule may be a network schedule, bar chart, or other standard schedule format. The Weekly Look-Ahead Schedule shall be submitted to the Engineer by the midpoint of the week preceding the scheduled Work or some other mutually agreed upon submittal time.

B.3 Monthly Progress Meetings and Bar Chart Progress Schedule Updates

The Contractor and the Engineer will meet monthly to assess progress and jointly add update information to the initial schedule. At a minimum, updates will include the actual start and finish of each activity, percentage complete, and remaining durations of activities started but not yet completed.

B.4 Revised Schedule

The Engineer may request a Revised Update when any of the following events occur:

1. The project has experienced a change that affects controlling items of work.
2.. The sequence of Work is changed from that in the approved schedule.
3. The project is significantly delayed.
4. The Engineer has granted an extension of Contract Time.

The Contractor shall submit the Revised Schedule within 7 calendar days of receiving a written request, or when an update is required by any other provision of the Contract.

In addition to the other requirements of this Section, Revised Schedules shall reflect the following information:

1. The actual duration and sequence of as-constructed Work activities, including revised Work.
2. Approved time extensions.
3. Any construction delays or other conditions that affect the progress of the Work.
4. Any modifications to the as-planned sequence or duration of remaining activities.
5. The Physical Completion of all remaining Work in the remaining Contract time.

B.5 Recovery Schedule

If the progress schedule projects a finish date for the Project more than 7 calendar days later than the Completion Date, the Contractor shall submit a revised schedule showing a plan to finish by the Completion Date. The Engineer will use the schedule to evaluate time extensions and associated costs requested by the Contractor.

C Weather and Duration Contingency

The Contractor shall allow for normal weather delays when developing the Progress Schedule. The Department will extend the Contract Time, except as limited by 1806.4, "Extension of Contract Time Due to Weather on calendar Day and Completion Date Contracts," for delays in excess of the anticipated work days lost to inclement weather as specified in Table 1803-2; the days in Table 1803-2 are cumulative and prorated when Contract Time starts or ends mid-month. For example, if Contract Time starts May 15 and there are days lost to weather in May or June, then the Contract must lose 7 days to weather (2 days from May and 5 days from June) in addition to the anticipated days in July before a time extension would be considered due to weather days lost in July.

Table 1803-2 Anticipated Work Days Lost Due to Weather Per Time Period	
Time Period	**Anticipated Work Days Lost**
January	20
February	15
March	9
April 1-15	3
April 16-30	2
May	4
June	5
July	4
August	3
September	3
October	3
November 1-14	2
November 15-30	5
December	17

1803.3 CRITICAL PATH METHOD (CPM) SCHEDULES

A General Requirements

If the Contractor intends to use Critical Path Method (CPM) schedules, or when the Department specifies the Work under this Contract shall be scheduled using CPM, the Work shall be planned, accomplished, and reported using CPM for the Contractor's Progress Schedules.

A.1 Software

The Department uses "Primavera Project Manager (P6)". If the Contractor uses software other than (P6), the Contractor is responsible for any conversion discrepancies.

A.2 Schedule Calculations, Codes, and Settings

The Contractor shall not prepare a schedule with User Defined fields. The Contractor shall use project-level calendars, not Global or Resources Calendars. The Contractor shall use project-level codes, not Global- or EPS-level codes.

A.3 File-Naming Convention

The Contractor shall use a file-naming convention as modeled in Table 1803-3. If the schedule in not accepted, the Contractor shall resubmit under the file name as modeled for the 2nd version, etc. The ####-### indicates a placeholder for the State Project Number.

Table 1803-3 Progress Schedule Filename convention			
Schedules	**1st Version**	**2nd Version**	**3rd Version**
1st Baseline Schedule (All Schedules until it is Accepted as Baseline)	####-###-BS-1	####-###-BS -2	####-###-BS -3
1st Update to Progress Schedule	####-###-1BSU-1	####-###-1BSU-2	####-###-1BSU-3
2nd Update to Progress Schedule, etc	####-###-2BSU-1	####-###-2BSU-2	####-###-2BSU-3
1st Revised Schedule	####-###-1RE-1	####-###-1RE-2	####-###-1RE-3
1st Update to Revised Schedule	####-###-1REU-1	####-###-1REU-2	####-###-1REU-3
2nd Revised Schedule, etc	####-###-2RE-1	####-###-2RE-2	####-###-2RE-3
1st Impact Schedule	####-###-1IS-1	####-###-1IS-2	####-###-1RE-3
2nd Impact Schedule, etc	####-###-2IS-1	####-###-2IS-2	####-###-2IS-3

A.4 Float Suppression / Sequestered Float

The Contractor shall not suppress or sequester float. Examples of prohibited float suppression or sequestration include, but are not limited to:

(1) Logic relationships that provide no tangible or sequential value between unrelated activities.
(2) Logic relationships that demand completion of an activity that could otherwise continue beyond a Successor's start or finish dates.
(3) Excessively long durations.

The Contractor shall obtain the Engineer's approval before using lags or leads. The Contractor shall remove any lags or leads and replace with an activity identifying the lag or lead upon the request of the Engineer, regardless of whether the Department allowed the lag or lead in a previous Progress Schedule.

The Contractor shall not be entitled to compensation or a time extension for delays that could have been avoided by revising activity durations or logic used to sequester float.

A.5 Use of Float

The Contractor acknowledges that all float (including Total Float, Free Float, and Sequestered Float) is a shared commodity available to the Project and is not for the exclusive benefit of any party; float is an expiring resource available to accommodate changes in the Work, however originated, or to mitigate the effect of events that may delay performance or completion of all or part of the Work.

It is understood that identified contingencies, as described in 1803.3.D, "Weather and Duration Contingency." become available Float as time elapses and the contingency is not used.

B Required Schedules

B.1 Preliminary Schedule

Acceptance of the first Preliminary Schedule is a condition of Contract Approval and NTP1. A delay in submitting the Preliminary Schedule is a non-excusable delay under 1806.3.A, "Non-Excusable Delays," and the Contractor is not entitled to an extension of the Contract Time.

All schedules submitted before the Department accepts the Baseline Schedule will be considered Preliminary Schedules until the Preliminary Schedule is accepted as the Baseline Schedule in accordance with 1803.3.B.2, "Baseline Schedule"; the Contractor shall continue to improve upon the Preliminary Schedules and show the status of Work actually completed by incorporating actual start and finish dates and by reasonably estimating the remaining duration for each incomplete activity.

At a minimum, the Contractor shall include the following level of detail in the Preliminary Schedules:

(1) First Preliminary Schedule: show all Milestone dates are understood and provide a detailed schedule for a 30-day look-ahead period.
(2) Subsequent Preliminary Schedules: show all Milestone dates are understood and provide a detailed schedule for a 45-day look-ahead period.
(3) Changes to the First Preliminary Schedule in subsequent submissions shall be closely coordinated with the Engineer and are subject to the Engineer's review and acceptance.

B.2 Baseline Schedule

Baseline Schedule acceptance is a condition of NTP2. The Baseline Schedule shall include the entire scope of work and how the Contractor plans to complete all work contracted. The Engineer may review the resource allocations using historical data, Means Productivity Standards, or equivalents to determine if the Schedule is practicable

The Baseline shall indicate:

(1) Actual Dates of Work performed if the Contractor chooses to perform any Work prior to the Baseline being Accepted.
(2) All Contract Time dates, Milestones, and staging restrictions are understood and scheduled to complete within the Contract Time.
(3) Each Activity shall:
  (3.1) Possess a unique activity description and include a VOL (Verb, Object and Location) for each description.
  (3.2) Be expressed in working days with duration of not more 20, or less than 5 working days, unless otherwise authorized by the Engineer.
  (3.3) Have at least one predecessor activity except for the first activity in the schedule.
  (3.4) Have at least one successor activity except for the last activity in the schedule.
(4) No more than twenty (20) percent Critical Activities, nor more than thirty (30) percent Near-Critical Activities, unless otherwise authorized by the Engineer.
(5) The minimum following level of detail:
  (5.1) Mobilization
  (5.2) Work to be performed by the Contractor, Subcontractors, and suppliers. (5.3) Work to be performed by the Department, other contractors, and third parties such as government agencies and authorities, permitting authorities, or other entities.
  (5.4) The project Milestones (start or finish dates specified in the Contract), project highlights (i.e. traffic switches and phases) availability dates specified in the Contract.
  (5.5) Submittal, review, and acceptance activities when applicable, including time periods for the Department's acceptance as specified in the Contract.

(5.6) Fabrication, delivery, installation, testing, and similar activities for materials, plants, and equipment.
(5.7) Settlement or surcharge periods.
(5.8) Utility notification and relocation.
(5.9) Installation, erection and removal, and similar activities related to temporary systems or structures such as temporary electrical systems or shoring.
(5.10) Installation, erection and removal, and similar activities related to temporary systems or structures such as temporary electrical systems or shoring.
(5.11) Durations for receipt of permits.
(5.12) Substantial Completion
(5.13) Final Completion

B.3 Update Schedule

The Contractor shall update the last accepted schedule to create the Update Schedule. The Contractor shall update the Progress Schedule by incorporating actual start and finish dates and by reasonably estimating the remaining duration for each in complete activity. The Contractor shall minimize the number of changes. The Contractor shall describe the reason for changes to the schedule in the Narrative Report submitted with the Update Schedule. If the changes are significant, then the Contractor shall submit the schedule as a "Revised Schedule."

A significant schedule revision is defined as a revision that results in one of the following:

(1) Alters the Critical Path(s) or Near Critical Path(s).
(2) Extends the scheduled Milestone date(s) compared to the dates shown on the Progress Schedule.
(3) Disrupts the integrity or comparative relationship between the Progress Schedule and the Update Schedule. An example of such a revision would be the renaming of activities or changing activity descriptions.

The requirements for the Update Schedule are otherwise the same as the Baseline Schedule.

B.4 Look-Ahead Schedule

The Contractor shall submit a detailed Two-Week Look-Ahead Schedule to the Engineer each week until all Work is completed. The Contractor shall prepare the schedule in the bar chart format by hand or by using a computer. This schedule shall span a forward-looking, rolling period of at least 14 calendar days. This schedule is intended to represent the Contractor's best effort to fully communicate the Work planned for the rolling 14-day period and shall not contain extraneous information. The Work activities included in the Two-Week Look-Ahead Schedule shall specifically reference the applicable Activity IDs in the Progress Schedule.

The Two-Week Look-Ahead Schedule shall include, at a minimum, the following level of detail:

(1) Bridges:
- (1.1) Test piling
- (1.2) Test holes
- (1.3) Embankment for each abutment location
- (1.4) Fabrication and delivery of piling
- (1.5) Structural Steel fabrication and delivery, per structure
- (1.6) Pile installation, per bent, per structure
- (1.7) Drilled shaft installation, per pier, per structure
- (1.8) Pile caps, per bent, per structure
- (1.9) Footings, per pier, per structure
- (1.10) Columns, per pier, per structure
- (1.11) Caps, per pier, per structure
- (1.12) End bents, per structure
- (1.13) Beam or girder erection, per structure
- (1.14) Diaphragms
- (1.15) Deck placement, per structure
- (1.16) Parapets, per structure
- (1.17) Erection and removal of falsework and shoring

(2) Roadway:
- (2.1) Traffic switches
- (2.2) Submission of job mix formula for asphalt pavement
- (2.3) Delivery schedule for items such as drainage pipe, guardrail, sign structures and signs, permanent lighting facilities, and permanent traffic signals
- (2.4) Internal access and haul roads (location and duration in-place) (2.5) Clearing and grubbing by stationing and roadway
- (2.6) Excavation
- (2.7) Embankment placed for each roadway
- (2.8) Drainage – by run with structures for each roadway

(2.9) Retaining walls per location
(2.10) Subgrade for each roadway
(2.11) Base for roadway
(2.12) Curb, barrier wall and sidewalks for each roadway
(2.13) Pavement (asphalt and/or concrete) for each roadway
(2.14) Bridge approach slabs per location
(2.15) Guardrail for each roadway
(2.16) Slope pavement or riprap
(2.17) Roadway lighting for each roadway
(2.18) Signing for each sign structure location and for each roadway
(2.19) Striping for each roadway
(2.20) Traffic signals per location
(2.21) Topsoil, sodding, seeding and mulching for each roadway
(2.22) Landscaping
(2.23) Finishing roadway and final cleanup

B.5 Revised Schedule

The Contractor shall not perform Work substantially different than depicted on the approved Progress Schedule in accordance with 1803.4, "Prosecution Control" and shall seek an Accepted Revised Schedule to become the new Progress Schedule.

The Contractor shall submit a Revised Schedule upon one of the following:

(1) The Contractor desires to substantially deviate from the current Progress Schedule sequence or durations of planned Work. An example would include but not limited to an altered Critical Path.
(2) Department's Request.
  (2.1) Where the Department requires the Contractor to demonstrate how to recover any scheduled Milestone date(s) that differ from any dates established by the Contract or the Contract Time.
  (2.2) The Department concludes that there is a substantial difference between the actual sequence or actual duration of the Work, and the Work as depicted in the Progress Schedule.
(3) The issuance of a Contract Revision document that changes the planned sequence of Work or the method and manner of its performance.

The requirement to prepare a Revised Schedule is not a directive by the Department to accelerate the Work but rather a directive for the Contractor to seek the Department's Acceptance of a proposal to revise the accepted Progress Schedule, which may or may not include acceleration. The requirements of the Revised Schedule are otherwise the same as the Baseline Schedule.

The requirements of the Revised Schedule are otherwise the same as the Baseline Schedule.

B.6 Impact Schedule

The Contractor shall prepare an Impact Schedule:

(1) To quantify the effects of any contemporaneous or prospective impacts to the Progress Schedule
(2) To establish the need for a time extension to a Milestone
(3) At the Department's request. An example of a reason, is the negotiation of a potential Contract Revision document that changes the planned sequence of Work or the method and manner of its performance

The standard for preparation of the Impact Schedule is specified in 1806, "Determination and Extension of Contract Time," concerning the analysis of delays using a prospective time impact analysis. The requirement to prepare an Impact Schedule is not a directive by the Department to accelerate the Work but rather a directive for the Contractor to provide a proposal to demonstrate the effects of impacts to the accepted Progress Schedule. The requirements of the Revised Schedule are otherwise the same as the Baseline Schedule.

C Schedule Submission Requirements

The Contractor shall include the following with the CPM schedule in its schedule submission:

C.1 Narrative Reports

The Contractor shall include a narrative for each schedule submittal to include and discuss:

(1) Baseline, Revised, or Impact Schedules will include:
  (1.1) Explanation of the overall plan to complete the Project, including where the Work will begin and how Work and crews will flow through the Project.
  (1.2) The working days per week, number of shifts per day, number of hours per shift, the holidays to be observed, and how the schedule accommodates adverse weather days for each month or activity.
  (1.3) A statement describing the status of required permits.
  (1.4) The quantity and estimated production rates for Critical Activities

(1.5) Activities requiring coordination with the Department and/or 3rd parties (i.e. utilities)
(1.6) A statement identifying Constraints and an explanation of the reason for and purpose of each constraint
(1.7) A statement describing the reason for the use of each lag or lead.

(2) Update Schedules will include:
(2.1) A description of the reasons for any changes made to the schedule.
(2.2) A statement describing the status of permits.
(2.3) Status of Activities requiring coordination with The Department and/or 3rd parties (i.e. Utilities)
(2.4) A description of the status of the scheduled Milestone dates. Elaborate on any differences from the previous submission.
(2.5) A statement explaining why the scheduled Milestone dates are forecast to occur before or after the Contract Milestone date.
(2.6) A description of unusual labor, shift, equipment, or material conditions or restrictions encountered or anticipated since the previous Update Schedule.
(2.7) A statement identifying any new Constraints and an explanation of the reason for and purpose of each constraint.
(2.8) A statement describing the reason for the use any new lag or lead.

C.2 Gantt Chart

C.2.a Gantt Chart Names

The Contractor shall include the following Gantt charts with each schedule submission. Each schedule shall be sorted by Early Start. The Engineer may require the contractor to submit a .pdf version as well as hard copy.

(1) "All Activities Chart". All activities with the Longest Path indicated in red.
(2) " Milestone Chart(s)". Each Milestone's Critical Path.
(3) "Near-Critical Chart". All Near-Critical Activities. (4) Any chart requested by the Department.

C.2.b Gantt Chart Information

Each Gantt Chart shall contain the following information:

(1) Activity ID
(2) Activity Description,
(3) Early Start
(4) Late Start
(5) Duration (Working Days)
(6) Late Finish
(7) Total Float
(8) Progress Bar
(8.1) Current Schedule Progress Bar
(8.2) Baseline Progress Bar (The Engineer may require this to be any past accepted schedule)
(9) Title block
(9.1) Data date
(9.2) Run date
(9.3) Gantt Chart name

C.3 Electronic File

Compressed format (.xer files).

C.4 Submission Timeline

It is the Contractor's responsibility to meet with the Engineer as often as necessary to satisfy the Department's comments with timeframe stated in Table 1803-4.

Table 1803-4 CPM Submission Timelines					
Schedule Type	**Section**	**Data Date**	**Submission Due Date**	**Department Review Length**	**Resubmission Due Date**
First Preliminary	1803.3.B.1	Letting Date, or as directed by the Department.	Condition of Contract Approval	7 Calendar Days after Submitted	Condition of Contract Approval
Subsequent Preliminary	1803.3.B.1	No later than the 15th of the month following the last accepted Preliminary Schedule.	4 Business Days after Data Date	7 Calendar Days after Submitted	7 Calendar Days
Baseline*	1803.3.B.2	*See Note	*See Note	*See Note	*See Note
Update	1803.3.B.3	15th of Every Month	4 Business Days after Data Date	7 Business Days after submitted	3 Business Days
Revised	1803.3.B.4	As needed or directed by the Department.	4 Business Days after Data Date	7 Business Days after submitted	7 Calendar Days
Impact	1803.3.B.5	No earlier than last accepted schedule's data date	7 Business Days after Data Date	7 Business Days after submitted	As directed by Department
*The Preliminary Schedule becomes the Baseline after Baseline criteria is met.					

If the Department does not accept the Update Schedule, the Contractor shall correct the comments and resubmit to the Department within timeframe indicated in Table 1803.2.

D. Weather and Duration Contingency

It is the responsibility of the Contractor to estimate a sufficient amount of contingency to account for normal weather. The duration of each activity shall only include the necessary working days to actually complete the work defined by the activity; weather or any other contingency shall not be built into the durations but shall be accounted for within the project calendars.

Each activity shall be assigned an appropriate calendar. The Project calendars shall indicate planned working and nonworking days. Each calendar, with the exception of the calendar used for tracking calendar days, shall include contingent nonworking days. The Contractor shall indicate contingent nonworking days on Monday through Friday only. The Engineer reserves the right to accept or reject the estimated amount of contingency in accordance with "Acceptance of Schedule" section contained herein.

The Schedule shall use a minimum of the following calendars:

(1) Calendar to indicate calendar days (cure time, etc),
(2) Calendar for work that can progress year round, and
(3) Calendar for each major item of Work affected by weather or seasonal limitations. The Contractor shall include a minimum of 15 percent weather contingency.

Contingency will be the numbers of indicated nonworking days compared to a description of the duration (in hours) of the normal working day, as indicated in the narrative, of the work week, e.g., M-F (10 hrs) and Sat (6 hrs) for every calendar.

1803.4 PROSECUTION CONTROL

The Contractor shall commence and prosecute the work with forces and equipment adequate to complete the Controlling Activity(s) of the Progress Schedule within the planned duration. The Contractor shall prosecute the work continuously and diligently from as many different points and in such parts and sequences as will ensure progress in accordance with the Progress Schedule.

The Contractor shall prosecute the Work substantially in the same sequence as the Progress Schedule. The Department will provide written notice to the Contractor when the Department deems Work is being performed substantially out of sequence; any Work the Contractor continues to perform out of sequence will be considered unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work".

The Contractor shall mitigate the effects of any delay to the extent practicable, and demonstrate recovery through submission of a Revised Schedule, in accordance with 1803.2.B.5, "Revised Schedule," or 1803.3.B.5, "Revised Schedule," as appropriate.

1803.5 LIMITATION OF OPERATIONS

The Contractor shall conduct the Work in a manner and sequence that will ensure the least interference with traffic, with due regard given to the location of detours and to the provisions for handling traffic. The Contractor shall not open up Work to the prejudice or detriment of Work already started. The Engineer may require the Contractor to finish a section on which Work is in progress before starting Work on any additional sections if the opening of that section to traffic is essential for public convenience.

The Contractor shall not perform Work during the hours of darkness without the prior approval of the Engineer. When the Engineer authorizes night work the Contractor shall furnish sufficient artificial lighting to permit proper and safe inspection, as well as to ensure quality workmanship equal to that achievable during daylight hours.

The Contractor shall not perform Work on Sundays or legal holidays unless specifically allowed for in the Contract. The Contractor shall suspend construction operations for a period of 24 hours from approximately 6:00 a.m. on each Sunday or legal holiday until 6:00 a.m. on the following day. The Engineer may allow slight changes in these hours, but the Contractor shall comply with the intent of this policy. The Contractor does not have to obtain the Engineer's permission to perform minor operations on Sundays and legal holidays that may be necessary to protect the work or to maintain and protect traffic.

1803.6 TEMPORARY SUSPENSIONS

A Suspension of Work Ordered by the Engineer

The Engineer will issue all suspension-of-work orders in writing specifying the effective start date and end date of the suspension, the operations to be suspended, and the reasons for the suspension. The Contractor may not resume work until so authorized in writing by the Engineer and shall resume work within a reasonable time upon the Engineer's direction. The Engineer will order the resumption of Work upon determining that the conditions that caused the suspension no longer exist.

If the Engineer issues a temporary suspension-of-work order because of any action or inaction by the Department, or because of incomplete Work under other contracts, and if the Contractor has not been advised in the Contract that such a suspension may be necessary, the Contractor shall refer to 1402.4, "Suspensions of Work Ordered by the Engineer," regarding compensation and extension of Contract Time.

If the Engineer issues a temporary suspension-of-work order due to the Contractor's fault or negligence, such suspension is a non-excusable delay as specified in 1806.2.C, "Non-Excusable Delays," and is non-compensable.

B Suspension of Work Requested by the Contractor

The Contractor shall send a written request for the temporary suspension of work to the Engineer. The Contractor's request shall include the proposed effective start and end dates, the operations to be suspended, and the reasons for requesting the suspension. The Contractor shall not suspend all or any part of the Work without the Engineer's written authorization. Suspension of the Work for any cause whatsoever shall not relieve the Contractor of the responsibility for maintenance of traffic, except as otherwise provided in 1404, "Maintenance of Traffic," or by written agreement between the Contractor and the Department.

The Engineer will not authorize the Contractor to temporarily suspend operations until the following conditions are met:

(1) The roads that are being used by traffic and any temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, residences, garages, and farms are in such condition that only routine maintenance will be required to adequately accommodate through and local traffic during the anticipated period of suspension.
(2) The Contractor has performed such work as is necessary to protect all completed or partially completed work during the anticipated suspension period.
(3) The Contractor has placed all traffic control devices as specified in 1710, "Traffic Control Devices."

Should the Contractor fail to perform any of this Work before suspension, the Department reserves the right to have the Work performed by others and to deduct the associated costs from any moneys due or becoming due the Contractor.

1804 FAILURE TO MAINTAIN SATISFACTORY PROGRESS

Should the Contractor fail to maintain satisfactory progress, in accordance with 1803, "Progress Schedules," the Engineer will require that the Contractor provide additional resources (labor, materials, equipment, etc.) as necessary to bring the Work up to the level of progress reflected in the current approved progress schedule. The Department will consider any failure by the Contractor to adhere to the approved progress schedule as a failure to provide sufficient resources to ensure completion of the Work within the Contract Time. The Department may issue a notice of default to the Contractor in accordance with 1808, "Default of Contractor," if the Contractor fails to do either of the following:

(1) Adhere to the current approved progress schedule, or
(2) Take action as ordered to remedy unsatisfactory progress.

1805 METHODS AND EQUIPMENT

The Contractor shall use methods and Equipment capable of performing the Work specified in the Contract. The Contractor shall ensure the Equipment does not damage the Roadway, adjacent property, or other Highways.

When methods and Equipment are specified in the Contract, the Contractor shall request permission from the Engineer, in writing, to use alternate methods and Equipment. The Contractor shall describe the proposed methods and Equipment and the

reasons for the change. The Contractor shall perform the Work in accordance with the original basis of payment and Contract Time.

When methods and Equipment are not specified in the Contract, the Contractor may use any methods and Equipment that complete the Work in accordance with the Contract requirements.

The Contractor shall discontinue performing the Work using alternate methods or Equipment, if the Work does not meet the Contract requirements. The Contractor shall remove and replace or repair unacceptable work at no additional cost to the Department.

1806 DETERMINATION AND EXTENSION OF CONTRACT TIME

1806.1 GENERAL

The Proposal Package will specify the Contract Time. The Contractor shall prosecute the Work continuously and effectively, with the least possible delay, to the end that all Work is completed within the Contract Time.

If the Department issues a Notice to Proceed, the Contract Start Date established in the Notice to Proceed takes precedence over the Contract Start Date specified in the Proposal Package.

The Department will not consider a plea by the Contractor that the Contract Time was not sufficient as a valid reason for an extension of the Contract Time.

If the Department grants an extension of the Contract Time, the extended time for completion will be in full force and effect as though it was originally specified.

The Department will only extend the Contract Time if an excusable delay, as specified in 1806.2.A, "Excusable, Non-Compensable Delays," or 1806.2.B, "Excusable, Compensable Delays," delays Work on the Critical Path as described in items 1, 2, 3, and 4, below.

Mitigation of delay, whether caused by the Department, Contractor, a third-party, or an event, is a shared contract and legal requirement. Mitigation efforts include, but are not limited to, re-sequencing work activities, acceleration, and continuation of work through an otherwise planned shutdown period. The Contractor and Engineer will explore and discuss potential mitigation efforts promptly and agree upon costs or cost-sharing responsibilities prior to the implementation of mitigation efforts.

The Department will not evaluate a request for extension of the Contract Time unless the Contractor notifies the Engineer as specified in 1403, "Notification for Contract Revisions," and provides the required analysis as follows.

The Contractor shall evaluate delays and calculate the appropriate time extension due based on the following:

(1) The Contractor shall base all evaluations of delay and all calculations of the appropriate time extensions due on the schedules submitted to and accepted by the Department. The Contractor shall not use schedules that did not exist on the project or create schedules after the delay has occurred to demonstrate entitlement to a time extension.

(2) The Contractor shall base evaluations and calculations related to the determination of extensions of time on the Critical Path as established by the schedules submitted to and accepted by the Department. The Contractor is not entitled to a time extension for delays that do not delay the Critical Path.

(3) The evaluations and calculations required to establish entitlement to a time extension will vary depending on the nature and timing of the delay and whether the Contract Time is measured in working days, calendar days, or based on a fixed completion date. It will also vary depending on whether the Contract requires a bar chart or CPM schedule.

(4) The schedules relevant to the evaluation and calculation of time extensions are the most current schedules submitted to and accepted by the Department. For example, if the Department determines that Extra Work is required and the Supplemental Agreement adding this work will be dated June 2, then the determination of the time extension due the Contractor will be based on the last schedule submitted and accepted by the Department prior to June 2 of the same year.

(5) The Contractor's evaluations and calculations shall comply with the following Recommended Practices published by the Association for the Advancement of Cost Engineering, International:

(5.1) Recommended Practice No. 52R-06, Time Impact Analysis As Applied in Construction. The Contractor shall use this Recommended Practice for delays that are in the future (prospective). The Contractor shall not use this recommended practice to evaluate delays that have already occurred (retrospective).

(5.2) Recommended Practice No. 29R-03, Forensic Schedule Analysis, MIP 3.4 Observational/ Dynamic/Contemporaneous Split approach. The Contractor shall use MIP 3.4 when evaluating delays that have already occurred.

The Engineer will review the Contractor's evaluations and calculations and determine the time extension due, if any. The Engineer will measure extensions to the Contract Time in working days for Working Day Contracts and in calendar days for Completion Date and Calendar Day Contracts.

The Department will relieve the Contractor from associated liquidated damages, as specified in 1807, "Failure to Complete the Work on Time," if the Department extends the Contract Time under this section (1806).

1806.2 TYPES OF DELAYS

A Excusable, Non-Compensable Delays

Excusable, non-compensable delays are delays that are not the Contractor's or the Department's fault or responsibility, and that could not have been foreseen by the Contractor. The Department will not compensate the Contractor for excusable, non-compensable delays.

Excusable, non-compensable delays include, but are not limited to:

(1) Delays due to fires, floods, tornadoes, lightning strikes, earthquakes, epidemics, or other cataclysmic phenomena of nature.
(2) Delays due to weather if the Contractor is entitled to a time extension for weather as specified in 1806.3, "Determination of Charges on Working Day Contracts," and 1806.4, "Extension of Contract Time Due to Weather on Calendar Day and Completion Date Contracts."
(3) Extraordinary delays in material deliveries the Contractor or its suppliers cannot foresee or avoid resulting from freight embargoes, government acts, or regional material shortages.
(4) Delays due to civil disturbances.
(5) Delays due to acts of the public enemy.
(6) Delays due to labor strikes that are beyond the Contractor's, subcontractor's, or supplier's power to settle and are not caused by improper acts or omissions of the Contractor, subcontractor, or supplier.
(7) Delays due to acts of the government or a political subdivision other than the Department.
(8) All other delays not the Contractor's or Department's fault or responsibility and which could not have been foreseen by the Contractor.

B Excusable, Compensable Delays

Excusable, compensable delays are delays that are not the Contractor's fault or responsibility, and are the Department's fault or responsibility, or are determined by judicial proceeding to be the Department's sole responsibility.

Excusable, compensable, delays include, but are not limited to:

(1) Delays due to revised Work as specified in 1402.2, "Differing Site Conditions," 1402.3, "Significant Changes to the Character of Work," and 1402.5, "Extra Work."
(2) Delays due to utility or railroad interference on the Project Site that are not anticipated as a concurrent move or activity by the Contract.
(3) Delays due to an Engineer-ordered suspension as specified in 1402.4, "Suspensions of Work Ordered by the Engineer."
(4) Delays due to the neglect of the Department or its failure to act in a timely manner.

C Non-Excusable Delays

Non-excusable delays are delays that are the Contractor's fault or responsibility. All non-excusable delays are non-compensable.

Non-excusable delays include, but are not limited to:

(1) Delays due to the Contractor's, subcontractor's, or supplier's insolvency or mismanagement.
(2) Delays due to slow delivery of materials from the supplier or fabricator when the material was available in warehouse stock, or when delivery was delayed for reasons of priority, late ordering, financial considerations, or other causes.
(3) Delays due to the Contractor's failure to provide sufficient forces and equipment to maintain satisfactory progress in completing the Controlling Activities.
(4) Delays caused by plant and equipment failure or delays due to the Contractor's failure to provide and maintain the equipment in good mechanical condition or to provide for immediate emergency repairs.
(5) Delays caused by conditions on the project, including traffic conditions that could be foreseen or anticipated before the date of bid opening. Weather delays are addressed in 1806.3, "Determination of Charges on Working Day Contracts," and 1806.4, "Extension of Contract Time Due to Weather on Calendar Day and Completion Date Contracts."

D Concurrent Delays

Concurrent delays are independent sources of delay that occur at the same time.. When a non-excusable delay is concurrent with an excusable delay, the Contractor is not entitled to an extension of Contract Time for the period the non-excusable

delay is concurrent with the excusable delay. When a non-compensable delay is concurrent with a compensable delay, the Contractor is entitled to an extension of Contract Time, but not entitled to compensation for the period the non-compensable delay is concurrent with the compensable delay.

1806.3 DETERMINATION OF CHARGES ON WORKING DAY CONTRACTS

The Department will determine working day charges as follows:

(1) One whole day for each day of work that the Contractor makes progress or could have made progress during a working day on one or more Critical Activities for at least 6 continuous hours.
(2) One whole day when the Engineer orders a work suspension for reasons of Contractor's fault or negligence.
(3) One whole day for Non-Excusable Delays as specified in 1806.2.C, "Non-Excusable Delays."
(4) One half (1/2) day for each day of work that the Contractor makes progress or could have made progress during a working day on one or more Critical Activities for at least 2 continuous hours.

The Department will not charge a working day:

(1) When the Contractor could not effectively prosecute Critical Activities for at least 2 continuous hours during a working day due to:
  (1.1) Excusable, Non-Compensable Delays as specified in 1806.2.A, "Excusable, Non-Compensable Delays."
  (1.2) Excusable, Compensable Delays as specified in 1806.2.B, "Excusable, Compensable Delays."
  (1.3) Concurrent Delays as specified in 1806.2.D, "Concurrent Delays."
(2) On Saturdays, Sundays, and legal holidays.
(3) During the inclusive period from November 15 through April 15, except as specified in 1806.1, "Determination and Extension of Contract Time, General."
(4) During Suspensions of Work Ordered by the Engineer as specified in 1402.4, "Suspensions of Work Ordered by the Engineer," except for work suspensions ordered by the Engineer for reasons of Contractor's fault or negligence.

The Department will add or subtract working days via Supplemental Agreement to the Contract. The number of working days to be added or subtracted will be determined as specified in 1806.1, "Determination and Extension of Contract Time, General":

(1) For Differing Site Conditions as specified in 1402.2, "Differing Site Conditions."
(2) For Significant Changes in the Character of the Work as specified in 1402.3, "Significant Changes to the Character of Work."
(3) For Extra Work as specified in 1402.5, "Extra Work."

The Engineer will furnish the Contractor a weekly statement showing the working days charged to the project, except during periods when the Engineer determines that working day charges will not be made. The statement will include an accounting of all delays affecting the Critical Path. The Engineer will classify each of these delays as excusable non-compensable, or excusable compensable, or non-excusable, in accordance with 1806.2, "Types of Delays," or weather-related in accordance with 1806.3, "Determination of Charges on Working Day Contracts," and 1806.4, "Extension of Contract Time Due to Weather on Calendar Day and Completion Date Contracts."

The Engineer will commence assessing working day charges on the Contract Starting Date and cease when the Contractor has completed all Work, including maintenance and final cleanup operations. However, assessments will be made for work conducted before the Contract Starting Date when the operations in progress result in traffic restriction. In that case, the work causing the traffic restriction will be considered Critical Path Work and working days will be assessed.

Objections by the Contractor as to an improper or excessive assessment of working day charges shall be in the form of a written protest to the Engineer, within 10 calendar days of receipt of statement, setting forth the specific dates and justifications for reduced charges. If the Engineer finds the Contractor's protest to be valid or if the Department detects an error, the Engineer will issue corrected weekly statements. Once accepted by the Contractor, whether explicitly or as a result of the Contractor's failure to file a timely protest, the weekly statement is final and the Contractor waives entitlement to an extension of Contract Time or compensation for any delays not explicitly identified by the weekly statement. In case of disagreement, the Contractor may request an administrative review of contested charges by the Department's Construction Engineer.

1806.4 EXTENSION OF CONTRACT TIME DUE TO WEATHER ON CALENDAR DAY AND COMPLETION DATE CONTRACTS

The Department will not consider weekends, holidays, or any days between November 15 and April 15, inclusive, as eligible for extensions of Contract Time due to weather unless the Engineer directs the Contractor to work those days, or the Contractor's accepted progress schedule in place at the time the delay occurred indicated that the Contractor intended to perform Critical Path Work on those days.

1807 FAILURE TO COMPLETE THE WORK ON TIME

The Department is entitled to damages for failure of the Contractor to complete the Work within the Contract Time. In view of the difficulty in making a precise determination of actual damages incurred, the Department will assess a daily charge not as a penalty but as liquidated damages to compensate the Department for the additional costs incurred.

In suits involving assessment or recovery of liquidated damages, the reasonableness of daily charges will be presumed and the amount assessed will be in addition to every other remedy enforceable at law, in equity, by statute, or under the Contract.

1807.1 ASSESSMENT OF LIQUIDATED DAMAGES

The Department will deduct from money due the Contractor a daily charge for each calendar day that the Work remains incomplete after the Contract Time expires. The Engineer will assess the daily charge based on the original Contract Amount and Table 1807-1.

Table 1807-1
Schedule of Liquidated Damages

Original Contract Amount		Liquidated damage charge per calendar day, $
From more than, $	To and including, $	
0	25,000	300
25,000	100,000	400
100,000	500,000	900
500,000	1,000,000	1,200
1,000,000	2,000,000	1,500
2,000,000	5,000,000	2,500
5,000,000	10,000,000	3,000
10,000,000	—	3,500

1807.2 WAIVER OF LIQUIDATED DAMAGES

The Department may waive all or any portion of the liquidated damage assessment after the date the Work is substantially completed if the Engineer determines that the Work is in a condition that no longer requires ongoing inspection by the Department.

The Department will not assess liquidated damages during periods of authorized suspension.

The Department does not waive any of its rights under the Contract by allowing the Contractor to continue and finish the Work or any part of the Work after the Contract Time expires. The Department does not waive its rights to recover liquidated damages from the Contractor or its Surety by either:

(1) Taking over the Work, or
(2) Terminating the Contract.

1808 DEFAULT OF CONTRACTOR

The Commissioner, after giving due notice to the Contractor and its Sureties, will have full power and authority to take the prosecution of the Work out of the hands of the Contractor without violating the terms of the Contract if the Contractor commits any of the following events of default:

(1) Fails to start the Work by the Contract starting date and any intermediate starting date, as required in 1806, "Determination and Extension of Contact Time,"
(2) Fails to perform the Work with sufficient workers and equipment or with sufficient Materials to ensure prompt completion of the Work as required in 1804, "Failure to Maintain Satisfactory Progress,"
(3) Fails to perform the Work satisfactorily as required by 1512, "Unacceptable and Unauthorized Work,"
(4) Suspends the prosecution of Work without permission of the Engineer as required in 1803.6, "Temporary Suspensions,"
(5) Neglects or refuses to remove Materials or reconstruct Work rejected as defective or unacceptable as required in 1512, "Unacceptable and Unauthorized Work,"
(6) Fails to resume suspended Work within a reasonable time after notice to do so, as required by 1803.6, "Temporary Suspensions,"
(7) Becomes insolvent, is declared bankrupt, or is the subject of a voluntary or involuntary bankruptcy petition,
(8) Makes an assignment for the benefit of creditors,
(9) Fails to comply with the Labor Provisions required by the Contract, or
(10) Fails to carry on the Work in an acceptable manner for any other cause whatsoever.
(11) Repeatedly fails to make payment in accordance with the Contract to subcontractors or suppliers for labor or materials.

The Engineer will give the Contractor and Sureties written notice of any default, and will identify the facts of the events of default together with a demand that the Contractor correct such events of default to the satisfaction of the Engineer. If within a

period of 10 business days after such notice the Contractor and Sureties fail to correct the identified events of default, the Commissioner will exercise any lawful authority and take any lawful action with respect to such default and with respect to securing performance of the Work.

The Contractor and Department acknowledge the following:

(1) A notice of default is duly served when it is delivered in person or by registered mail to the Contractor and Sureties or to their authorized representatives, including persons in charge of their offices; and
(2) The service of the notice is complete and sufficient when a properly addressed and stamped envelope containing the notice is registered and deposited in any post office or U.S. letter box in the State.

The Commissioner's authority to take the prosecution of the Work out of the hands of the Contractor shall include the right to appropriate or use any or all Materials and equipment on the ground as may be suitable and acceptable, and to enter into an agreement with others for completion of the Work according to the terms and provisions of the Contract, or to use such other methods as may be required to complete the Work in an acceptable manner.

The Department will deduct all costs and charges incurred by the Department, together with the cost of completing the Work under Contract, from any moneys due the Contractor or that would have become due the Contractor under the Contract if the Contractor had completed the Work. If the cost and charges incurred by the Department exceed the amount that would have been payable under the Contract, the Contractor and the Sureties shall be liable for the excess.

If a default of the Contractor is later determined to be without cause, the default of the Contractor will revert to a termination of the Contract in the best public interest as allowed in 1809, "Termination of Contract."

1809 TERMINATION OF CONTRACT

The Department may issue a written termination of the Contract or any portion thereof for any of the following reasons beyond the Contractor's control:

(1) If the Department determines that the Contractor is prevented from proceeding with or completing the Work within a reasonable period of time because of, but not limited to, the following:
  (1.1) Labor or material shortage;
  (1.2) Limitations imposed by law, rule, regulation, or order of the local, State, or Federal government; or
  (1.3) Actions of the public enemy, including those related to priorities and third-party actions.
(2) If the Department determines it is in the best public, State, Department, or national interest, because of, but not limited to, the following:
  (2.1) Lack of funding or a funding reallocation that prevents the completion of the Work as planned,
  (2.2) Discovery of significant hazardous material problems,
  (2.3) Right Of Way acquisition problems, or
  (2.4) Utility conflicts that would cause substantial delays or expense to the Contract.

If the Department issues a termination of the Contract or portion thereof, the Department relieves the Contractor of its obligation to perform such portions of the Contract. The Department does not relieve the Contractor of its responsibilities for the Work completed before the termination, or the Contractor's Surety of its responsibilities for any just claims arising out of the performance of the Work before the termination.

The Department may direct the Contractor to complete certain elements of the Work before termination of the Contract. The Department will compensate the Contractor for completed and partially completed quantities of eliminated Contract Items in accordance with 1904, "Compensation for Contract Revisions," and 1905, "Compensation for Eliminated Items."

Measurement and Payment

1901 MEASUREMENT OF QUANTITIES

Unless otherwise specified, the Engineer will measure in accordance with this section.

The Engineer will determine quantities of acceptable Work using one of the following methods:

(1) Plan dimensions — for Contract Items or portions of Contract Items designated as "P" in the Statement of Estimated Quantities on the Plans, the Department will use the Plan quantities for payment;
(2) Field measurement — for Contract Items with no "P" designation shown on the Plans, the Engineer will field measure quantities of Work performed; or
(3) A combination of Plan dimensions and field measurements.

The Engineer may adjust quantities for portions of the Work or the entire Project. The Engineer will not adjust quantities if a difference results from use of commonly accepted dimensional approximations.

The Engineer will determine quantities using the US customary system of weights and measures or the metric system. The units and the methods of measurement in the Contract for each class of work will supplement or modify the provisions in this section by the following:

(1) Imposing measurement limitations;
(2) Describing measurements or computation procedures;
(3) Establishing conversion factors or adjustment conditions; and
(4) Providing for the determination of accurate and representative pay quantities.

Item names for pay quantities may include designated terms to indicate the basis for unit measurements, such as where or when the Engineer will take the unit measurements or make computations. Unless otherwise required by the Contract, the Engineer will make measurements and computations as specified in this section.

The Contractor may dispute the Engineer's determination of pay quantities by submitting a written request to the Engineer. The Contractor shall state the Contract Item and sections of the Project disputed and provide details to justify the Engineer's review of the pay quantity. The request must be consistent with conditions governing the Contract Item. The Engineer will not review quantities unless the Contractor provides evidence substantiating that the quantity is incorrect.

1901.1 "P" QUANTITIES

If the Department places a "P" designation on individual Contract Items or specific portions of Contract Items in the Statement of Estimated Quantities on the Plans, the Department will use the Plan dimensions to calculate the pay quantity for that Contract Item. The Department will limit use of the "P" designated quantities to Contract Items with specified dimensions and controlled by field checks during, or after construction.

The purpose of the Department's use of "P" designated quantities is to avoid the expense of measuring dimensions, if original Plan dimensions remain valid. The Engineer will determine the quantities of Contract Items that do not have a "P" designation, using the methods of measurement required by the Contract, unless otherwise agreed in writing. The Engineer will use Plan dimensions as applicable for completed Work. The Engineer will only use field dimensions if required by the Contract or as necessary to accurately dimension completed Work.

The Engineer will adjust a "P" designated quantity if the Engineer revises the dimensions of the Work or decides the "P" designated quantity is incorrect. The Engineer will only adjust quantities for the revised or corrected portions of the "P" designated Contract Item.

1901.2 AREAS

For longitudinal measurements, the Engineer will measure horizontally for computing an area and will not make deductions for Structures with an area no greater than 1 sq yd [1 sq. m]. For transverse measurements, the Engineer will use the neat line dimensions shown in the Plans or ordered by the Engineer.

1901.3 STRUCTURES

The Engineer will measure Structures using the neat line dimensions shown on the Plans, or the dimensions as altered to fit field conditions.

1901.4 LENGTH

The Engineer will measure Contract Items requiring a linear unit of measure, such as pipe culverts, guardrail, and underdrains, parallel to the base or foundation on which the Structure is placed.

1901.5 VOLUME

A Excavated Volume (EV) — Cubic Yard [Cubic Meter]

The Engineer will determine the cubic yards [cubic meters] of Excavated Volume (EV) using the cross-section method or digital surface model method to measure the material in its original position.

B Compacted Volume (CV) — Cubic Yard [Cubic Meter]

The Engineer will determine the cubic yards [cubic meters] of Compacted Volume (CV) using the cross-section method or digital surface model method to measure the compacted material in its final position, in accordance with the placement dimensions required by the Contract or directed by the Engineer.

C Loose Volume in Vehicular Measure — Cubic Yard [Cubic Meter]

The Engineer will determine the cubic yards [cubic meters] of Loose Volume (LV) using the vehicular measure method. The Contractor shall haul material in Engineer-approved vehicles as specified by 1513, "Restrictions on Movement and Storage of Heavy Loads and Equipment." The Engineer will measure the material at the point of delivery to the nearest 0.13 cu yd [0.1 cu m]. The Contractor may use vehicles for hauling material to the Project of any size or type approved by the Engineer if the Engineer can easily determine the vehicle body capacity and view the contents. The Engineer will determine the struck capacity for each vehicle. The Contractor shall mark the struck or level perimeter line on the inside of the box of each vehicle.

The Contractor shall load the vehicle and level the load as directed by the Engineer. The Contractor shall provide over-allowance for settlement of the load during transit. The Engineer may direct the Contractor to level any load upon its arrival at the point of delivery. The Engineer will not measure material heaped above the struck capacity of the vehicle. The Engineer will make deductions in 0.65 cu. yd [0.5 cu. m] increments on loads that contain less than the struck capacity. The Contractor shall provide hauling vehicles with a conspicuous, legible identification mark that is acceptable to the Engineer.

D Stockpiled Volume (SV) — Cubic Yard [Cubic Meter]

The Engineer will determine the cubic yards [cubic meters] of Stockpiled Volume (SV) using the cross section method or the digital surface model method to measure material in the stockpiled position. The Contractor shall shape the stockpile to a condition directed by the Engineer before measurement.

1901.6 (BLANK)

1901.7 (BLANK)

1901.8 MASS

For measuring or proportioning Material by mass, the Contractor shall provide certified weights or weigh Material on calibrated, approved scales. The Department will not allow the use of front-end loader scales. The Contractor shall give the Engineer a copy of the inspection certificate.

The Contractor shall provide an automated weighing device for Materials hauled in trucks and paid for by mass.

A Certified Weights

If the Contractor includes a Department-approved delivery ticket form, certified by the weigh master, or if the Contractor delivers the Material in original containers marked with the certified weight, the Contractor may provide certified weights as an alternative to weighing the Material in the presence of the Engineer. The Contractor shall not unseal Material delivered in sealed containers until the Engineer approves. If the Engineer suspects a loss of Material, the Engineer will require the Contractor to reweigh the Material.

B (Blank)

C Scale Testing and Calibration

The Contractor shall ensure an authorized person tests and calibrates scales before use on the Project. The Contractor shall provide test weights, accessories, and assistance required for testing and calibrating the scales. The Contractor shall test and calibrate the scales in accordance with the frequency, criteria, tolerances, and sensitivity requirements in this section.

C.1 Authorized Person

An authorized person, as defined by one of the following descriptions, shall test and calibrate the scales:

(1) A scale service person with a valid placing-in-service registration issued by the Minnesota Department of Commerce, or
(2) The Contractor, with approval of the Engineer and under the supervision of the Engineer.

C.2 Frequency

The Contractor shall test and calibrate the scales in accordance with the following:

(1) Inspect, test, and calibrate the scales each year before use on the Project,

(2) Spot check scales for accuracy and sensitivity at the discretion of the Engineer as Work progresses,
(3) Check the vehicle tare and gross mass at a frequency directed by the Engineer for Materials weighed in the hauling vehicle,
(4) Test and calibrate scales at three-month intervals for the duration of the Project, unless otherwise approved by the Engineer, and
(5) Test and calibrate scales as specified by these Standard Specifications.

C.3 Testing and Calibration Criteria

The authorized person shall test and calibrate the scales with calibrated test weights. The Contractor shall provide calibrated test weights certified by the Minnesota Department of Commerce within the preceding 12 months, unless otherwise allowed by the Engineer. The authorized person may weigh the supplemental mass of Material or Equipment on the scales after initial calibration and use to supplement the calibrated test weights.

The Contractor shall verify commercial scales have current approval from the Minnesota Department of Commerce before the Engineer will allow use on the Project.

C.3.a Testing and Calibration by Registered Scale Service Person

If a registered scale service person performs testing and calibrating, the service person shall test scales up to the maximum expected load weighed on the Project. The Contractor shall provide evidence to the Engineer that scales meet the Contract requirements.

C.3.a(1) Truck Scales

The registered scale service person shall use at least 22,050 lb [10,000 kg] of calibrated test weights along with the supplemental mass.

C.3.a(2) Batch Scales

The registered scale service person shall use at least 1,100 lb [500 kg] of calibrated test weights along with the supplemental mass.

C.3.b. Testing and Calibration by the Contractor

If the Contractor tests and calibrates the scales, the Contractor shall perform a comparison test. The Contractor shall perform the comparison test at the minimum and maximum expected loads weighed during the Project.

C.3.b(1) Truck Scales

The Contractor shall weigh an empty truck and a loaded truck of the size and capacity the Contractor will use on the Project on an approved commercial scale, then, weigh the same empty truck and loaded truck on the scale the Contractor will use on the Project.

C.3.b(2) Batch Scales

The Contractor shall make calibrated test weights available at each scale installation, at all times to provide a total test mass of 30 percent of the net load the Contractor will weigh not exceeding 1,100 lb [500 kg] of test weights. The Engineer may allow the Contractor to weigh a load, or series of loads, in a hopper then drop the load into a truck that has been weighed on an approved commercial scale. The Contractor shall weigh the loaded truck on the same approved scale.

C.4 Scale Tolerance

C.4.a Calibration with Calibrated Test Weights

The Contractor shall use scales with scale indications within 1 percent of the value of the calibrated and supplemental test weights applied to the scale.

C.4.b Calibration with an Approved Commercial Scale

Indicated loads on the calibrated scale shall agree within 1 percent with the indicated loads on the approved commercial scale.

C.5 Scale Sensitivity

C.5.a Weighbeam Indicators

The scale indicator, at the normal minimum and maximum loads, shall sense a change in load equal to 0.2 percent of the load on the scale.

C.5.b Dial or Digital Indicators

A sensitivity test is not applicable, but the dial or digital indicator shall respond uniformly and smoothly to changes in loads on the scale.

D Automated Weighing Device

If the Department pays for Materials, hauled in trucks, by mass, the Contractor shall provide scales integrated with a ticket printer. Tickets shall include the date, Project number, Contract Item number, truck or tractor and trailer identification, truck tare, and net mass. The truck driver shall give the ticket to the Inspector on the Project.

1901.9 BITUMINOUS MATERIALS

The Engineer will measure bituminous Materials by the gallon [liter] or ton [metric ton], and make corrections for loss, waste, foaming, and quantities not incorporated in the Work. The Engineer will make volumetric measurements of bituminous Materials at 60 °F [15.6 °C] or will correct the amount based on a volume at 60 °F [15.6 °C], using the Bituminous Manual.

The Engineer will determine the volumetric content of transport and storage tanks using the tank manufacturer's calibrated measuring devices and outage tables, based on the computed or certified tank capacity, or the Engineer will compute the content from the density factors derived from tests.

1901.10 (BLANK)

1901.11 OTHER BASIS OF MEASUREMENT

If the Contractor and Engineer mutually agree in writing, the Engineer may measure Materials in units other than the units of measure specified as the basis of payment. The Engineer will convert the measured quantities to the unit of measure specified in the method of measurement section. The Engineer will establish the factors for conversion from one unit of measurement to another as mutually agreed.

1901.12 (BLANK)

1901.13 TIMBER AND LUMBER

The Engineer will measure timber and lumber by at least one of the following:

(1) Each,
(2) Lump sum,
(3) Area in square feet [square meters], or
(4) Volume in cubic yards [cubic meters] in the structure based on the nominal width, thickness, and the extreme length of each piece in the finished Structure.

1901.14 LUMP SUM

If used as a unit of measure, the term "lump sum" shall mean complete payment for the Contract Item as described in the Contract.

1901.15 INDIVIDUAL UNIT OR EACH

If a complete Structure, Contract Item, or lump sum unit is specified as the unit of measure, the Engineer will measure the unit based on physical count and will include fittings and accessories.

1901.16 RENTAL EQUIPMENT

The Engineer will measure rental Equipment based on time in hours of actual working time and traveling time of the Equipment within the Project.

1901.17 STANDARDS AND TOLERANCES ..... 1503 & 1603

If the Contract specifies standard manufactured items, such as fencing, wire, plates, rolled shapes, pipe conduit, unit mass and section dimensions, the Engineer will consider the identification of these items as nominal.

1902 SCOPE OF PAYMENT

The Contractor shall receive compensation provided for in the Contract as full payment for providing Materials and performing Work in accordance with the Contract requirements. This includes compensation for all risk, loss, damage, and expense incurred by the Contractor for performing the Work required by the Contract subject to 1720, "No Waiver of Legal Rights."

1903 COMPENSATION FOR ALTERED QUANTITIES

If the Department pays for the Work of a Contract Item on an actual quantity basis and the accepted quantities of Work vary from the quantities in the Contract but do not meet the requirements established for significant changes in 1402.3, "Significant Changes to the Character of Work," the Department will pay for the work of the Contract Item as follows:

(1) The Department's payment based on the Contract Unit Prices is payment in full for the quantities of work performed by the Contractor and accepted by the Engineer.
(2) The Department will not pay for increased expenses, loss of expected reimbursement, or loss of anticipated profits or overhead suffered or claimed by the Contractor due to differences between the actual quantities of Work and the quantities in the Contract.

(3) The Department will not pay for loss of expected reimbursements from unbalanced allocation of costs among the Contract Items due to differences between the actual quantities of Work and the quantities in the Contract.

1904 COMPENSATION FOR CONTRACT REVISIONS

1904.1 GENERAL

If the Department revises the Contract as provided in 1402, "Contract Revisions," the Department will compensate the Contractor for the Contract revision following the sequence specified in 1904.2 through 1904.4. Such compensation for the Contract revision constitutes final and full compensation for performing the revised Work, delay costs, and all other costs not expressly precluded by 1904.5, "Non-Allowable Charges." The Engineer will determine the pricing method following the sequence specified in 1904.2 through 1904.4 before directing the Contractor to perform the Work in the Contract revision.

If the Contract revision includes a time extension for compensable delays as provided by 1806, "Determination and Extension of Contract Time," the Department will compensate the Contractor for the costs associated with the time extension in accordance with 1904.6, "Compensation for Delay."

1904.2 CONTRACT UNIT PRICES

Before proceeding to another pricing method, the Engineer will attempt to price and pay for the Contract revision using Contract Unit Prices.

1904.3 NEGOTIATED PRICES

If the Engineer and Contractor are unable to agree on compensation in accordance with 1904.2, "Contract Unit Prices," they will attempt to negotiate unit or lump sum prices using one or more of the following methods:

(1) Original Contract Unit Prices for similar Contract Items adjusted for increased or decreased Material costs;
(2) State-wide average unit prices awarded for the Contract Item(s) as listed in the Department's annual "Summary of Contracts Awarded;"
(3) The average of unit prices awarded on three different projects of similar work and quantity;
(4) Unit prices computed by the Office of Estimating; or
(5) Cost analysis of labor, material, equipment, and mark ups as allowed in 1904.4, "Force Account."

The Department will not compensate by a negotiated price for Contract Revision work performed by a subcontractor that includes a Contractor mark-up that exceeds that provided for in 1904.4.H, "Contractor Mark-Up."

Within 5 business days of the Department's request, the Contractor shall submit a written proposal that includes pricing, cost justification, and a schedule for the Contract revision. The Department will respond within 5 business days after receipt of the Contractor's submittal. The Department and the Contractor can mutually agree to extend these 5-business-day time limits.

1904.4 FORCE ACCOUNT

If the Engineer and Contractor are unable to negotiate a price for the Contract revision in accordance with 1904.3, "Negotiated Prices," the Engineer may direct the Contractor to perform all or part of the revised Work on a force account basis. When the Engineer directs the Contractor to perform revised Work on a force account basis, the Department will pay the Contractor as specified in 1904.4.A through 1904.4.J.

A Labor

The Department will compensate the Contractor for labor at the actual rate of wage paid and shown on the payroll for every hour that the labor and foreman are actually engaged in the revised Work. The foreman must be in direct charge of the specific operations and must be at the Project Site in order to be included in this compensation. Unless already included in the wage rates paid, the Contractor will also receive the actual labor-related costs incurred by reason of subsistence and travel allowances, health and welfare benefits, pension fund, or other fringe benefits, provided those payments are required by collective bargaining agreement or other employment contract generally applicable to the classes of labor employed on the Work.

The Department will prorate the wages of any foreman who is employed partly on the revised Work and partly on other Work. The Department will determine the prorated wage based on the number of workers employed on each class of Work as shown by the payrolls. The Department will prorate any subsistence or travel allowances paid to the foreman on the same basis as the prorated direct wages.

The Department will pay the Contractor an amount equal to 62 percent of the actual taxable rate of wage as full compensation for overhead, profit, additional bond, property damage and liability insurance premiums, workers' compensation insurance premiums, unemployment insurance contributions, employer Social Security taxes, and other indirect labor force costs. This compensation is based on a Workers' Compensation insurance premium of $21.00 per $100.00 of payroll. If the revised Work involves labor in a classification with a higher premium rate, the Contractor may submit a written request in accordance with 1403, "Notification for Contract Revisions," for the additional premium amount. The request shall include:

(1) A certified copy of the Contractor's latest Workers' Compensation Final Insurance Audit, and

(2) A certification from the insurance carrier, listing the Workers' Compensation classification code numbers and the premium rates that are being paid in the current year.

B Materials

The Department will pay the Contractor the actual cost of acceptable Materials delivered and used in the revised Work, including transportation charges paid by the Contractor (exclusive of equipment rentals), plus an additional 15 percent for field and home office overhead costs and profit.

C Equipment

The Department will pay the Contractor for Equipment at the rental rates established by the Commissioner's Equipment Rental Schedule available on the Department's website and effective on the date the two parties execute the force account agreement (Supplemental Agreement or Work Order). This compensation is for Equipment, fuel, and lubricants that the Engineer authorizes and the Contractor uses on the Project. The Department will not pay for small tools. The Department will pay for the actual time the Equipment is in operation on the revised Work, plus travel time or transportation allowances. The Department will not pay for any additional Equipment costs except as provided under 1904.4.D, "Miscellaneous Compensation."

If the Equipment is moved to and from the location of the revised Work under its own power, the Department will pay for the travel time at the above rental rates. If the Equipment is moved to and from the location of the revised Work by means other than its own power, the Department will pay for the actual operating time during periods of loading and unloading at the above rental rates and will pay for the actual transportation costs.

D Miscellaneous Compensation

If the Engineer directs the Contractor to perform the revised Work on the right of way of a railroad, in addition to the compensation for labor, Materials, and Equipment, the Department will pay the Contractor for actual costs related to satisfying the requirements of 1708, "Railroad-Highway Provisions." The Department will only pay for these costs to the extent that there is no duplication or overlapping of charges provided under 1904.4.A, "Labor," 1904.4.B, "Materials," and 1904.4.C, "Equipment," or by any existing contract items.

The Department will pay the Contractor for the actual cost of miscellaneous fees plus five percent incurred in performing the revised Work, including but not limited to dump fees, permits, and licenses.

The Department will not pay the Contractor for other miscellaneous costs that the Contract does not provide for specifically.

E Daily Records

The Engineer and Contractor will document the labor, Materials, and Equipment used in performing the revised Work on a *Daily Force Account Record* (Form 2137). At the end of each workday, the Engineer and Contractor will compare and sign the *Daily Force Account Record*. *Daily Force Account Records* signed by both the Department and Contractor will govern over other Department and Contractor records.

In the event the Contractor declines to sign the *Daily Force Account Record,* the Department's records shall govern.

F. Payments

The Department will not pay for the revised Work until the Engineer has accepted the revised Work and the Contractor has submitted to the Engineer itemized statements of the cost, including the following:

(1) Name, classification, date, daily hours, total hours, rate, and extension for each laborer and foreman.
(2) Designation, dates, daily hours, total hours, rental rate, and extension for each unit of Equipment.
(3) Quantities of acceptable Materials, prices, and extensions.
(4) Transportation costs of Materials and Equipment.
(5) Invoices for Materials used and for transportation charges. If the Contractor uses Materials on the revised Work that the Contractor did not specifically purchase for the Work but were taken from the Contractor's stock, the Contractor shall submit an affidavit certifying that such Materials were taken from the Contractor's stock, that the quantity was actually used, and that the price and transportation costs represent the actual costs to the Contractor.

G Specialty Contract Work

If the Contractor uses specialty contracting firms to perform the revised Work, the Department will pay the Contractor by reasonable invoice at the discretion of the Engineer. "Specialty work" is unique work that cannot be performed by the Contractor, its subcontractors, or other contracting firms that generally perform work on highway construction projects.

The provisions of 1904.4.A through 1904.4.F shall not apply to payments made by reasonable invoice. All firms or contractors paid under these provisions and working on the Project are subject to all Labor Provisions required by the Contract.

The Contractor shall provide the Engineer with a cost estimate of the specialty Work or service and obtain the Engineer's approval before performing the specialty Work or service. As a minimum, the cost estimate shall include a complete description of

types of Equipment to be used, the number and job classifications of employees who will perform the specialty Work, and all Material costs.

H Contractor Mark-Up

For any force account work performed by a subcontractor (including work performed by a specialty contractor), the Department will pay the Contractor one additional mark-up on revised Work performed by a subcontractor to cover administration, general superintendence, overhead, profit, and expenses not otherwise recoverable. The additional mark-up will be a percentage of the total force account invoice for the subcontractor's portion of the revised Work equal to 10 percent of the first $50,000.00 plus 2 percent of the balance in excess of $50,000.00.

I Acceleration

The Engineer may order the Contractor to accelerate the Work to avoid delay costs or to complete the Project early. The Department will pay for accelerations in accordance with this section (1904).

J Inefficiency

The Department will compensate the Contractor for inefficiency or loss of productivity resulting from 1402, "Contract Revisions." Use the Measured Mile analysis, or other reliable methods, comparing the productivity of work impacted by a change to the productivity of similar work performed under unimpacted (unchanged) conditions to quantify the inefficiency. The Department will pay for inefficiencies in accordance with this section (1904).

1904.5 NON-ALLOWABLE CHARGES

The Department will not pay the Contractor for the following, regardless of the method of payment for the revised Work:

(1) Loss of anticipated profits;
(2) Consequential damages, including loss of bonding capacity, loss of bidding opportunities, and insolvency;
(3) Indirect costs;
(4) Attorney's fees, claims preparation expenses, or costs of litigation.

Per 1402.4, "Suspensions of Work Ordered by the Engineer," the Department will not pay the Contractor for profit on suspensions or delays ordered by the Engineer. The Department will remove profit from the mark-ups in 1904.4.A, "Labor,"1904.4.B, "Materials," and 1904.4.H, "Contractor Mark-Up," by reducing the mark-up percentages as follows:

(1) Labor: from 62 percent to 57 percent;
(2) Materials: from 15 percent to 10 percent; and
(3) Contractor mark-up: from 10 percent for the first $50,000.00 to 5 percent for the first $50,000.00.

1904.6 COMPENSATION FOR DELAY

A General

For compensable delays as identified in 1806, "Determination and Extension of Contract Time," the Department will pay for the costs specified in 1904.6.B, "Allowable Delay Costs." The Department will not pay for non-allowable charges specified in 1904.5, "Non-Allowable Charges," or duplicate payment made under 1904.2 through 1904.4.

The Department will not pay for delay costs before the Contractor submits an itemized statement of those costs. The Contractor shall include the following content for the applicable items in the statement.

B Allowable Delay Costs

1 Extended Field Overhead

The Department will pay the Contractor for extended field overhead costs that include costs for general field supervision, field office facilities and supplies, and for maintenance of field operations.

General field supervision labor costs include, but are not limited to, field supervisors, assistants, watchman, clerical, and other field support staff. The Contractor shall calculate these labor costs as specified in 1904.4.A, "Labor." For salaried personnel, the Contractor shall calculate the daily wage rate actually paid by dividing the weekly salary by 5 days per week.

Field office facility and supply costs include, but are not limited to, field office trailers, tool trailers, office equipment rental, temporary toilets, and other incidental facilities and supplies. The Contractor shall calculate these costs to provide these services on a calendar-day basis using actual costs incurred due to the delay.

Maintenance of field operations costs include, but are not limited to, telephone, electric, water, and other similar expenses. The Contractor shall calculate these costs to maintain these services on a calendar-day basis using actual costs incurred due to the delay.

2 Idle Labor

The Contractor shall calculate labor costs during delays as specified in 1904.4.A, "Labor," for all non-salaried personnel remaining on the Project as required under collective bargaining agreements or for other Engineer-approved reasons.

3 Escalated Labor

To receive payment for escalated labor, the Contractor shall demonstrate that the Department-caused delay forced the work to be performed during a period when labor costs were higher than planned at the time of bid. The Contractor shall provide adequate support documentation for labor costs, allowances, and benefits.

4 Idle Equipment or Equipment Mobilization and Demobilization

The Department will pay the Contractor for equipment, other than small tools, that must remain on the Project during Department-caused delays at the idle Equipment rate calculated in 1904.4.C, "Equipment." The Department will pay the Contractor's transportation costs to remove and return Equipment not required on the Project during Department-caused delays.

5 Materials Escalation or Material Storage

The Department will pay the Contractor for increased Material costs or Material storage costs due to the Department-caused delay. The Contractor shall obtain the Engineer's approval before storing Material due to a delay.

6 Extended or Unabsorbed Home Office Overhead

The Department will pay the Contractor for unabsorbed or extended home office overhead costs in accordance with the Federal Acquisition Regulations, specifically 48 C.F.R. § 31. The Department will audit all extended or unabsorbed home office overhead claims in accordance with 1721, "Audits." The Department will compensate the Contractor using the standard Eichleay formula.

To recover home office overhead, the Contractor's claim shall prove:

(1) the delay was caused by the Owner suspending the entire project, in accordance with 1402.4, "Suspensions of the Work Ordered by the Engineer".
(2) the Owner required the Contractor to standby during the suspension period;
(3) it was impractical for the Contractor to obtain replacement work during the suspension period;
(4) the suspension caused the contractor to be unable to complete the contract within the original contract performance period, as extended by any modifications; and
(5) the Contractor suffered actual damages as a result of the delay caused by the suspension.

The Department will consider Subcontractors eligible for separate extended or unabsorbed home office overhead using the standard Eichleay formula, if the Subcontract does not contain language disallowing such claim compensation.

To recover home office overhead, the Subcontractor's claim shall prove:

(1) the delay was caused by the Owner suspending the entire project, in accordance with 1402.4, "Suspensions of the Work Ordered by the Engineer"; and
(2) the Subcontractor was on the project site directly before and directly after the suspension; and
(3) the Owner required the Subcontractor to standby during the suspension; and
(4) it was impractical for the Subcontractor to obtain replacement work during the suspension period; and
(5) the Subcontractor suffered actual damages as a result of the delay or caused by the suspension; and either
(6) the delay caused the Subcontractor to be unable to complete the subcontract within the original subcontract performance period, as extended by any modifications.

The Department will not allow compensation for home office overhead for the Contractor or Subcontractor if:

(1) it was not impractical to obtain replacement work during the suspension period;
(2) the inability to obtain other work was not caused by the suspension; or
(3) the Contractor or Subcontractor was able to reduce fixed overhead expenses during the period of delay or suspension.

1905 COMPENSATION FOR ELIMINATED ITEMS

The Department will compensate the Contractor for eliminated items in accordance with the following:

(1) For completed quantities of eliminated Contract Items, the Department will compensate the Contractor for the accepted quantities at the Contract Unit Price.
(2) For materials that the Contractor has ordered but not incorporated in the Work, the Department will compensate the Contractor in accordance with 1907, "Payment for Surplus Material."
(3) For partially completed quantities of eliminated Contract Items, the Department will compensate the Contractor for that portion of the quantity of the work the Contractor has performed on the eliminated Contract Item on the basis of a percentage of the Contract Unit Price equal to the percentage of work performed toward completion of that quantity of the Contract Item. To calculate this percentage, the Engineer will consider the value of materials incorporated in the partially completed quantity of the eliminated Contract Items to be the invoice cost of the materials plus transportation costs. The Engineer will add a 15 percent mark-up to the sum of the invoice and transportation costs.

(4) For the cost of equipment, mobilization, and overhead that the Engineer considers directly attributable to the eliminated Contract Items and that the Department has not compensated the Contractor for through provisions (1), (2), and (3) of this list, the Department will compensate the Contractor in accordance with 1904, "Compensation for Contract Revisions."

The Department will not compensate the Contractor for loss of anticipated profits on completely or partially eliminated Work. The Department's compensation to the Contractor for completed or partially completed quantities of Work on eliminated Contract Items in accordance with 1905 constitutes final and full compensation for the Work the Contractor has performed on eliminated or partially eliminated Contract Items.

The Contractor shall allow the Department access, in accordance with 1721, "Audits," to the Contractor's cost records and other data relating to the Contract as needed by the Department to determine compensation for eliminated Work.

1906 PARTIAL PAYMENTS

1906.1 GENERAL

At least once a month at regular intervals, the Engineer will prepare an estimate of the value of the Work completed to date. Each estimate will show the documented quantity of Work completed or substantially completed under each Contract Item.

The Department will make partial payments once per month based on the amount of Work performed, unless the Engineer authorizes semi-monthly partial payments.

The Department reserves the right to withhold partial payments under this Contract if the Contractor fails to provide documents as required by any other contract with the Department that prevent the Department from making the Final Estimate or executing the Certificate of Final Acceptance for the other contract.

The Department reserves the right to deduct, from any payment due to the Contractor, such amount to protect the Department's interests in consideration of charges or assessments against the Contractor, whether arising from this Contract or any other contract with the Department. The Department may withhold payment of such amount until the Contractor pays or satisfies the charges or assessments.

The Department's payment of partial estimates does not relieve the Contractor from the sole responsibility for all Materials and Work for which payments have been made or for the restoration of any damaged Work. The payments are not a waiver by the Department of any provision of the Contract or of the Department's rights to require the Contractor to fulfill all terms of the Contract.

The Contractor's acceptance of partial payment constitutes a certification by the Contractor that the Work covered by the partial payment meets the Contract requirements.

1906.2 MATERIAL ON HAND

The Contractor may request partial payments for the value of "materials on hand," defined as acceptable Materials produced for or provided to the Project, but not yet incorporated into the Work.

The Department will pay for Materials on hand when the Contractor meets the following requirements:

(1) Requests payment for at least $5,000;
(2) Provides Materials specifically manufactured, produced, or supplied for permanent incorporation into the Project;
(3) When the Contractor provided storage as approved by the Engineer for Materials delivered to, or adjacent to, the Project Site;
(4) When the Contractor irrevocably assigns the Materials to the Project, stores the Materials separately from other similar Materials, ensures the Materials are not available for use on other projects, and makes the Materials available for inspection by the Department at the material storage location for Materials not yet delivered to, or adjacent to, the Project Site; and
(5) Provides Materials as shown on the Plans and in accordance with the Specifications.

The Department will not make partial payments for living plant or perishable materials as Materials on hand.

The Contractor shall provide the following actual, authentic, customary, and auditable documents, produced in the normal course of business, to receive payment for Materials on hand:

(1) Invoices and proof of payment for the Materials,
(2) An itemized list detailing the cost of Contractor-produced Material, and
(3) Documents containing complete Material description and identification.

The Department will pay for Materials on hand in an amount not greater than the delivered cost of the Material as verified by Contractor-provided invoices or not greater than the Contract Unit Price for the Material complete in place. The Department reserves the right to recover payments made by the Department for Materials on hand if the Department believes the Contractor has not paid its Subcontractors or suppliers for the Materials on hand. The Department may recover the applicable payment by deducting such amount from the next partial payment.

1907 PAYMENT FOR SURPLUS MATERIAL

The Department will pay for Materials ordered for the Work, but not used, if the Engineer cancels a portion of the Work or the Contract, orders the termination of the Work before completion of the entire unit, or orders a quantity greater than the quantity needed for the Work, in accordance with the following:

(1) If the Contract Item only includes providing and delivering the Material, the Department will pay for purchased surplus Materials shipped or delivered to the Project at the Contract Unit Price;

(2) If the Contract Unit Price includes the cost of providing and placing of the Material, the Department will perform the following:

- (2.1) Take possession of the purchased surplus Material shipped or delivered to the Project, and pay the actual purchase price and transportation cost plus 15 percent, or
- (2.2) Order the Material returned to the supplier for credit and pay the Contractor the actual purchase price and transportation costs plus 15 percent of the total, less credits the Contractor received for the returned Materials.

(3) The Department will pay the actual purchase price and transportation cost plus 15 percent, upon delivery, for Materials that required special manufacture, fabrication, or processing, making the Materials unsuitable for general use, only if the supplier refuses to cancel or modify the order for Materials.

The foregoing items (1) to (3) will not apply and the Department will not pay for Materials ordered for the Work, but not used, if the Contractor or supplier takes possession of the surplus Material at no additional cost to the Department.

The Department will pay an amount for surplus Materials not greater than the Contract Unit Price for the same quantity of Materials complete in place. The Contractor shall provide receipted invoices or an affidavit showing the purchase price and transportation charges for surplus Materials that will become the property of the Department.

The Contractor shall deliver surplus Materials that the Department purchases to the storage sites designated by the Engineer.

The Department will only pay for Materials incorporated in the Work, except as otherwise specified in this section.

The Department will only pay for surplus materials inspected, tested, or approved for use and for material properly preserved, stored, and maintained in accordance with 1606, "Storage of Materials," and 1607, "Handling Materials," until delivered to the Department.

1908 FINAL ESTIMATE AND PAYMENT – CONDITIONS AND PROCESS

1908.1 GENERAL

The Department will initiate the final estimate and payment process in accordance with this section after the Contractor achieves Project acceptance as specified in 1516.2, "Project Acceptance."

The Department may make corrections to estimates for partial payments in the final estimate.

If the final estimate shows that the total of all partial payments exceeds the total amount due the Contractor, the Contractor shall promptly refund the overpayment. If the Contractor fails to refund the overpayment, the Department may deduct the amount of overpayment from any moneys due or becoming due to the Contractor under any other contract. This right survives the completion and closeout of the Contract.

1908.2 SEMI-FINAL ESTIMATE FOLLOWING PROJECT ACCEPTANCE

After granting Project acceptance in accordance with 1516.2, "Project Acceptance," the Engineer will prepare a semi-final estimate showing the accepted quantity and value of each Contract Item performed by the Contractor, and the amounts the Department will retain or deduct as required by the Contract. The Contractor shall review and comment on the semi-final estimate.

1908.3 FINAL ESTIMATE FOLLOWING COMPLETION OF WORK

The Department will review records and other factors indicating compliance with the requirements of 1516.3, "Completion of the Work." The Department will prepare and provide the final estimate and Certificate of Final Acceptance to the Contractor after the Contractor completes the Work in accordance with 1516.3, "Completion of the Work." The Contractor shall execute and return the Certificate of Final Acceptance to the Department within 90 calendar days of receipt. If the Contractor does not return the executed Certificate of Final Acceptance within the time specified in this section, the Department will deem the Certificate accepted by the Contractor.

The Contractor's acceptance of the final payment constitutes a certification by the Contractor that the Contractor performed the Work in accordance with all Contract requirements.

The Department will make final payment to the Contractor after the Contractor executes and returns the Certificate of Final Acceptance or the Department deems the certificate accepted.

Creating the final estimate and making final payment shall not relieve the Contractor of financial liabilities imposed by statute or waive Department claims, under Minnesota Statutes Chapter 15C or otherwise, with respect to any overcharges or any claims made by the Contractor under or related to the Contract. Final payment and Contract closeout by the Department does not affect the rights of any claimants under Minnesota Statutes §177.44.

1909 ASSIGNMENT OF PAYMENTS

The Department will not recognize assignments or orders executed by the Contractor that direct payments of money due to the Contractor under the Contract, unless the Surety's consent is attached to the assignment or order by endorsement or other means, or the assignment or order is of an account defined in the Uniform Commercial Code as enacted in Minnesota.

The Department may accept or reject orders or assignments, except in cases where acceptance is required by law.

1910 COST ESCALATION

The Department will not make adjustments for cost escalation, unless the Contract requires otherwise.

1911 (BLANK)

DIVISION II

CONSTRUCTION DETAILS

General

2021 MOBILIZATION

2021.1 DESCRIPTION

This work consists of preparatory work and operations, including the movement of personnel, equipment, supplies, and incidentals to the project to establish contractor's offices and buildings or other facilities. This work may also include obtaining bonds, permits, and demobilizing.

2021.2 MATERIALS — (BLANK)

2021.3 CONSTRUCTION REQUIREMENTS — (BLANK)

2021.4 METHOD OF MEASUREMENT — (BLANK)

2021.5 BASIS OF PAYMENT

The Department will provide partial payments for mobilization in accordance with the following table:

Table 2021-1
Mobilization Partial Payments

When	Pay Lesser of these Two Amounts	
Percent of Original Contract Amount Completed*	**Percent of Mobilization**	**Percent of Original Contract Amount ***
5	50	3
15	75	5
25	100	5
95	100	—

* The percent of Original Contract Amount = the amount earned by the Contractor, excluding money earned for mobilization and material on hand, divided by the total value of the original contract (all contract items).
If the contract unit price for mobilization exceeds 5 percent of the total original contract amount, the Department may withhold (on any partial estimate) the portion in excess of 5 percent until the Contractor earns at least 95 percent of the original contract amount.

The Department will not pay more than the original contract unit price for the mobilization item, even if the Contractor shuts down work on the project or moves equipment away from the project and then back again.

If the contract does not contain a lump sum item for mobilization, all costs incurred by the Contractor for mobilization shall be incidental to other work.

The Department will pay for mobilization on the basis of the following schedule:

Item No.:	Item:	Unit:
2021.501	Mobilization	lump sum

2031 FIELD OFFICE AND LABORATORY

2031.1 DESCRIPTION

This work consists of providing, maintaining, and removing field office and laboratory facilities for the exclusive use of Department personnel to perform field tests and write reports, for storage of records and equipment, and as field headquarters for the Engineer.

2031.2 MATERIALS

Obtain the Engineer's approval of facilities and services before installing on the project site. The facilities shall remain the property of the Contractor. Provide, maintain, and service the facilities with fuel, electrical power, sanitary services, access roads,

and other items required by the contract. Provide telephone service, including a modular jack and voice activated, beeperless, telephone recorder to all field office and laboratory facilities. Provide for the telephone installation, provide basic monthly phone service, and remove the telephone at project completion at no additional cost to the Department. Submit invoices for long distance telephone charges to the Engineer for payment.

Do not place field offices, laboratories, equipment, or supplies within 26 ft [8 m] outside of the dripline of specimen trees or other vegetation designated for preservation unless otherwise approved by the Engineer. Restrict traffic movement from this protected area. Provide temporary fence and other protection measures as specified in 2572, "Protection and Restoration of Vegetation" and as directed by the Engineer.

Locate, relocate, and maintain the facilities as approved by the Engineer unless otherwise specified by the contract. Locate the field office and laboratory sites within the right-of-way if possible. If a site within the right-of-way is not possible, arrange for a site adjacent to the right-of-way. If site rental is necessary, the Department will compensate the Contractor for rental costs as Extra Work. The Engineer will notify the Contractor when to deliver a unit to the project, ready it for occupancy, and relocate or remove it. Do not relocate or remove any unit from the project unless otherwise approved by the Engineer.

The Engineer may use field office units for the full life of the contract including periods of work suspension and until the execution of the Certificate of final acceptance. The Engineer will not use the laboratory units during periods of authorized winter suspension without the Contractor's permission or unless otherwise required by the contract.

The Engineer will release field laboratory units upon completion of field inspection work and acceptance in accordance with 1516, "Acceptance," unless otherwise required by the contract.

The Engineer will decide all disputes concerning site selection, placement conditions, service needs, and other functional matters.

2031.3 CONSTRUCTION REQUIREMENTS

A Basic Requirements

Provide each field office and laboratory as a separate mobile unit or building unless otherwise approved by the Engineer. The Engineer may accept separate quarters in stationary structures or combination trailer units if they satisfy the Department's location and mobility needs.

Construct and equip each field office or laboratory meeting the following characteristics and requirements:

(1) Weatherproof thermal resistant construction with finished interior walls, ceiling, and floor, capable of being easily maintained and cleaned;
(2) Exterior width of at least 8 ft [2.4 m] and a floor to ceiling height of at least 7 ft [2.1 m];
(3) At least two entrance doors with inside latches and at least one of those doors functioning as an exterior door equipped with an outside lock and having an opening of at least 30 in × 76 in [750 mm × 1,930 mm];
(4) Commercial type windows of normal number and size, with a total window area of at least 20 percent of the unit floor area, and with inside latches on all vent windows;
(5) Ceiling ventilator or exhaust fan, insect-proof screening on each exterior door and all vent windows, and Venetian blinds or effective awnings over all windows;
(6) Artificial lighting system with fixtures providing adequate illumination over each desk and all work areas;
(7) Portable or wall mounted plans rack;
(8) At least one multipurpose fire extinguisher meeting the requirements of applicable Federal and State safety and health regulations;
(9) Electric heating system capable of maintaining a uniform temperature of at least 70 °F [22 °C] throughout the interior in all zones; and
(10) Floor area, based on exterior dimensions, of at least 230 sq. ft [21 sq. m] for the field office and at least 150 sq. ft [14 sq. m] for the field laboratory.

Ensure the exterior doors provide convenient and safe egress from the ends of the unit. Provide a main door with dimensions of at least 30 in × 76 in [750 mm × 1,930 mm]. The Contractor may install a smaller auxiliary door on laboratory units as approved by the Engineer, if it fulfills the basic needs for an emergency exit. Ensure the doors and passageways provide easy access to all areas of the unit.

B Specific Requirements

Design or arrange the interior layout of each unit to make the furnishings easy to use, accommodate the use and storage of ordinary office machines or testing apparatus, and provide a reasonably modern and universally acceptable facility. Provide built-in furnishings and fixtures. Provide desks, tables, and work top surfaces surfaced or finished with mar resistant materials.

Provide appliance installations, sanitary facilities, electrical circuitry, waste and water supply systems, venting, and safety features meeting the requirements of Federal, State, and local regulations.

Equip the field office or laboratory with the following:

B.1 Field Office Furnishings

B.1.a Desks
Provide at least two pedestal type desks meeting the following characteristics and requirements:

(1) Contains supply drawers,
(2) Top width of at least 30 in [750 mm],
(3) Either the portable or built-in type, and
(4) Top length of at least 60 in [1,500 mm].

The Contractor may mount at least one end of the desk flush with a wall, provided the top length is at least 72 in [1,800 mm].

Provide vacant wall space for placement of a Department-furnished stenographic desk.

B.1.b File Drawers
Provide at least three letter or legal size file drawers, either of the built-in or portable cabinet type.

B.1.c Drafting Desk
Provide a drafting desk meeting the following requirements and characteristics:

(1) Contains a plan sheet and pencil drawer,
(2) Top dimensions of at least 36 in × 72 in [900 mm × 1,800 mm],
(3) Commercially built,
(4) Tilt or slant top desk, and
(5) Wall mounted, pedestal, or cabinet style.

Do not mount either end flush with a wall.

B.1.d Storage Cabinet
Provide an enclosed storage cabinet or closet with space for the usual outdoor garments, office supplies, and other materials not separately stored on open shelves or in desk drawers.

B.1.e Shelving
Provide at least 20 ft [6 m] of open shelving at least 12 in [300 mm] wide. Install shelving above desks or at other convenient locations.

B.1.f Drafting Stools and Desk Chairs
Provide one drafting stool for each drafting desk and one swivel-type desk chair for each desk. Provide at least two additional desk chairs for each facility.

B.2 Field Laboratory Furnishings

B.2.a Workbench
Provide a sturdily-built workbench with a work top at least 10 ft × 24 in [3 m × 600 mm] and with open space below for placement of a curing tank or other equipment. Install the workbench along a side wall.

B.2.b Service Sink
Provide a service sink meeting the following requirements and characteristics:

(1) At least 12 in [300 mm] deep,
(2) Capacity of at least 20 gal [75 L]
(3) Contains water supply, faucet, and an outside drain.

Install the sink near one end of the workbench. Recess the sink into the workbench.

B.2.c Storage Cabinet or Closet
Provide an enclosed storage cabinet or closet with space for the usual outdoor garments, standard supplies, and other miscellaneous equipment or apparatus that would ordinarily be stored for convenience or protection.

B.2.d Desk or Table
Provide a desk or table with a work top at least 30 in × 60 in [750 mm × 1,500 mm].

B.2.e File drawers
Provide at least two letter or legal size file drawers, either of the built-in or portable cabinet type.

B.2.f Stools or Chairs

Provide at least two stools or chairs of a height that will provide seating at the workbench and clerical desk.

B.2.g Shelving

Provide at least 12 ft [3,600 mm] of open shelving at least 12 in [300 mm] wide above the workbench or at other convenient locations.

B.2.h Stove

Provide an electric kitchen stove with four heating plates and electric oven. The Contractor may substitute separate heating plates as approved by the Engineer.

B.2.i Exhaust Fan

Provide an electric exhaust fan.

C Special Requirements

Level and support units at the project site. Rigidly support the field laboratory to eliminate floor and workbench vibrations for accurate weighing on a bench-supported scale.

Provide a curing tank with adequate capacity and in dimensions that allow installation below a laboratory workbench for concrete test cylinder curing when the work involves casting of standard concrete test cylinders. The Contractor may place the tank outside when used at the site of a field office, as approved by the Engineer.

Equip the field office or laboratory with the following special services in accordance with the type required by the contract.

C.1 Type A Service

Provide a pressurized water supply of sufficient capacity to meet materials testing and cylinder curing needs for the project. If a pressurized water supply is not available, provide and install a storage tank with a 50 gal [180 L] water capacity at each field laboratory site. Install the tank to produce sufficient gravity pressure to maintain constant flow through the sink faucet.

C.2 Type B Service

For Type B Service, provide Type A service and add toilet and lavatory facilities, drinking water facilities, and trash disposal service. Install detached portable toilets in locations as directed by the Engineer. Provide a closed faucet-equipped drinking-water container or cooler with an adequate supply of potable water, if a potable pressure water system is not available. Provide trash containers and regularly remove trash from the project site.

C.3 Type C Service

For Type C Service, provide Type B service and add electrical power supply and fixtures, including duplex outlet receptacles capable of providing adequate amperage for electric lighting and other appliance needs.

Provide an electrically powered mechanical sieving apparatus meeting the following characteristics and requirements to determine particle size distribution of fine aggregate (−No. 4 sieve [−4.75 mm]):

(1) Capable of accommodating six Department-provided full height 4 in [200 mm] round sieves with pan and cover,
(2) Equipped with an automatic timing device of at least 15 min duration, and
(3) Meeting the requirements of the AASHTO T 27 sieving sufficiency.

C.4 Type D Service

For Type D Service, provide Type C service and add a thermostatically controlled heating and cooling system capable of maintaining a uniform temperature from 72 °F to 85 °F [22 °C to 29 °C] in all zones. The Contractor may provide separate systems.

C.5 Type X Service

Provide Type X Service only for field laboratory units in combination with the requirements of one of the service types specified in this section. If the contract requires Type AX, Type BX, Type CX, or Type DX, the Engineer may use the specified laboratory unit as a combination office-laboratory facility during the contract time, including periods of work suspension, until the Department executes the Certificate of Final Contract Acceptance in accordance with 1516, "Acceptance." Provide the service requirements based on the first letter of the service type specified, i.e. for Type AX provide Type A Service.

2031.4 METHOD OF MEASUREMENT

The Engineer will separately measure accepted field office and field laboratory units by the number and type provided and used as required by the contract, regardless of the duration of its use at any one or different locations on the project site.

2031.5 BASIS OF PAYMENT

The contract unit price for field office or field laboratory units of each type includes the cost of providing, placing, relocating, maintaining, and servicing the complete facility as required, including removal and relocation. The Department will separately pay for public utility connections for facility relocations directed by the Engineer after the initial public utility connections made at the original site. The Department will not pay for ordinary relocation expenses not involving public utility changes.

The Department will pay for field office and laboratory on the basis of the following schedule:

Item No.:	Item:	Unit:
2031.501	Field Office, Type ___	Each
2031.503	Field Laboratory, Type ___	Each

2051 MAINTENANCE AND RESTORATION OF HAUL ROADS

2051.1 DESCRIPTION

This work consists of the maintenance, repair, and restoration of designated haul roads for materials hauled for the work covered by the contract.

2051.2 DEFINITIONS

The Department defines "designated haul road" as any public road or street officially designated as a haul road, except for a Minnesota trunk highway or road officially designated by the Commissioner as a detour around a construction project, over which the following materials are hauled:

(1) Soil or other material for embankment construction,
(2) Sand, gravel, or other material for backfill,
(3) Sand, gravel, or crushed rock for base or surfacing courses,
(4) Aggregates for bituminous surfacing, including hauling bituminous mixtures from the mixing plant,
(5) Aggregates for concrete base or pavement, including hauling concrete batches from batch plants, and
(6) Bituminous materials and portland cement for paving mixtures.

The Contractor may haul materials to the project or to other locations outside the project if required to complete the work specified in the contract.

2051.3 DESIGNATION AND USE OF HAUL ROADS

If the contract specifies *Maintenance and Restoration of Haul Roads* as a contract item, do not haul material from any source until the Commissioner designates the haul road from that source as a haul road. Once the Commissioner designates the haul road from a source, haul all materials from that source over that road.

Make all vehicle trips, both loaded or unloaded, between material sources and the project on designated haul roads.

If the contract is with MnDOT for State Trunk Highway Projects, select haul roads and notify the Engineer of the selections. Within 15 calendar days after receipt of notification of the haul road selections, the Commissioner will determine the acceptability of the selected haul roads. If the haul roads are acceptable, the Commissioner will designate the roads as temporary trunk highway haul roads.

If the contract is with or for a governmental agency other than MnDOT, select a haul road and notify the Engineer representing that governmental agency of the selection. Within 15 calendar days after receipt of notification of the haul road selection, the Engineer will determine if the selected road is an acceptable road. If the road is acceptable, the Engineer will approve that road as a designated haul road.

After a haul road is officially designated, the Contractor may select a different road for official designation using the same procedure specified in this section. If the haul road designation changes and any of the above described materials were hauled over the previously designated haul road, the Contractor shall restore the previously designated haul road to the original condition.

A Bituminous Roadways

Reimburse local government agencies for haul road use on bituminous roadways in accordance with the following:

(1) Verify spring load capacities of proposed haul roads with the local government agencies,
(2) For a designated haul road with a bituminous surface and a spring load capacity less than 9 tons [8.2 metric tons, reimburse the local government agency for haul road use at a rate of $0.01 per ton per mile [$0.007 per metric ton per kilometer] of material hauled,
(3) Make full payment to the local government agency upon receiving notice of payment due and computations from the Engineer, and
(4) Provide the Engineer with confirmation of payment to the local agency.

The Department will not require payment if the amount due to an individual local government agency is less than $500.00.

The Department will not require the Contractor to reimburse local government agencies for concrete surfaced roadways.

2051.4 MAINTENANCE AND RESTORATION

While hauling operations are in progress, maintain the haul road as approved by the Engineer. This work includes application of water, bituminous material, or calcium chloride to the road surface as necessary to alleviate dust nuisance and eliminate traffic hazards.

After the completion of hauling operations over a haul road, perform one of the following:

(1) Restore that haul road to a condition at least equal to the condition existing at the start of the hauling operations, or
(2) Compensate the local government agency in the amount approved by the local government agency and the Engineer for the restoration of that haul road by the local government agency.

The fact that other traffic used the haul road concurrently with the Contractor's material hauling operation does not relieve the Contractor of the obligation to maintain and restore the haul road as required in this section. If other contractors, performing highway construction under a contract with the same governmental agency, haul materials over the same road concurrently with the Contractor's material hauling operation, the Engineer will determine the amount of maintenance and restoration obligation to be shared by each.

The Engineer will determine the kind and amount of maintenance and restoration work required to restore the haul road to a condition equal to the condition existing at the time the hauling operations started. The Engineer's decision is final, binding, and conclusive.

When hauling over any designated haul road is completed and the Contractor has restored the road or has compensated the governmental agency for the restoration as required, the Engineer will accept such restoration or concur in such financial settlement for the restoration of the haul road in writing, and such acceptance shall relieve the Contractor of additional obligation in connection with the restoration of the designated haul road.

2051.5 BASIS OF PAYMENT

The contract lump sum amount for *Maintenance and Restoration of Haul Roads* includes the cost of maintenance, restoration, and the reimbursement to any local government agencies as specified in this section for use of haul roads officially designated and used in conjunction with the contract work.

The Department will not make payment for *Maintenance and Restoration of Haul Roads* unless one or more haul roads were officially designated and used for hauling materials. The Department will make payment at the contract lump sum amount if these two conditions were met and regardless of the amount of maintenance and restoration work required, provided work was completed or the local government agency certified receipt of payment for such restoration.

If the Contractor fails or refuses to perform haul road restoration or to make satisfactory financial settlement for such restoration as required within the period specified by the Engineer in writing, the Department will complete the restoration work and deduct the costs from any moneys that are or may become due the Contractor or require reimbursement from the Contractor's Surety.

The Department will pay for maintenance and restoration of haul roads on the basis of the following schedule:

Item No.:	Item:	Unit:
2051.501	Maintenance and Restoration of Haul Roads	lump sum

Grading

2101 CLEARING AND GRUBBING

2101.1 DESCRIPTION

This work consists of removing and disposing of the trees, brush, stumps, roots, and other plant life, including dead and decayed matter, within the construction area, unless otherwise designated to remain by the contract or as directed by the Engineer.

2101.2 (BLANK)

2101.3 CONSTRUCTION REQUIREMENTS

The Engineer will establish the right-of-way lines and construction limits confining the clearing and grubbing operations. The Engineer will designate those trees, brush, and other vegetation for preservation and those for removal. Remove and dispose of the trees, brush, stumps, and roots from the limits designated for clearing and grubbing.

Salvage topsoil in accordance with 2105, "Excavation and Embankment."

Protect the items designated to remain in accordance with 1712, "Protection and Restoration of Property," and 2572, "Protection and Restoration of Vegetation," place temporary fence, and perform clearing and grubbing operations in a manner that will not damage or jeopardize the surrounding plant life and property.

Prune branches for the following reasons:

(1) For pedestrian, vehicle, and infrastructure clearance;
(2) To reduce risk of branch failure;
(3) To improve a site line and sign visibility; and
(4) To maintain tree health in accordance with 2571.3, "Plant Installation and Establishment, Construction Requirements."

A Clearing and Grubbing Operations

Cut off, remove, and dispose of the trees, brush, stumps, and roots from designated areas within the construction limits as a clearing and grubbing operation. Perform clearing and grubbing on the project to construct the proposed improvements, including the clearing and grubbing of designated areas outside those construction limits as shown on the plans or as designated by the Engineer and in accordance with the following:

(1) Within the right-of-way, remove trees, brush, stumps, and other items that can be viewed from the traveled way as directed by the Engineer, and
(2) Within 15 ft [5 m] of the construction limits outside of structures, remove trees, stumps, roots, brush, and branches to protect and maintain the completed improvements as directed by the Engineer.

B Clearing Operations

Cut off, remove, and dispose of trees and brush in the areas identified as a clearing operation on the plans or as directed by the Engineer. If the contract does not require grubbing or if the Engineer directs the Contractor not to perform grubbing, cut off at a point within 6 in [150 mm] of the ground.

C Grubbing Operations

Remove and dispose of the brush, stumps, roots, and other remains in the areas designated as a grubbing operation on the plans, or as directed by the Engineer. Completely remove stumps in accordance with 2104.3.C, "Removal Operations," unless otherwise approved by the Engineer. If the Engineer approves of a stump to remain, cut the stump no greater than 6 in [150 mm] above the ground, and flush with or below the ground surface if directed by the Engineer.

Fill depressions resulting from the grubbing operations with suitable material in accordance with 2105.2.B, "Borrow Material," and compact the material as approved by the Engineer, except in those areas to be excavated as part of the work.

D Disposal Limitations

Dispose of trees, brush, stumps, roots, and other debris or byproducts by chipping, tub grinding, or marketing. The Contractor may chip the wood through a chipping machine or tub grinding, and use or dispose of the chips as approved by the Engineer within the construction limits. Provide to the Engineer an Emerald Ash Borer compliance agreement with the Minnesota Department of Agriculture. Dispose of ash, pine, elm, and oak wilt infected trees in accordance with proper forestry disposal standards that prevent spreading insects and disease pests.

D.1 Marketable Trees

The Contractor may make market trees designated for removal to wood-using industries, biofuel industries, or both. Do not market any part of an ash tree from a quarantined area to wood-using industries or individuals without an Emerald Ash Borer compliance agreement with Minnesota Department of Agriculture.

The Department defines marketable trees as all trees except for the following:

(1) Elm trees,
(2) Oak wilt infected oak trees, and
(3) Ash trees that have a diameter of 6 in [150 mm] or more when measured at a point 24 in [600 mm] above the ground surface.

D.2 Elm, Oak Wilt Infected Oak Trees and Ash

D.2.a Elm Trees
Dispose of elm trees, brush, stumps, roots, and debris by chipping or tub grinding and using the mulch within the construction limits for erosion control, construction of exit pads or landscaping purposes.

D.2.b Oak Wilt Infected Oak Trees
Dispose of stumps, roots, and debris from oak wilt infected oak trees by chipping or tub grinding and using the mulch within the construction limits for erosion control, construction of exit pads or landscaping purposes.

D2c Disposal Deadlines and Locations
Dispose of elm and oak wilt infected oak trees in accordance with the following:

(1) Within 20 calendar days of notification or of clearing and grubbing, whichever comes first, when performing the cutting operations between April 1 and September 15;
(2) By April 1 when performing cutting operations between September 15 and March 31,
(3) Within the right of way by tub grinding or chipping and using the mulch within the construction limits for erosion control, construction exit pads, or landscaping purposes; and
(4) Off the right of way provided the tree logs are processed by debarking or made into wood chip mulch to prevent the spread of Dutch elm disease and oak wilt.

D.3 Pine
Dispose of all non-marketable pine trees, brush, stumps, roots, and slash debris by chipping, tub grinding, or debarking within 20 calendar days of being cleared during the growing season to prevent the infestation and spread of pine bark beetles.

D.4 Ash Trees (Fraxinus species)
Do not market ash trees to the wood-using industries or individuals without having an Emerald Ash Borer compliance agreement with the Minnesota Department of Agriculture. Do not make ash or non-coniferous species with bark attached available to the public for use as firewood from the quarantined area. Do not transport entire ash trees, limbs, branches, logs, chips, ash lumber with bark, stumps, and roots outside of a quarantined county without fulfilling the requirements of an Emerald Ash Borer compliance agreement with the Minnesota Department of Agriculture. Contact the Minnesota Department of Agriculture to speak with a regulatory official and visit the Minnesota Department of Agriculture Emerald Ash Borer website to determine the quarantine area.

D.4 Ash Tree Disposal and Locations
Dispose of ash trees in accordance with the following:

(1) The Emerald Ash Borer compliance agreement, and
(2) Use the ash wood chips within the construction limits for erosion control, construction exit pads, or landscaping purposes.

D.5 Burning not allowed 2104.3

D.6 Burying not allowed 2104.3

2101.4 METHOD OF MEASUREMENT
The Engineer will measure clearing and grubbing by area, lump sum, or individual unit as required by the contract. The Engineer will measure tree diameter by measuring the circumference of the tree at 4.5 ft above the ground and dividing the circumference by 3.14, or by measuring the diameter or the tree stump after removal.

A Qualifying Trees and Stumps
The Engineer will only measure trees for payment having a diameter greater than 4 in [100 mm] at a point measured 24 in [600 mm] above the ground surface.

The Engineer will only measure stumps for payment having a diameter greater than 4 in [100 mm] when measured at one of the following points:

(1) 2 ft [600 mm] above the ground surface for a tree cleared under the contract, or
(2) The point of cutoff for an existing stump not cleared under the contract.

The Engineer will not measure for the removal and disposal of stumps and brush with a diameter equal to or less than 4 in [100 mm] at the point of cutoff.

B Area Basis

If the contract specifies the unit as a hectare, the Engineer will determine quantities by measuring, to the nearest 0.05 acre [0.02 ha], all areas cleared and all areas grubbed within the limits as shown on the plans or staked by the Engineer. The Engineer will make all measurements horizontally to points 10 ft [3.0 m] outside the trunks of qualifying trees or stumps on the perimeter of the area being measured. The Engineer will measure separate areas less than 0.05 acre [0.02 ha] as 0.05 acre [0.02 ha].

If isolated trees or stumps require removal outside the areas designated for clearing or grubbing by the hectare, and no unit price is provided in the contract for clearing and grubbing individual trees or stumps, the Department will pay based on the following:

(1) The Engineer will consider each isolated qualifying tree less than 40 in [1 m] in diameter when measured at a point 2 ft [600 mm] above the ground surface, and each isolated qualifying stump measuring less than 40 in [1 m] at the point of cutoff as 0.05 acre [0.02 ha].

(2) The Engineer will consider each isolated tree or stump at least 40 in [1 m] in diameter when measured at the points described in (1) above as 0.1 acre [0.04 ha].

C Individual Unit Basis

When the contract specifies "tree" as the unit, the Engineer will count the number of qualifying trees cleared and the number of qualifying stumps grubbed to determine the quantity.

D Lump Sum Basis

The Engineer will not measure an individual area, tree, or stump if the contract specifies clearing and grubbing as a lump sum item.

2101.5 BASIS OF PAYMENT

The contract unit prices for the accepted quantities of clearing and grubbing includes the cost for removal and disposal; securing outside disposal sites in accordance with 2104.3.D, "Disposal of Materials and Debris;" bringing in a tub grinder if necessary; securing an Emerald Ash Borer compliance agreement with the Minnesota Department of Agriculture; and performing the required treatment for disposing of elm, oak wilt infected oaks, pine, ash, and marketable trees.

The contract lump sum price for *Clearing and Grubbing*, regardless of the sizes of the trees and stumps, includes the cost of all clearing and grubbing required by the contract.

The Department will include the costs for removing and disposing of brush and stumps with a diameter equal to or less than 4 in [100 mm] at the point of cutoff in the contract unit prices of other relevant pay items.

The Department will not pay for pruning except as specified in 2572.5, "Protection and Restoration of Vegetation, Basis of Payment."

If the contract does not specify a pay item for clearing and grubbing, the Department will pay for clearing and grubbing of qualifying trees and stumps as specified in 2101.4, "Clearing and Grubbing, Method of Measurement," as extra work in accordance with 1402, "Contract Revisions."

The Department will pay for clearing and grubbing items on the basis of the following schedule:

Item No.:	Item:	Unit:
2101.501	Clearing	acre [hectare]
2101.502	Clearing	tree
2101.506	Grubbing	acre [hectare]
2101.507	Grubbing	tree
2101.511	Clearing and Grubbing	lump sum

2102 PAVEMENT MARKING REMOVAL

2102.1 DESCRIPTION

This work consists of removing temporary and permanent pavement markings, except for removable preformed plastic pavement markings, that conflict with revised traffic patterns.

2102.2 MATERIALS — (BLANK)

2102.3 CONSTRUCTION REQUIREMENTS

Before making a change in traffic pattern, remove conflicting pavement markings as required by the contract and as directed by the Engineer without damaging the pavement structure or surface texture. If determined by the Engineer, repair damaged areas as directed by the Engineer at no additional cost to the Department.

Control or restrict operations to avoid exposing traffic to hazardous conditions in accordance with 1701, "Laws to be Observed," 1707, "Public Convenience and Safety," and 1717, "Air, Land, and Water Pollution." Remove expended materials or agents used in the pavement marking removal process from the pavement surface as the work progresses. Dispose of removed marking material in accordance with 1701, "Laws to be Observed," and 1717, "Air, Land, and Water Pollution."

Removed pavement marking material shall become the property of the Contractor.

2102.4 METHOD OF MEASUREMENT

The Engineer will measure *Pavement Marking Removal* by area or length of the original markings as removed.

The Engineer will measure removal areas on the basis of nominal widths and actual lengths as originally applied and still visible at the time of pavement marking removal. The Engineer will enclose irregularly shaped markings within rectangular boundaries of least dimension as determined by the Engineer.

The Engineer will measure removal length by the actual length of each 4 in [100 mm] wide pavement marking removed. The Engineer will measure longitudinal pavement marking removal quantities greater than 4 in [100 mm] wide based on a ratio of actual pavement marking width relative to 4 in [100 mm]. The Engineer will not include the gap between the broken lines in the removal length measurement.

The Department will include the cost of removing removable preformed pavement marking tape with the relevant contract unit prices in accordance with 2581, "Removable Preformed Pavement Marking Tape."

2102.5 BASIS OF PAYMENT

The contract unit price for *Pavement Marking Removal* includes the cost of obliterating the markings as required by the contract and for restoring the original pavement texture as directed by the Engineer.

Unless the contract requires otherwise, the Department will pay for the removal of markings of all types under a single contract item.

The Department will pay for pavement marking removal on the basis of the following schedule:

Item No.:	Item:	Unit:
2102.501	Pavement Marking Removal	square foot [square meter]
2102.502	Pavement Marking Removal	linear foot [linear meter]

2103 BUILDING REMOVAL

2103.1 DESCRIPTION

This work consists of removing unsalvageable and vacated buildings from the right-of-way, making sewer and water service disconnections, and removing sidewalks, driveways, or miscellaneous structures, unless otherwise required by the contract.

2103.2 BLANK

2103.3 REMOVAL REQUIREMENTS

A General

Perform building removals as required by the contract. The contract will provide a general description and the street addresses or references to a survey station for the buildings and miscellaneous items requiring removal.

Remove buildings, including all fixtures except those owned by public or private utilities by demolition before removal from the right-of-way.

The Contractor is responsible for any damage caused to adjacent property during the building removal process.

The Department assumes no responsibility for the condition of any buildings at any time, and no guarantee is made or implied that any building will remain in the condition the bidder finds it at the time of examination before preparing the Proposal.

B Removal

Remove buildings and structures, including steps, basement floors and walls, floor slabs, and footings from the right-of-way. If the building rests on a concrete surface slab, remove the entire slab and related footings.

C Utilities **1507**

C.1 Disconnection of Sewer and Water Services

Locate, expose, cut off, and plug all sewer and water service connections at the sewer and water mains. Plug all sewers leading from the building using watertight plugs at no additional cost to the Department.

Abandon wells in accordance with 2104, "Removing Pavement and Miscellaneous Structures."

C.2 Other Utilities

The utility owners will disconnect telephone, electric power, other wire services, and gas service pipes outside the buildings. The utility owners will also remove utility-owned fixtures in accordance with 1507, "Utility Property and Service."

D Disposal of Materials and Debris

Dispose of the demolished building in accordance with 2104.3.D, "Disposal of Materials and Debris," at a demolition landfill permitted by the Minnesota Pollution Control Agency, except the Contractor may recycle parts of the building as approved by the Engineer. Do not dispose of buildings at permit-by-rule landfills, transfer stations, or waste storage facilities.

E Filling Basement Excavations

If the building was removed by another contract, fill all basement excavations and other excavations previously made as required by the contract. Fill the excavation to the level of the existing ground surface using backfill that matches the existing soil conditions. Provide the fill material from sources outside the right-of-way in accordance with 1405, "Use of Materials Found on the Project." Compact the fill in accordance with the quality compaction requirements in 2105, "Excavation and Embankment."

If the building removal is included with the grading in this contract, remove the foundations in accordance with 2103.3.B, "Removal," and fill basement excavations in accordance with 2105.3.H, "Finishing Operations."

2103.4 METHOD OF MEASUREMENT

A Building Removal

The Engineer will measure all buildings listed for removal as a single lump sum.

B Basement Excavation Fill

The Engineer will measure the volume of fill provided by the Contractor by the volume of the basements below the ground surface as required by the contract.

C Disconnection of Sewer and Water Services

The Engineer will measure each sewer and water service connection cut off and plugged at the main.

2103.5 BASIS OF PAYMENT

The contract unit price for the *Disconnect Sewer Service* and *Disconnect Water Service* includes the cost of the restoration of street and property surfaces.

The Department will pay for building removal based on the following schedule:

Item No.:	Item:	Unit:
2103.501	Building Removal	lump sum
2103.505	Disconnect Sewer Service	each
2103.507	Disconnect Water Service	each
2103.511	Basement Excavation Fill	cubic yard [cubic meter]

2104 REMOVING PAVEMENT AND MISCELLANEOUS STRUCTURES

2104.1 DESCRIPTION

This work consists of removing and disposing of pavement, sewers, culverts, guardrails, abandoned structures, and other obstructions on the right-of-way, except as specified in 2442, "Removal of Existing Bridges," and 2103, "Building Removal." This work also consists of salvaging material and backfilling trenches, holes, and depressions.

2104.2 MATERIALS — (BLANK)

2104.3 CONSTRUCTION REQUIREMENTS

A General

Remove and dispose of structures and obstructions as required by the contract.

B Salvage Operations

Remove, dismantle, and store salvaged materials to allow re-use.

When salvaging guardrail and fences, coil the wire and cable, pull posts from the ground, and remove nails and staples from posts and boards.

Stockpile materials designated for salvage by the Department on the right-of-way at locations approved by the Engineer. Remove, dismantle, and clean materials as required by the contract before stockpiling.

C Removal Operations

C.1 Removing Portion of Structure

Do not damage existing structures to be retained for use during the removal operations. Ensure a length of at least 40 bar diameters from the face of the cut for existing reinforcement bars for concrete structures left in place.

C.2 Pavements and Sidewalks

Saw the existing concrete pavement or sidewalks or bituminous pavement at the locations as shown on the plans and as staked by the Engineer to establish a neat line for extending the new work.

C.3 Concrete and Masonry Structures

Remove concrete and masonry structures to the excavation limits as shown on the plans.

Remove septic tanks, cisterns, and cesspools.

Rebuild and reconnect live sewers after removing related manholes, catch basins, and drop inlets. Provide a by-pass and maintain the service during the removal operations.

Use concrete or masonry plugs to plug pipes draining into abandoned basements, manholes, or similar structures.

C.4 Timber Structures and Underground Tanks

Remove timber structures and underground tanks meeting the requirements of applicable laws and regulations.

C.5 Wells and Holes

Refer to Minnesota Rules, Chapter 4725, "Wells and Borings," for the definition of "wells" and "borings." Construct and seal most wells and borings meeting the requirements of Minnesota Rules, Chapter 4725, "Wells and Borings."

Seal wells and borings taken out of service meeting the requirements of Minnesota Rule Chapter 4725, "Wells and Borings." Protect wells and borings until permanently meeting the requirements of Minnesota Rule Chapter 4725, "Wells and Borings," during the work to prevent surface drainage from entering the opening. Cut and remove casing in the well or boring to the elevation as shown on the plans or as directed by the Engineer after sealing. Submit one copy of the sealing record to the Minnesota Department of Health and one copy to the Engineer within 30 calendar days after sealing a well or boring.

C.6 Miscellaneous Items

When removing railroad tracks, remove rails, ties, paving, crossings, track encasements, and other appurtenances.

D Disposal of Materials and Debris

D.1 Disposal Plan

Provide the Engineer with information and documentation substantiating proper disposal arrangements and operations. The Department will not pay for removal before acceptance of the initial disposal plan or, if required, a modified disposal plan.

D.2 Disposal within Right-of-Way

Do not dispose material or debris within the right-of-way, except for wood ashes.

The Contractor may burn untreated wood within the right-of-way, after obtaining the required burning permits. Conduct burning operations under the constant care of a competent caretaker in accordance with 1506.2, "Competent Individual," and in accordance with the requirements of the permit.

The Contractor may incorporate the ashes from a burning operation into the soil on the proposed backslope or dispose off the right-of-way.

D.3 Disposal outside Right-of-Way

Dispose of materials and debris, resulting from removal or demolition operations having no specific disposal provisions, outside the right-of-way.

Assume full responsibility for acceptable disposition of the material and for damages resulting from the disposal operations.

The Engineer may not give final acceptance of the work:

(1) Unless disposal is made at a publicly controlled dumping site, or
(2) Until the disposal areas are in acceptable condition with respect to the Contractor's obligations.

E Backfilling Depressions
Backfill depressions with material in accordance with 2105, "Excavation and Embankment."

2104.4 METHOD OF MEASUREMENT

A Area
The Engineer will measure pavements, sidewalks, surfacing, and other uniform thickness items by area without specifying the thickness.

The Engineer will classify pavement removal by kind of paving material when the material is comprised entirely of portland cement concrete (remove concrete pavement) or entirely of bituminous-aggregate mixtures (remove bituminous pavement). If the pavement is comprised of a combination of different paving materials, such as a concrete base or pavement overlaid with bituminous surfacing, the Engineer will measure the removal of the entire structure as the unclassified item of "remove pavement." Regardless of classification, the Engineer will include the removal of integrant curb removed as a part of pavement removal.

The Engineer will separately measure the removal of pavement as part of the excavation of trenches for installation of drainage structures or utility items as the pay item for remove trench pavement. Remove trench pavement will include the removal of paving courses including unclassified materials.

B Length
The Engineer will measure the length along the longitudinal centerline of the structure, parallel to the base or foundation supporting the structure, and from end to end of the removed structure. The Engineer will measure pipe from center to center of junction fittings, catch basins, or manholes. The Engineer will include the length of aprons removed as shown on the plans with the pipe measurements.

The Engineer will measure sawing of concrete and bituminous pavements by length along the saw cut lines as staked by the Engineer, if included as contract items.

C Volume
The Engineer will determine the volume of concrete or masonry structures by taking measurements on the in-place structure as it is being uncovered and removed, except if otherwise established.

D Number (Complete Unit)
The Engineer will measure contract items with a contract "each" price by counting the number of individual units removed, salvaged, or abandoned, including all appurtenances.

E Lump Sum
The Engineer will measure portions of completed work.

2104.5 BASIS OF PAYMENT
The contract unit prices for *Remove*, *Salvage*, or *Abandon* includes the cost of the following:

(1) Removing the material or portions of the material as specified by the contract,
(2) Disposing of the materials removed,
(3) Salvaging of parts as specified by the contract,
(4) Backfilling depressions and other restoration work as specified by the contract,
(5) Performing well abandonment procedures, and
(6) Other work of a special nature as specified in the contract or imposed by laws, ordinances, and regulations.

The contract unit prices for sawing only includes sawing of concrete and bituminous pavements using a saw. Use of any other method, approved by the Engineer, at the option of the Contractor, will be at no additional cost to the Department. The Department will include the cost of sawing with other relevant contract pay items if the contract does not include a contract pay item for sawing.

The contract unit price for fence removal includes the cost of removing abandoned fences. The Department will include the cost of removal of abandoned fences with other relevant contract pay items, if the contract does not include a contract item for fence removal.

For salvage items, the Department will only pay for units removed in a condition acceptable for re-use. The Department will include the cost of the necessary removal of damaged or deteriorated units with other relevant removal contract items or as extra work in accordance with 1402, "Contract Revisions."

If the Contractor's negligence damages materials designated for salvage, the Department will deduct from any moneys due or becoming due the Contractor an amount equal to 60 percent of the current delivered price of new material of the same type and size as that damaged and equal to the quantity of material so damaged. The damaged material shall then become the property of the Contractor.

The Department will pay for the removal of the ends of old box culverts preparatory to extending the structure by the cubic yard [cubic meter] or by each unit.

The Department will pay for backfilling depressions resulting from the removal of structures as embankment construction.

The Department will pay for removing pavement and miscellaneous structures on the basis of the following schedule:

Item No.:	Item:	Unit:
2104.501	Remove*	linear foot [meter]
2104.503	Remove*	square foot [square meter]
2104.505	Remove*	[square yard]
2104.507	Remove*	cubic yard [cubic meter]
2104.509	Remove*	each
2104.510	Remove*	lump sum
2104.511	Sawing Concrete Pavement	linear foot [meter]
2104.513	Sawing Bituminous Pavement	linear foot [meter]
2104.521	Salvage*	linear foot [meter]
2104.523	Salvage*	each
2104.525	Abandon*	each

* Specify item name, such as: culvert pipe, sewer pipe, drain pipe, curb and gutter, curb, sidewalk, fence, concrete or masonry structures, railway track, manholes or catch basins, integrant curb, concrete pavement, bituminous pavement, pavement, trench pavement, guardrail, water well, etc.

2105 EXCAVATION AND EMBANKMENT

2105.1 DESCRIPTION

This work consists of excavating and placing embankment.

A Definitions

A.1 Road Core

The road core is the area below the grading grade to the bottom of the excavation and between the following:

(1) For embankment heights ≤ 30 ft [10 m], from the grading grade point of intersections (P.I.s) with a 1:1 (V:H) slope and
(2) For embankment heights > 30 ft [10 m], from the grading grade point of intersections (P.I.s) with a 1:1½ (V:H) slope.

A.2 Grading Grade

Grading grade is the bottom of the aggregate base.

A.3 Top of Subgrade

The top of the subgrade is the surface of material immediately beneath the granular material. If there is no granular layer, then the top of subgrade is the Grading Grade.

A.4 Optimum Moisture Content

The optimum moisture content is determined by the:

- Moisture Density Test Method (Proctor), or
- One-Point Proctor Method or
- Estimated Optimum Moisture Content Form G&B-305.

A.5 Maximum Density

Maximum density is the maximum density determined by the Moisture Density Test Method (Proctor) test in the Grading and Base Manual.

A.6 Select Grading Material

Select grading **materials** are all mineral soils found in the Triaxial Chart in the Grading and Base Manual, excluding silt. Silt is defined as soils containing 80% or more silt-sized particles. Marl and organic soils are also excluded.

A.7 Granular Materials
Granular materials meet the requirements of 3149.2.B.1.

A.8 Non-Structural Grading Materials
Non-Structural grading materials are all mineral soils, excess topsoil, and organic soils, capable of supporting construction equipment.

A.9 Uniform Soils
Uniform soils have the same soil class per the Triaxial Chart in the Grading and Base Manual and have similar color, moisture content and performance characteristics.

A.10 Organic Soils
Organic soils contain ≥ 5 percent organic content.

2105.2 MATERIALS
A Excavation Material
The Engineer will classify the excavation using the following categories:

A.1 Common Excavation
Material not classified in any other category.

A.2 Subgrade Excavation
All excavation in the road core below the grading grade, exclusive of rock, muck, channel or rock channel excavation.

A.3 Rock Excavation
Material that requires drilling, blasting or ripping before excavation. This includes boulders and other detached rock larger than 1 cu. yd. [1 cu. m.].

A.4 Muck Excavation
The removal of organic soils as defined in 2105.1.A.10, "Organic Soils," and other unstable soils as designated by the plan, and below the natural ground level of marshes, swamps, or bogs, regardless of the moisture content. Muck excavation is limited to areas over which the roadway embankment or a Structure is to be constructed.

A.5 Channel and Pond Excavation
Material from channel changes, waterways, and ponds outside of the roadway embankment not classified as rock channel excavation.

A.6 Rock Channel Excavation
Material classified as rock excavation from channel changes and waterways outside of the roadway embankment.

A.7 Blank

B Borrow Material
Provide borrow meeting the specifications in Table 2105-1.

Table 2105-1
Borrow Specifications

Material	Specification
Common Borrow	2105.1.A.6, "Select Grading Material"
Granular Borrow	3149.2.B.1, "Granular Material"
Select Granular Borrow	3149.2.B.2, "Select Granular Material"
Topsoil Borrow	3877, "Topsoil Material"

Materials obtained by the Contractor from sources outside the roadway must comply with 1601, "Source of Supply and Quality," and with 1602, "Natural Material Sources."

Excess materials from within the excavation limits shown on the plans that meet the specified requirements can be used by the Contractor for borrow items shown on the plans. These excess materials must comply with 1405, "Use of Materials Found on the Project."

C Blank

D Stabilizing Aggregate 3149.2.C
If the plans show a contract pay item for Stabilizing Aggregate place it in accordance with 2211, "Aggregate Base".

2105.3 CONSTRUCTION REQUIREMENTS

A General

For road core embankment, use either select grading material per 2105.1.A.6 or granular materials per 3149.2.B.1.

Non-structural grading materials per 2105.1.A.8 may be used as embankment outside the road core.

All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated, all test procedures are in the Grading and Base Manual.

Perform excavation and embankment operations within the plan excavation limits as required by the contract.

Before beginning excavation and embankment operations, comply with the requirements of 2101, "Clearing and Grubbing."

Maintain drainage in excavations and embankment operations at all times. Provide and maintain temporary drainage facilities until the permanent facilities are complete and operational. These requirements do not override the provisions of 1806, "Determination and Extension of Contract Time".

Provide and maintain temporary preparation and erosion control on embankment and stockpiles until finishing operations are complete.

Repair or replace settlement plates damaged by construction operations.

Protect Structures during construction operations. Repair Structures damaged by construction operations.

Materials containing recycled bituminous can only be placed in and above the road core, or used in base per 3138, "Aggregate for Surface and Base Courses".

B Contractor Quality Control (QC) Testing

Perform tests as required in the Schedule of Materials Control.

Submit results to the Engineer within one hour after sampling.

Test corrected areas that fail either QC or Quality Assurance (QA).

Submit a preliminary, required before work commences, and final Grading and Base Report (G&B-001), and a weekly summary report of tests completed and retests of failing materials (G&B-003).

B.1 Aggregate Certification

Certify granular materials on Form G&B-104. Attach all required aggregate test results to Form G&B-104.

Material placed without certifications is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

B.2 Moisture Control

Determine the optimum moisture content.

Test for the moisture content in areas that appear least likely to meet specifications.

Determine the moisture content during compaction using test methods listed in the Grading and Base Manual or by alternate methods as approved by the Engineer.

Meet the moisture content requirements listed in Table 2105-2.

Table 2105-2
Moisture Content Requirements

Minimum Compaction Requirements	Relative Moisture Content *
100 % of maximum density	65 % – 102 %
95 % of maximum density	65 % – 115 %
Quality Compaction	65 % – 102 %
Penetration Index Method	≥ 65 %
* As determined on form G&B-105	

Correct for moisture content in areas represented by failing moisture tests, before testing the compaction. Compaction tests taken in areas represented by failing moisture tests are not valid.

B.3 Test Rolling

Test roll, per the Schedule of Materials Control and Contract, the top surface of non-granular subgrade and the top of any granular surface not meeting the requirements of 3149.2.B.2 per 2111 using the test roller as specified in the Contract. If no test roller is specified, use test roller TR10.

C Preparation of Embankment Foundation

Construct steps, before placing embankment material, at a minimum width of 12 in [300 mm] when slopes are steeper than 1:4 (V:H).

Ensure the foundation area drains freely.

Compact the bottom of the excavation according to Table 2105-3.

Table 2105-3
Required Compaction for Bottom of Excavation

Excavation Depth Below Grading Grade *	Relative Moisture Content ‖	Required Compaction
< 30 in [750 mm]	65% to 102%	Compact to 100% of maximum density
≥ 30 in [750 mm]	65% to 115%	Compact to 95% of maximum density or compact with 4 passes of a roller, except around Structures †
Around Structures	65% to 102%	Compact to 100% of maximum density, or meet DCP requirements of Table 2105-6

*: Excavation below the planned subgrade may be subject to 1402, "Contract Revisions"

‖: An estimated value for the optimum moisture content may be used instead of determining this value using Form G&B-305.

†: Roller must be adequate to compact lift thicknesses as placed. The Engineer may waive the four pass requirement, if the subgrade will not support the roller.

Granular material ≥ 30" in depth must meet the compaction requirements of Table 2105-6.

See Plan sheets for modifications, note especially compaction requirements directly beneath pipes, where no compaction may be required.

Remove surfacing and excavate an existing road core in accordance with the Contract. Then perform subgrade preparation on the excavated portion and the new roadcore in accordance with 2112, "Subgrade Preparation," before placing new embankment material.

D Excavating Operations

Obtain the Engineer's written approval before excavating beyond the limits and elevations established by the contract.

Remove rock outcroppings from within the slope lines and to the elevations shown on the plans. Remove loosened rock from the backslopes. Provide drainage for the shoulder slopes. Do not leave undrainable depressions.

Presplit rock back slopes steeper than 1:1 (V:H). Control blasting operations to eliminate flying rock or debris.

Excavation below the planned subgrade to correct unstable conditions may be subject to 1402, "Contract Revisions"

E Placing Embankment Materials

Place embankments in uniform lifts, parallel to the Plan profile grade, over the full width of the roadway. Construct each lift of material using uniform soil.

Protect Structures during placement of embankments.

Place granular materials in the uppermost portion of the subgrade, if it does not significantly change normal grading operations.

Excavate, stockpile, and place topsoil as required by the contract.

Obtain written permission from the Engineer before removing topsoil or granular material from the project.

Embankment materials placed on the road core may not increase the moisture content of the underlying material beyond the specified limits.

Non-granular materials placed above granular material must be at least 4 ft. [1.2 m.] thick.

Maximum lift thicknesses are controlled by the capability of the equipment to uniformly compact the entire lift in accordance with the following:

(1) The Engineer will restrict lift thickness to no greater than 12 in [300 mm] (loose thickness), when uniform results are not achieved.
(2) The Engineer may allow thicker lifts over saturated foundation soils. The top of the thicker lift must be at least 4 ft. [1.2 m] below the grading grade.

Uniformly blend the entire thickness of each lift before testing moisture content and compaction. Disc soils with greater than 20 percent passing the No. 200 [75 µm] sieve.

Stagger construction traffic uniformly over the full width of the roadway embankment.

Remove snow, ice, and frozen soils from road core before placing embankment.

Use embankment material in the road core with particle sizes no larger than specified in Table 2105-4:

Table 2105-4
Maximum Particle Size in Road Core

Depth from Grading Grade	Maximum Particle Size	
	Inches	mm
< 12 in [300 mm]	3	75
1 ft. – 3 ft. [300 mm – 900 mm]	6	150
3 ft. – 6 ft. [900 mm – 1,800 mm]	12	300
> 6 ft. [1,800 mm]	24	600
≤ 2 ft. [600 mm] from a Structure	3	75
Areas where piling is to be placed	6	150

Remove surcharges as directed by the contract.

Install settlement plates, if required by the contract. Do not disturb settlement plates.

F Compacting Embankments

Maintain moisture content during compaction per Table 2105-2.

Meeting the requirements of 100% density for the specified density method is equivalent to meeting the requirements for the penetration index method.

Correct the moisture in areas represented by failing tests before testing the compaction.

Compaction tests taken in areas represented by failing moisture tests are not valid.

Uniformly compact each lift of the road core:

- to the Specified Density requirements in 2105.3.F.1 for materials not meeting the requirements of 3149.2.B.1, "Granular Materials".
- or to the Penetration Index (PI) requirements in 2105.3.F.3 for materials meeting the requirements of 3149.2.B.1, "Granular Materials". For granular materials with less than 6% passing the #200 sieve, the Engineer may elect to use the Quality Compaction method, 2105.3.F.2.

Compact all roadway embankment outside of the road core from 80 to 85 percent of the Maximum Density, except for an excavated trench, meet the requirements of Table 2105-5.

Compact the entire length and width of each lift with a roller. Construction traffic does not replace the rolling requirement.

Compaction requirements on swamp backfills start when the road core embankment is 4 ft. [1.2 m] above the water elevation at the time of construction operations.

The Engineer may waive mechanical compaction requirements on embankment containing predominately rock or topsoil.

Compact soils around Structures with appropriate equipment or hand methods, to prevent damage to adjacent Structures.

Correct or replace materials in areas represented by a failing test.

Maintain the required compaction until the next layer is placed.

The requirements of 2105.3.F.1, 2105.3.F.3 and 2105.3.F.4 include the requirements of Quality Compaction in 2105.3.F.2.

F.1 Specified Density

Compact to meet the requirements of Table 2105-5.

Table 2105-5
Specified Density Requirements

Embankment Location	Required Compaction (Relative Density)
≤ 3ft (1 m) Below Grading Grade of Road Core	100%
Subgrade Preparation	100%
Within an excavation trench*	100%
Remaining embankment in the road core	95%
* See Plan sheets for modifications, note especially compaction requirements directly beneath pipes, where no compaction may be required.	

F.2 Quality Compaction

Compact each lift until there is no evidence of consolidation during compaction or under traffic, with no:

- Pumping – vertical displacement of the top surface of the compacted layer, not directly under the vehicle tire
- Reaction – a movement back to a former or less advanced condition.
- Yielding – giving under pressure (flexible)
- Cracking – cracking of material on visible surface
- Lateral movement – sideways movement of the top surface

F.3 Penetration Index (PI)

Compact the entire lift to achieve a dynamic cone penetration index (DPI) value per Table 2105-6.

Table 2105-6
Maximum Allowable Penetration for DCP

Grading Number †	Moisture Content ‖	Maximum Allowable DPI, *mm/blow*	Maximum Allowable Seat, *mm*
3.1 – 3.5	< 5.0	10	No Requirement
	5.0 – 8.0	12	
	> 8.0	16	
3.6 – 4.0	< 5.0	10	
	5.0 – 8.0	15	
	> 8.0	19	
4.1 – 4.5	< 5.0	13	
	5.0 – 8.0	17	
	> 8.0	21	
4.6 – 5.0	< 5.0	15	
	5.0 – 8.0	19	
	> 8.0	23	
5.1 – 5.5	< 5.0	17	
	5.0 – 8.0	21	
	> 8.0	25	
5.6 – 6.0	< 5.0	19	
	5.0 – 8.0	24	
	> 8.0	28	

† As determined by Form G&B-203
‖ Percent of dry weight.
Note that a moisture test is not required, if the material meets the toughest requirements for the Grading Number.

F.4 Light Weight Deflectometer (LWD) Method

Compact the entire lift to achieve the LWD target value as required per the LWD procedure for 2105 in the Grading and Base Manual.

G Agency Quality Assurance (QA)

Test according to the Schedule of Materials Control.

G.1 Material Testing

Perform the following QA tests:

(1) Gradation,
(2) Crushing,
(3) Aggregate Quality and
(4) Bitumen content (using procedure 1852 in the Laboratory Manual).

Sample the granular materials from the road core after spreading but before compaction.

Select crushing, aggregate quality and bitumen samples using the random sampling method in the Grading and Base manual. Select gradation samples from locations that are at risk of not meeting the specification requirements.

G.2 Compaction Testing

Test for Compaction using either:

- Penetration Index (PI) Method, or
- Specified Density Method, or
- Quality Compaction Method or
- Light Weight Deflectometer (LWD) Method.

Use the Specified Density method for acceptance for materials not meeting the requirements of 3149.2.B.1, "Granular Materials".

Use the granular penetration index method for materials meeting the requirements of 3149.2.B.1, "Granular Materials".

Test for compaction in areas with the greatest rutting or deflection, and near Structures.

Correct any area represented by a failing test. Perform additional tests in areas with the greatest rutting or deflection.

Use the Specified Density Method for virgin materials only.

G.3 Test Rolling

Observe and document all test rolling, per the Schedule of Materials Control and Contract.

H Finishing Operations

Shape and maintain the roadway core to the required grade and cross section and within the tolerance in accordance with 2112.3.E, "Tolerances" until the next layer is placed.

Perform earthwork finishing and topsoil placement operations concurrently to allow timely completion of erosion control items. Shape and maintain disturbed areas outside the road core to final grade prior to placing erosion control. Scarify the surface to a minimum depth of 3 in [75 mm] before placing topsoil. Complete soil preparation, erosion control and turf establishment, as required by 2574, "Soil Preparation", and 2575, "Establishing Turf and Controlling Erosion".

I Disposition of Excavated Material

All surplus materials become the property of the Contractor. Dispose of these materials in accordance with a disposal plan approved by the Engineer. The disposal plan must comply with all applicable environmental regulations, permit requirements and 2104, "Removing Pavement and Miscellaneous Structures". Disposal of materials before acceptance of the disposal plan is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work".

J Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2105.4 METHOD OF MEASUREMENT

A Excavation Material

The Engineer will measure and calculate excavated material quantities according to 1901, "Measurement of Quantities".

The Engineer will investigate disputed quantities and may adjust quantities based on excavation and embankment measurements taken during construction and after completion, in accordance with 1901, "Measurement of Quantities".

Quantities are limited to measurements within specified construction limits and variances authorized by the Engineer.

The Engineer will measure excavated quantities by excavated volume (EV).

The Engineer will take measurements to determine the limits of material classifications during excavation.

A.1 Rock Excavation
The Engineer will include the following in the measurement for rock excavation:

(1) Overbreakage if the plane of the bottom of the excavation falls within a layer or stratum of rock,
(2) 6 in [150 mm] overbreak allowance outside the grading section or as indicated in the plans and
(3) 24 in [600 mm] measured horizontally, overbreak allowance outside the backslopes for hard rock types.

The Engineer will not provide an allowance for overbreak of pre-split backslopes.

B Borrow Material
The Engineer will measure borrow material quantities by volume in accordance with 1901, "Measurement of Quantities."

The Engineer will deduct borrow quantities caused by excavation beyond the Contract limits.

The Engineer will deduct borrow quantities caused by placing embankment beyond the Contract limits.

The Engineer will measure all borrow quantities by compacted volume (CV).

C Blank

D Stabilizing Aggregate
The Engineer will measure Stabilizing Aggregate quantities by compacted volume (CV).

2105.5 BASIS OF PAYMENT
A Stabilizing Aggregate
The contract cubic yard [cubic meter] price for Stabilizing Aggregate includes the cost of production, testing, compaction and placement.

B Blank

C Borrow Materials
The contract unit price for borrow materials includes the cost of source preparation, excavation, testing, delivery, placement, compaction and final finishing.

Payment for necessary site preparation and restoration from stipulated sources will be compensated separately or as per 1402.5, "Extra Work", in the absence of a payment provision.

The Department will pay the contract unit prices of both the excavation and borrow contract item for excess material used as a borrow item.

D Excavated Materials
The contract unit price for excavated materials includes the cost of excavation, testing, final placement, construction of steps in existing slopes and disposal.

If the plans do not include a contract pay item for removal and disposal of debris, the Department will pay for these in accordance with 1402, "Contract Revisions."

D.1 Channel and Pond Excavation
The Department will pay an additional $1.00 per cubic yard [$1.30 per cubic meter] when the Engineer reclassifies *Common Excavation* to *Channel and Pond Excavation*.

D.2 Rock Excavation
The Department will pay an additional $20.00 per cubic yard [$26.00 per cubic meter] when the Engineer reclassifies *Common Excavation, Subgrade,* or *Channel and Pond Excavation* to *Rock Excavation*. The Department can only apply this price adjustment if the contract does not contain *Rock Excavation* and cannot exceed 250 cu. yd. [200 cu. m].

D.3 Rock Channel Excavation

The Department will pay an additional $100.00 per cubic yard [$130.00 per cubic meter] when the Engineer reclassifies *Channel and Pond Excavation* to *Rock Channel Excavation*. The Department can only apply this price adjustment, if the contract does not contain *Rock Channel Excavation* and cannot exceed 25 cu. yd. [20 cu. m].

D.4 Muck Excavation

The Department will pay for muck excavation deeper than the depth shown on the plans, in accordance with Table 2105-7.

Table 2105-7
Price Adjustments for Additional Muck Excavation

Depth below natural surface	Compensation
0 ft. – 15 ft. [0 m – 5 m]	*Muck Excavation* Contract Unit Price
> 15 ft. – 20 ft. [> 5 m – 7 m]	*Muck Excavation* Contract Unit Price plus $0.30 per cubic yard [$0.39 per cubic meter]
> 20 ft – 25 ft. [> 7 m – 9 m]	*Muck Excavation* Contract Unit Price plus $0.50 per cubic yard [$0.65 per cubic meter]
> 25 ft. [> 9 m]	Negotiated Price

NOTE: These price adjustments are payment in full for all additional costs incurred.
Exception: Compensation for additional Muck Excavation may be subject to the provisions of 1402, "Contract Revisions".

E Subgrade Preparation

Payment for subgrade preparation under 2105.3.C is incidental, unless there is a pay item for 2112, "Subgrade Preparation".

F (Blank)

G Partial Payment Withholdings

Comply with the payment withholding requirements of 2574, "Soil Preparation."

H Topsoil Borrow

The Department will pay for topsoil borrow in accordance with 2574, "Soil Preparation".

I Water

The cost of water used for compaction is incidental to embankment contract items.

J Monetary Price Adjustments Granular Materials

The Engineer may allow the Contractor to accept a monetary price adjustment instead of correcting failing granular material using granular monetary price adjustment tables found on the Grading and Base website.

The Department will add monetary price adjustments for each failing aggregate quality, crushing, sieve and bitumen content test result.

The maximum monetary price adjustment is 50%. The Department will apply the monetary price adjustment against the entire quantity represented by the failing test.

K Contract Item Schedule

The Department will pay for excavation and embankment on the basis of the following schedule:

Item No.:	Item:	Unit:
2105.501	Common Excavation	cubic yard [cubic meter]
2105.503	Rock Excavation	cubic yard [cubic meter]
2105.505	Muck Excavation	cubic yard [cubic meter]
2105.507	Subgrade Excavation	cubic yard [cubic meter]
2105.511	Channel and Pond Excavation	cubic yard [cubic meter]
2105.513	Rock Channel Excavation	cubic yard [cubic meter]
2105.521	Granular Borrow (1)	cubic yard [cubic meter]
2105.522	Select Granular Borrow (1)	cubic yard [cubic meter]
2105.523	Common Borrow (1)	cubic yard [cubic meter]
2105.541	Stabilizing Aggregate (1)	cubic yard [cubic meter]
2105.543	Stabilizing Aggregate	ton [metric ton]

NOTE: (1) Specify basis of measure: EV, LV, SV, or CV. See 2105.4 and 1901.

2106 EXCAVATION AND EMBANKMENT – COMPACTED VOLUME METHOD

2106.1 DESCRIPTION

This work consists of excavating and placing embankment. This work differs with 2105 in that it separates payment for both the excavation of in place soils, and the placement of embankment.

A Definitions

A.1 Road Core
The road core is the area below the grading grade to the bottom of the excavation and between the following:

(1) For embankment heights ≤ 30 ft, from the grading grade point of intersections (P.I.s) with a 1:1 (V:H) slope and
(2) For embankment heights > 30 ft, from the grading grade point of intersections (P.I.s) with a 1:1½ (V:H) slope.

A.2 Grading Grade
Grading grade is the bottom of the aggregate base.

A.3 Top of Subgrade
The top of the subgrade is the surface of material immediately beneath the granular material. If there is no granular layer, then the top of subgrade is the Grading Grade.

A.4 Optimum Moisture Content
The optimum moisture content is determined by the:

- Moisture Density Test Method (Proctor), or
- One-Point Proctor Method or
- Estimated Optimum Moisture Content Form G&B-305.

A.5 Maximum Density
Maximum density is the maximum density determined by the Moisture Density Test Method (Proctor) test in the Grading and Base Manual.

A.6 Select Grading Material
Select grading materials are all mineral soils found in the Triaxial Chart in the Grading and Base Manual, excluding silt. Silt is defined as soils containing 80% or more silt-sized particles. Marl and organic soils are also excluded.

A.7 Granular Materials
Granular materials meet the requirements of 3149.2.B.1.

A.8 Non-Structural Grading Materials
Non-Structural grading materials are all mineral soils, excess topsoil, and organic soils, capable of supporting construction equipment.

A.9 Uniform Soils
Uniform soils have the same soil class per the Triaxial Chart in the Grading and Base Manual and have similar color, moisture content and performance characteristics.

A.10 Organic Soils
Organic soils contain ≥ 5 percent organic content.

2106.2 MATERIALS

A Excavation Material
The Engineer will classify the excavation using the following categories:

A.1 Common Excavation
Material not classified in any other category.

A.2 Subgrade Excavation
All excavation in the road core below the grading grade, exclusive of rock, muck, channel or rock channel excavation.

A.3 Rock Excavation
Material that requires drilling, blasting or ripping before excavation. This includes boulders and other detached rock larger than 1 cu. yd.

A.4 Muck Excavation

The removal of organic soils as defined in 2106.1.A.10, "Organic Soils," and other unstable soils as designated by the plan, and below the natural ground level of marshes, swamps, or bogs, regardless of the moisture content. Muck excavation is limited to areas over which the roadway embankment or a Structure is to be constructed.

A.5 Channel and Pond Excavation

Material from channel changes, waterways, and ponds outside of the roadway embankment not classified as rock channel excavation.

A.6 Rock Channel Excavation

Material classified as rock excavation from channel changes and waterways outside of the roadway embankment.

A.7 Blank

B Embankment Material

Provide embankment material meeting the specifications in Table 2106-1.

Table 2106-1
Embankment Material Specifications

Material	Specification
Common Embankment	2106.1.A.6, "Select Grading Material"
Granular Embankment	3149.2.B.1, "Granular Material"
Select Granular Embankment	3149.2.B.2, "Select Granular Material"
Slope Dressing	3877, "Topsoil Material"

Materials obtained by the Contractor from sources outside the roadway must comply with 1601, "Source of Supply and Quality," and with 1602, "Natural Material Sources."

Excess materials from within the excavation limits shown on the plans that meet the specified requirements can be used by the Contractor for embankment items shown on the plans. These excess materials must comply with 1405, "Use of Materials Found on the Project."

C Blank

D Stabilizing Aggregate 3149.2.C

If the plans show a contract pay item for Stabilizing Aggregate, place it in accordance with 2211, "Aggregate Base".

2106.3 CONSTRUCTION REQUIREMENTS

A General

For road core embankment, use either select grading material per 2106.1.A.6 or granular materials per 3149.2.B.1.

Non-structural grading materials per 2106.1.A.8 may be used as embankment outside the road core.

All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated, all test procedures are in the Grading and Base Manual.

Perform excavation and embankment operations within the plan excavation limits as required by the contract.

Before beginning excavation and embankment operations, comply with the requirements of 2101, "Clearing and Grubbing."

Maintain drainage in excavations and embankment operations at all times. Provide and maintain temporary drainage facilities until the permanent facilities are complete and operational. These requirements do not override the provisions of 1806, "Determination and Extension of Contract Time".

Provide and maintain temporary preparation and erosion control on embankment and stockpiles until finishing operations are complete.

Repair or replace settlement plates damaged by construction operations.

Protect Structures during construction operations. Repair Structures damaged by construction operations.

Materials containing recycled bituminous can only be placed in and above the road core, or used in base per 3138, "Aggregate for Surface and Base Courses".

B Contractor Quality Control (QC) Testing

Perform tests as required in the Schedule of Materials Control.

Submit results to the Engineer within one hour after sampling.

Test corrected areas that fail either QC or Quality Assurance (QA) Testing.

Submit a preliminary, required before work commences, and final Grading and Base Report (G&B-001), and a weekly summary report of tests completed and retests of failing materials (G&B-003).

B.1 Aggregate Certification

Certify granular materials on Form G&B-104. Attach all required aggregate test results to Form G&B-104.

Material placed without certifications is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

B.2 Moisture Control

Determine the optimum moisture content.

Test for the moisture content in areas that appear least likely to meet specifications.

Determine the moisture content during compaction using test methods listed in the Grading and Base Manual or by alternate methods as approved by the Engineer.

Meet the moisture content requirements listed in Table 2106-2.

Table 2106-2
Moisture Content Requirements

Minimum Compaction Requirements	Relative Moisture Content *
100 % of maximum density	65 % – 102 %
95 % of maximum density	65 % – 115 %
Quality Compaction	65 % – 102 %
Penetration Index Method	≥ 65 %
* As determined on form G&B-105	

Correct for moisture content in areas represented by failing moisture tests, before testing the compaction. Compaction tests taken in areas represented by failing moisture tests are not valid.

B.3 Test Rolling

Test roll, per the Schedule of Materials Control and Contract, the top surface of non-granular subgrade and the top of any granular surface not meeting the requirements of 3149.2.B.2 per 2111 using the test roller as specified in the Contract. If no test roller is specified, use test roller TR10.

C Preparation of Embankment Foundation

Construct steps, before placing embankment material, at a minimum width of 12 in when slopes are steeper than 1:4 (V:H).

Ensure the foundation area drains freely.

Compact the bottom of the excavation according to Table 2106-3.

Table 2106-3 Required Compaction for Bottom of Excavation		
Excavation Depth Below Grading Grade *	**Relative Moisture Content ‖**	**Required Compaction**
< 30 in	65% to 102%	Compact to 100% of maximum density
≥ 30 in	65% to 115%	Compact to 95% of maximum density or compact with 4 passes of a roller, except around Structures †
Around Structures	65% to 102%	Compact to 100% of maximum density, or meet DCP requirements of Table 2105-6
*: Excavation below the planned subgrade may be subject to 1402, "Contract Revisions" ‖: An estimated value for the optimum moisture content may be used instead of determining this value using Form G&B-305. †: Roller must be adequate to compact lift thicknesses as placed. The Engineer may waive the four pass requirement, if the subgrade will not support the roller. Granular material ≥ 30" in depth must meet the compaction requirements of Table 2106-6. See Plan sheets for modifications, note especially compaction requirements directly beneath pipes, where no compaction may be required.		

Remove surfacing and excavate an existing road core in accordance with the Contract. Then perform subgrade preparation on the excavated portion and the new roadcore in accordance with 2112, "Subgrade Preparation," before placing new embankment material.

D Excavating Operations

Obtain the Engineer's written approval before excavating beyond the limits and elevations established by the contract.

Remove rock outcroppings from within the slope lines and to the elevations shown on the plans. Remove loosened rock from the backslopes. Provide drainage for the shoulder slopes. Do not leave undrainable depressions.

Presplit rock back slopes steeper than 1:1 (V:H). Control blasting operations to eliminate flying rock or debris.

Excavation below the planned subgrade to correct unstable conditions may be subject to 1402, "Contract Revisions"

E Placing Embankment Materials

Place embankments in uniform lifts, parallel to the Plan profile grade, over the full width of the roadway. Construct each lift of material using uniform soil.

Protect Structures during placement of embankments.

Place granular materials in the uppermost portion of the subgrade, if it does not significantly change normal grading operations.

Excavate, stockpile, and place topsoil as required by the contract.

Obtain written permission from the Engineer before removing topsoil or granular material from the project.

Embankment materials placed on the road core may not increase the moisture content of the underlying material beyond the specified limits.

Non-granular materials placed above granular material must be at least 4 ft. thick.

Maximum lift thicknesses are controlled by the capability of the equipment to uniformly compact the entire lift in accordance with the following:

(1) The Engineer will restrict lift thickness to no greater than 12 in (loose thickness), when uniform results are not achieved.
(2) The Engineer may allow thicker lifts over saturated foundation soils. The top of the thicker lift must be at least 4 ft. below the grading grade.

Uniformly blend the entire thickness of each lift before testing moisture content and compaction. Disc soils with greater than 20 percent passing the No. 200 sieve.

Stagger construction traffic uniformly over the full width of the roadway embankment.

Remove snow, ice, and frozen soils from road core before placing embankment.

Use embankment material in the road core with particle sizes no larger than specified in Table 2106-4:

Table 2106-4
Maximum Particle Size in Road Core

Depth from Grading Grade	Max. Particle Size Inches
< 12 in	3
1 ft. – 3 ft.	6
3 ft. – 6 ft.	12
> 6 ft.	24
≤ 2 ft. from a Structure	3
Areas where piling is to be placed	6

Remove surcharges as directed by the contract.

Install settlement plates, if required by the contract. Do not disturb settlement plates.

F Compacting Embankments

Maintain moisture content during compaction per Table 2106-2.

Meeting the requirements of 100% density for the specified density method is equivalent to meet the requirements for the penetration index method.

Correct the moisture in areas represented by failing tests before testing the compaction.

Compaction tests taken in areas represented by failing moisture tests are not valid.

Uniformly compact each lift of the road core:

- to the Specified Density requirements in 2106.3.F.1 for materials not meeting the requirements of 3149.2.B.1, "Granular Materials".
- or to the Penetration Index (PI) requirements in 2106.3.F.3 for materials meeting the requirements of 3149.2.B.1, "Granular Materials". For clean granular materials with less than 6% passing the #200 sieve, the Engineer may elect to use the Quality Compaction method, 2106.3.F.2.

Compact all roadway embankment outside of the road core from 80 to 85 percent of the maximum density, except for an excavated trench, meet the requirements of Table 2106-5.

Compact the entire length and width of each lift with a roller. Construction traffic does not replace the rolling requirement.

Compaction requirements on swamp backfills start when the road core embankment is 4 ft. above the water elevation at the time of construction operations.

The Engineer may waive mechanical compaction requirements on embankment containing predominately rock or topsoil.

Compact soils around Structures with appropriate equipment or hand methods, to prevent damage to adjacent Structures.

Correct or replace materials in areas represented by a failing test.

Maintain the required compaction until the next layer is placed.

The requirements of 2105.3.F.1, 2105.3.F.3 and 2105.3.F.4 include the requirements of Quality Compaction in 2105.3.F.2.

F.1 Specified Density

Compact to meet the requirements of Table 2106-5.

Table 2106-5 Specified Density Requirements	
Embankment Location	**Required Compaction (Relative Density)**
≤ 3ft Below Grading Grade of Road Core	100%
Subgrade Preparation	100%
Within an excavation trench*	100%
Remaining embankment in the road core	95%
* See Plan sheets for modifications, note especially compaction requirements directly beneath pipes, where no compaction may be required.	

F.2 Quality Compaction

Compact each lift until there is no evidence of consolidation during compaction or under traffic, with no:

- Pumping – vertical displacement of the top surface of the compacted layer, not directly under the vehicle tire.
- Reaction – a movement back to a former or less advanced condition.
- Yielding – giving under pressure (flexible)
- Cracking – cracking of material on visible surface
- Lateral movement – sideways movement of the top surface

F.3 Penetration Index (PI)

Compact the entire lift to achieve a dynamic cone penetration index (DPI) value per Table 2106-6.

Table 2106-6 Maximum Allowable Penetration for DCP			
Grading Number †	**Moisture Content ‖**	**Maximum Allowable DPI, *mm/blow***	**Maximum Allowable Seat, *mm***
3.1 – 3.5	< 5.0	10	No Requirement
	5.0 – 8.0	12	
	> 8.0	16	
3.6 – 4.0	< 5.0	10	
	5.0 – 8.0	15	
	> 8.0	19	
4.1 – 4.5	< 5.0	13	
	5.0 – 8.0	17	
	> 8.0	21	
4.6 – 5.0	< 5.0	15	
	5.0 – 8.0	19	
	> 8.0	23	
5.1 – 5.5	< 5.0	17	
	5.0 – 8.0	21	
	> 8.0	25	
5.6 – 6.0	< 5.0	19	
	5.0 – 8.0	24	
	> 8.0	28	
† As determined by Form G&B-203 ‖ Percent of dry weight. Note that a moisture test is not required, if the material meets the toughest requirements for the Grading Number.			

F.4 Light Weight Deflectometer (LWD) Method

Compact the entire lift to achieve an LWD target value as required per the LWD procedure for 2105 in the Grading and Base Manual.

G Agency Quality Assurance Testing (QA)

Test according to the Schedule of Materials Control.

G.1 Material Testing

Perform the following QA tests:

(1) Gradation,
(2) Crushing,
(3) Aggregate Quality and
(4) Bitumen content (using procedure 1852 in the Laboratory Manual).

Sample the granular materials from the road core after spreading but before compaction.

Select crushing, aggregate quality and bitumen samples using the random sampling method in the Grading and Base manual. Select gradation samples from locations that are at risk of not meeting the specification requirements.

G.2 Compaction Testing

Test for Compaction using either:

- Penetration Index (PI) Method, or
- Specified Density Method, or
- Quality Compaction Method or
- Light Weight Deflectometer (LWD) Method.

Use the Specified Density method for acceptance for materials not meeting the requirements of 3149.2.B.1, "Granular Materials".

Use the granular penetration index method for materials meeting the requirements of 3149.2.B.1, "Granular Materials".

Test for compaction in areas with the greatest rutting or deflection, and near Structures.

Correct any area represented by a failing test. Perform additional tests in areas with the greatest rutting or deflection.

Use the Specified Density Method for virgin materials only.

G.3 Test Rolling

Observe and document all test rolling, per the Schedule of Materials Control and Contract.

H Finishing Operations

Shape and maintain the roadway core to the required grade and cross section and within the tolerance in accordance with 2112.3.E, "Tolerances" until the next layer is placed.

Perform earthwork finishing and topsoil placement operations concurrently to allow timely completion of erosion control items. Shape and maintain disturbed areas outside the road core to final grade prior to placing erosion control. Scarify the surface to a minimum depth of 3 in before placing topsoil. Complete soil preparation, erosion control and turf establishment, as required by 2574, "Soil Preparation", and 2575, "Establishing Turf and Controlling Erosion".

I Disposition of Excavated Material

All surplus materials become the property of the Contractor. Dispose of these materials in accordance with a disposal plan approved by the Engineer. The disposal plan must comply with all applicable environmental regulations, permit requirements and 2104, "Removing Pavement and Miscellaneous Structures". Disposal of materials before acceptance of the disposal plan is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work".

J Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2106.4 METHOD OF MEASUREMENT

A Excavation Material

The Engineer will measure and calculate excavated material quantities according to 1901, "Measurement of Quantities".

The Engineer will investigate disputed quantities and may adjust quantities based on excavation and embankment measurements taken during construction and after completion, in accordance with 1901, "Measurement of Quantities".

Quantities are limited to measurements within specified construction limits and variances authorized by the Engineer.

The Engineer will measure excavated quantities by excavated volume (EV).

The Engineer will take measurements to determine the limits of material classifications during excavation.

A.1 Rock Excavation

The Engineer will include the following in the measurement for rock excavation:

(1) Overbreakage if the plane of the bottom of the excavation falls within a layer or stratum of rock,
(2) 6 in overbreak allowance outside the grading section or as indicated in the plans and
(3) 24 in measured horizontally, overbreak allowance outside the backslopes for hard rock types.

The Engineer will not provide an allowance for overbreak of pre-split backslopes.

B Embankment Material

The Engineer will measure embankment material quantities by volume in accordance with 1901, "Measurement of Quantities."

The Engineer will measure all embankment quantities by compacted volume (CV).

C Blank

D Stabilizing Aggregate

The Engineer will measure Stabilizing Aggregate quantities by compacted volume (CV).

2106.5 BASIS OF PAYMENT

A Stabilizing Aggregate

The contract cubic yard price for Stabilizing Aggregate includes the cost of production, testing, compaction and placement.

B Blank

C Embankment Materials

The contract unit price for embankment materials includes the cost of testing, delivery, placement, compaction and final finishing.

Payment for necessary site preparation and restoration from stipulated sources will be compensated separately or as per 1402.5, "Extra Work", in the absence of a payment provision.

D Excavated Materials

The contract unit price for excavated materials includes the cost of excavation, testing, construction of steps in existing slopes and disposal.

If the plans do not include a contract pay item for removal and disposal of debris, the Department will pay for these in accordance with 1402, "Contract Revisions."

D.1 Channel and Pond Excavation

The Department will pay an additional $1.00 per cubic yard when the Engineer reclassifies Common *Excavation* to *Channel and Pond Excavation*.

D.2 Rock Excavation

The Department will pay an additional $20.00 per cubic yard when the Engineer reclassifies *Common Excavation, Subgrade,* or *Channel and Pond Excavation* to *Rock Excavation*. The Department can only apply this price adjustment if the contract does not contain *Rock Excavation* and cannot exceed 250 cu. yd.

D.3 Rock Channel Excavation

The Department will pay an additional $100.00 per cubic yard when the Engineer reclassifies *Channel and Pond Excavation* to *Rock Channel Excavation*. The Department can only apply this price adjustment, if the contract does not contain *Rock Channel Excavation* and cannot exceed 25 cu. yd.

D.4 Muck Excavation

The Department will pay for muck excavation deeper than the depth shown on the plans, in accordance with Table 2106-7.

Table 2106-7 Price Adjustments for Additional Muck Excavation	
Depth below natural surface	**Compensation**
0 ft. – 15 ft.	*Muck Excavation* Contract Unit Price
> 15 ft. – 20 ft.	*Muck Excavation* Contract Unit Price plus $0.30 per cubic yard
> 20 ft – 25 ft.	*Muck Excavation* Contract Unit Price plus $0.50 per cubic yard
> 25 ft.	Negotiated Price
NOTE: These price adjustments are payment in full for all additional costs incurred. Exception: Compensation for additional Muck Excavation may be subject to the provisions of 1402, "Contract Revisions".	

E Subgrade Preparation

Payment for subgrade preparation under 2106.3.C is incidental, unless there is a pay item for 2112, "Subgrade Preparation".

F (Blank)

G Partial Payment Withholdings

Comply with the payment withholding requirements of 2574, "Soil Preparation."

H (Blank)

I Water

The cost of water used for compaction is incidental to embankment contract items.

J Monetary Price Adjustments Granular Materials

The Engineer may allow the Contractor to accept a monetary price adjustment instead of correcting failing granular material using granular monetary price adjustment tables found on the Grading and Base website.

The Department will add monetary price adjustments for each failing aggregate quality, crushing, sieve and bitumen content test result.

The maximum monetary price adjustment is 50%. The Department will apply the monetary price adjustment against the entire quantity represented by the failing test.

K Contract Item Schedule

The Department will pay for excavation and embankment on the basis of the following schedule:

Item No.:	Item:	Unit:
2106.501	Excavation – Common	cubic yard [cubic meter]
2106.503	Excavation – Rock	cubic yard [cubic meter]
2106.505	Excavation – Muck	cubic yard [cubic meter]
2106.507	Excavation – Subgrade	cubic yard [cubic meter]
2106.511	Excavation – Channel and Pond	cubic yard [cubic meter]
2106.513	Excavation – Rock Channel	cubic yard [cubic meter]
2106.521	Granular Embankment (CV)	cubic yard [cubic meter]
2106.522	Select Granular Embankment (1) (CV)	cubic yard [cubic meter]
2106.523	Common Embankment (CV)	cubic yard [cubic meter]
2106.541	Stabilizing Aggregate (CV)	cubic yard [cubic meter]
2106.543	Stabilizing Aggregate	Ton [Metric Ton]

(1) Specify basis of percent modification (e.g. 5%, 7%, 10% etc.)

2111 TEST ROLLING

2111.1 DESCRIPTION

This work consists of providing and operating equipment to test roll roadway embankments.

A Definitions

A.1 Strip

Strip is the area covered by the rolling tire.

2111.2 EQUIPMENT

Provide one or both test roller(s), as specified in the Contract, meeting the following applicable requirements:

A.1 Pneumatic Tires for Test Roller – 30 (TR30)

(1) Two pneumatic tires spaced at least 6 ft [1.8 m] apart, center to center,
(2) Tire sizes of 18 × 24 or 18 × 25, and
(3) Inflate tires to 95 psi [650 kPa].

A.2 Pneumatic Tires for Test Roller – 10 (TR10)

(1) Tire width maximum of 17 inches for the front axle tires, and a maximum of 11 inches for the rear axle tires, and
(2) Inflate tires to within 2 psi of tire or vehicle manufacturer's maximum psi rating. The minimum psi rating must be 80 psi.

B.1 Load for TR30

Provide a mass load on each tire from 14.9 ton to 15.1 ton [13.5 metric ton to 13.7 metric ton].

B.2 Load for TR10

Provide a tandem truck with a minimum legal capacity of 52,000 pounds, and a minimum front axle capacity of 20,000 pounds. Load the truck such that the front axle is loaded to a minimum of 16,000 pounds, and the total weight of the truck and load is a minimum of 50,000 pounds.

C Deflection Measurement

Measure deflection from the top of the unrolled embankment to bottom of the rut at the time of rolling.

Mark failing areas with an approved deflection measurement device approved by the Engineer, set to measure a depth per 2111.3B and mounted over the center of the front axle and offset 12 inches [300 mm] from the outside edge of each tire. The Engineer may allow alternate deflection recording devices.

2111.3 CONSTRUCTION REQUIREMENTS

All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.

Test roll on the layer as specified in the Contract. Use TR10 on Aggregate Surfacing (2118), Aggregate Base (2211), Full-Depth Reclamation (2215), Stabilized Full-Depth Reclamation (2215) and Shoulder Base Aggregate (2221). If a test roller is not designated in the Contract for Excavation and Embankment (2105 or 2106), use TR10.

Construct the embankment surface to the design cross section and profile as per 2112, "Subgrade Preparation."

For TR30, position the roller tongue parallel to the grade at the time of testing.

After test rolling, repair and maintain the surface per 2112, "Subgrade Preparation" until placement of the next layer.

Test roll the entire length and width at the top of layers designated in the Contract, from shoulder point of intersection to shoulder point of intersection or width of the subcut. Roll the first strip at the PI, roll subsequent passes with one wheel centered between the wheel paths of the previous pass, until the entire surface is covered at approximately a four foot interval between the center of each pass.

Weigh the test roller at an independent certified scale facility, and provide documentation to the Engineer.

Repair Structures damaged by contractor's activities, negligence or neglect.

A Testing Requirements

A.1 General

Make two passes over each strip covered by the tire width for non-granular materials, and one pass over each strip covered by the tire for granular materials at an operating speed from 2.5 mph to 5 mph [4 kph to 8 kph]. Granular materials are defined as meeting the requirements of 3149.2.B.1.

Protect all Structures from damage that may be caused by the test roller.

Engineer is to observe testing from behind the roller and mark and record failing areas immediately.

The Engineer may require a layer be tested again, if the next layer is not placed within the same construction season.

Keep roller parallel to grade when testing.

Correct areas that fail test rolling.

Test Roll Stabilized Full Depth Reclamation (2215) the day following the completion of compaction.

A.2 Testing Requirements Specific

(1) Surface Preparation

(a) Embankment surface (2105/2106) – Prepare the embankment surface within 4 in of the design cross-section and profile.
(b) Base or Surfacing surface (2118, 2211, 2215, 2221) – Perform test rolling prior to tolerancing.
(c) Compact surface with a smooth-drum compactor immediately prior to test rolling.
(d) Ensure the surface is free of marks, tracks, rutting, or ridged material to prevent collection of false readings.

B Acceptance Requirements

B.1 Acceptance Requirements TR30
Meet the applicable requirement for 2105 or 2106 materials listed in Table 2111-1 for TR30.

Table 2111-1 TR30
Acceptance Criteria – Maximum Deflection
Granular & Non-Granular Materials (2105, 2106)

Material Type	Maximum Deflection
Granular materials not covered by stabilizing materials	3 in
All other materials, including granular materials covered by stabilizing materials.	2 in

B.2 Acceptance Requirements TR10
Meet the criteria listed in Table 2111-2 for TR10, and the criteria for quality compaction in 2105.3.F.2.

Table 2111-2 TR10
Acceptance Criteria – Maximum Deflection

Material Type	Maximum Deflection
Granular & Non-Granular Materials (2105, 2106)	0.6 inches
Aggregate Surfacing (2118) Full-Depth Reclamation (2215) Aggregate Base (2211) Shoulder Base Aggregate (2221)	0.4 inches
Stabilized Full Depth Reclamation (2215)	0.3 inches

C Testing Corrected Areas
Repeat testing after all failing areas have been repaired.

The Engineer may waive repeat testing on corrected areas that are less than 2 road stations [50 m] in length.

D Hold Point
Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2111.4 METHOD OF MEASUREMENT
The Engineer will measure test rolling by length for the entire width, when it is listed as a contract item in the contract.

The Engineer will separately measure test rolling on each roadbed for divided highways.

All Test Rolling shall be combined into one quantity.

2111.5 BASIS OF PAYMENT

Test rolling on embankment constructed under this contract is incidental to the embankment contract item, unless it is listed as a separate contract item.

The Department will pay for all repairs to failing sections constructed under a previous contract in accordance with 1402, "Contract Revisions."

The Department will pay for test rolling embankment constructed under a previous contract based on the following schedule:

Item No.:	Item:	Unit:
2111.501	Test Rolling	road station [meter]

2112 SUBGRADE PREPARATION

2112.1 DESCRIPTION

This work consists of shaping, mixing, and compacting the subgrade, as defined in 2105.

2112.2 MATERIALS — (BLANK)

2112.3 CONSTRUCTION REQUIREMENTS

A General

All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.

Scarify, mix, and compact the top 6 in [150 mm] of the subgrade. Correct areas represented by failing tests.

Excavation below the planned subgrade to correct unstable conditions may be subject to 1402, "Contract Revisions".

B Contractor QC Testing

Perform Contractor QC testing in accordance with the Schedule of Materials Control.

Submit results to the Engineer within one hour after completion of test.

Submit a preliminary, required before work commences, and final Grading and Base Report (G&B-001), and a weekly summary report of tests completed and retests of failing materials (G&B-003).

B.1 (Blank)

B.2 Moisture Control During Placement

Determine the moisture content during compaction using test methods approved by the Engineer.

Provide daily QC testing results for the moisture content to the Engineer.

Maintain the moisture content during compaction between 65 percent and 102 percent of optimum moisture content.

C Density

Test for compaction compliance per 2105. Use the Specified Density Method for materials not meeting 3149.2.B.1 and use the Penetration index method for materials meeting 3149.2.B.1. Achieve and maintain the compaction requirements, until placement of the next Lift.

D Agency Quality Assurance Testing (QA)

Test according to the Schedule of Materials Control. The Engineer will test for compaction in areas with the greatest rutting or deflection. Retest failing areas after correction.

E Tolerances

Finish the surface of each layer within 0.05 ft [15 mm] above to 0.10 ft. [30 mm] below the cross section shown on the plans before placing the next layer.

F Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2112.4 METHOD OF MEASUREMENT

The Engineer will measure subgrade preparation by length, along the centerline of the embankment. The Engineer will separately measure work on each embankment on divided highways.

2112.5 BASIS OF PAYMENT

The contract road station [meter] price for Subgrade Preparation includes all costs of subgrade preparation on embankment constructed as required by this contract.

Areas not represented by passing QC tests are unacceptable work per 1512, "Unacceptable and Unauthorized Work."

The Department will pay for subgrade preparation on the basis of the following schedule:

Item No.:	Item:	Unit:
2112.501	Subgrade Preparation	road station [meter]

2118 AGGREGATE SURFACING

2118.1 DESCRIPTION

This work consists of placing an aggregate wearing course on the roadway and shoulders.

2118.2 MATERIALS

A Aggregate.....3138

Provide the class of aggregate as required by the contract, except that class 1 with a minimum bitumen content of 1.5% may be substituted for class 2, when used for shoulder surfacing.

2118.3 CONSTRUCTION REQUIREMENTS

All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.

Construct aggregate surfacing in accordance with 2211, "Aggregate Base." Use the Quality Compaction Method specified in 2105.3.F.2. Maintain the moisture content at or above 5 percent by dry weight during compaction.

A Contractor Quality Control (QC) Testing

Comply with the QC requirements of 2211, "Aggregate Base", and the Schedule of Materials Control.

B Agency Quality Assurance Testing (QA)

Comply with the requirements of 2211.3.D, "Agency Quality Assurance Testing". Use 2211.3.D.2b, "Quality Compaction Method" to verify compaction. Test according to the Schedule of Materials Control.

C Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2118.4 METHOD OF MEASUREMENT

The Engineer will measure the aggregate surfacing in accordance with 1901, "Measurement of Quantities."

The Engineer will not make deductions for the mass or volume of water and admixtures.

Mass and Volume conversion tables are in the Grading and Base Manual.

2118.5 BASIS OF PAYMENT

The contract unit price for the accepted quantities of material includes the costs of production, testing, placement and compaction.

All aggregate surfacing placed before the Engineer accepts the Contractor's certification is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

The Engineer may allow the Contractor to accept a monetary price adjustment instead of correcting failing material in accordance with:

- Table 2211-4,
- Table 2211-5,
- Table 2211-6 and
- The monetary price adjustment table for aggregate surfacing quality on the Grading and Base website.

The Department will add monetary price adjustments for each failing aggregate quality, crushing, sieve and bitumen content results.

The maximum monetary price adjustment is 50%.

The Department will apply the monetary price adjustment against the entire quantity represented by the failing test or lot. Apply a monetary price adjustment to a Lot failure and an individual failing test within a Lot.

The Department will pay for aggregate surfacing on the basis of the following schedule:

Item No.:	Item:	Unit:
2118.501	Aggregate Surfacing, Class ___	ton [metric ton]
2118.502	Aggregate Surfacing, (LV), Class ___	cubic yard [cubic meter]

2123 EQUIPMENT RENTAL

2123.1 DESCRIPTION

This work consists of providing laborers and operating equipment for work required by the contract, directed by the Engineer, and paid by the Department.

2123.2 GENERAL REQUIREMENTS

Provide equipment as approved by the Engineer.

Provide equipment with rubber tires or smooth street plates when operating on bituminous or concrete surfaces.

Provide towing equipment with sufficient power to tow equipment required by the contract and not damage the work

2123.3 SPECIFIC REQUIREMENTS

Provide rental equipment in accordance with the following specific requirements regarding type, size, capacity, power, or dimensions.

A Motor Grader

Provide a self-propelled motor grader with the following characteristics:

(1) Pneumatic-tired wheels,
(2) Power-assisted controls
(3) A mass of at least 19,000 lb [8,600 kg],
(4) Moldboard at least 12 ft [3.6 m] long with a suitable cutting edge, and
(5) A suitable scarifier.

B Dozer

Provide a crawler-type tractor with at least 75 hp [56 kw] at the tow bar and power assisted controls, equipped with an angle or fixed dozer blade at least 90 in [2.3 m] wide. When providing an angle blade, ensure that the blade will adjust to an angle of 90 degrees with the direction of travel of the tractor.

The Department will consider the dozer blade and tractor as a single unit.

C Scraper

Provide scrapers meeting the following characteristics:

(1) Carryall type scrapers mounted on pneumatic-tired wheels, or
(2) Rotary type scrapers towed by a tractor of suitable size, and
(3) Having a volumetric capacity as required by the contract that shall correspond with the manufacturer's rated heaped capacity.

D Dragline

Provide a full-revolving type dragline equipped with a bucket of at least the size required by the contract.

Provide 1 cu. yd [0.75 cu. m] draglines with at least a 45 ft [13.7 m] boom and a working radius of at least 35 ft [10.6 m].

Provide 2½ cu. yd [1.9 cu. m] draglines with at least an 80 ft [24.3 m] boom and a working radius of at least 60 ft [18.2 m].

Provide draglines in other sizes with the boom length and working radius as required by the contract.

For swamp work, provide one set of mats for each dragline. Provide mats each with a length at least equal to twice the distance between the outside edges of the crawler treads. Ensure the combined width of all the mats equals at least twice the bearing length of the crawler treads.

E Power Shovel

Provide a full-revolving, crawler-type power shovel with a bucket in the size recommended by the manufacturer. Provide the shovel in the size required by the contract in accordance with the bucket capacity.

F Tractor

Provide a crawler type tractor with the power at the draw-bar as required by the contract. Measure the power in horsepower [kilowatts].

G Pneumatic-Tired Roller

Provide pneumatic-tired rollers meeting the following characteristics:

(1) Compacting width of at least 5 ft [1.5 m],
(2) Constructed to allow the gross mass to vary, as directed by the Engineer, from 100 lb per in to 250 lb per in [1,700 kg per m to 4,400 kg per m] of rolling width,
(3) Tires arranged to obtain compaction over the full compacting width with each pass of the roller, and
(4) Self-propelled or provided with suitable tractive equipment, unless otherwise required by the contract.

If a single tractive unit propels more than one roller, the Engineer will count the combination as a single roller unit.

H Tamping Roller

Provide a tamping roller meeting the following characteristics:

(1) Consists of two sections, each with a drum at least 48 in [1.2 m] in diameter; and
(2) A gross mass and number of pads as approved by the Engineer.

I (Blank)

J Steel-Wheeled Roller

Provide a self-propelled steel-wheeled roller meeting the following characteristics:

(1) A total mass of at least 8 tons [7.3 tonnes] unless otherwise required by the contract,
(2) Capable of reversing without backlash,
(3) Equipped with spray attachments for moistening rolls on both the front and back, and
(4) Either tandem type or three-wheeled type, unless otherwise required by the contract.

If using vibratory rollers, use rollers that produce 250 lb per in [45 kN per m] of width.

K Truck

Provide a truck meeting the following characteristics:

(1) A manufacturer's rated capacity of at least 1.5 ton [1.3 metric ton],
(2) A volumetric capacity of at least 5 cubic yards [3.6 cubic meters],
(3) A power-operated hoist,
(4) A end dump type metal dump box, and
(5) A rear axle equipped with dual wheels and tires at least 8 in [200 mm] wide in accordance with the manufacturer's designated size.

L Rotary Tiller

Provide a rotary tiller at least 54 in [1,370 mm] wide and adjustable to depths up to 9 in [225 mm].

M Front End Loader

Provide a crawler type or rubber-tired front end loader meeting the following characteristics:

(1) Equipped with a power-operated loader bucket with the minimum struck capacity required by the contract,
(2) Capable of excavating at least 10 in [250 mm] deep below the bottom of the treads or tires, and
(3) Capable of loading the excavated material on the trucks used for hauling.

N Disk Harrow

Provide a disk harrow of sufficient size and mass to manipulate the soils to 12 in [300 mm] deep as approved by the Engineer.

2123.4 METHOD OF MEASUREMENT

A Equipment Hours

The Engineer will measure rental of each unit of equipment by the number of hours of actual working time and necessary traveling time within the project.

B Common Laborer Hire

The Engineer will measure common laborer hire by the hours of actual working time and necessary traveling time within the project.

2123.5 BASIS OF PAYMENT

The contract price per hour for equipment rental includes the cost of the use and operation of equipment, the operators and any tractive equipment and required accessories. The contract price per hour is subject to the requirements of this section for additional compensation if the Contractor is obligated to pay overtime wages for work performed on Sundays, holidays, or during overtime periods.

The contract price per hour for *Common Laborers* includes the cost of hand tools used by laborers. The contract price per hour is subject to the requirements of this section for additional compensation if the Contractor is obligated to pay overtime wages for work on Sundays, holidays, or during overtime periods.

The Department will only compensate the Contractor in addition to the Contract price per hour for equipment rental or common laborer hire for work performed during overtime periods or on Sundays or holidays if the work is directed by the Engineer. If the Engineer directs the use of equipment or common laborers during overtime periods or on Sundays or holidays, the Department will pay the Contractor only the increased wages that the Contractor is obligated to pay under the terms of wage agreements. The Department will pay the increased wages to the Contractor by increasing the contract price per hour for the equipment or common laborers used by an amount equal to the difference between the normal hourly wage for straight time work and the overtime hourly wage actually paid the laborers for operating the equipment or performing the labor, based on the Contractor's payroll.

The contract price per hour for equipment rental includes the cost of supervision by the Contractor necessary to accomplish the work, as directed by the Engineer.

The Department will provide payment for equipment rental on the basis of the following schedule:

Item No.:	Item:	Unit:
2123.501	Common Laborers	hour
2123.503	Motor Grader	hour
2123.506	___ cubic yard [cubic meter] Dragline	hour
2123.507	___ cubic yard [cubic meter] Shovel	hour
2123.508	___ cubic yard [cubic meter] Scraper	hour
2123.509	Dozer	hour
2123.510	___ cubic yard [cubic meter]Truck	hour
2123.511	___ horsepower [kilowatt] Tractor	hour
2123.512	Rotary Tiller	hour
2123.513	Disk Harrow	hour
2123.514	___ cubic yard [cubic meter] Front End Loader	hour
2123.521	Pneumatic-Tired Roller	hour
2123.522	Pneumatic-Tired Roller (Tractor Drawn)	hour
2123.523	Pneumatic-Tired Roller (Self Propelled)	hour
2123.524	Tamping Roller	hour
2123.525	___ ton [metric ton] Steel-Wheeled Roller	hour

2130 APPLICATION OF WATER FOR DUST CONTROL

2130.1 DESCRIPTION

This work consists of providing and applying water to control dust created by the traveling public within the project as directed by the Engineer.

2130.2 MATERIALS

Provide reasonably clean water.

2130.3 CONSTRUCTION REQUIREMENTS

Use a water supply and equipment capable of applying the quantity of water required to abate dust and avoid unwarranted loss of water through evaporation, absorption, or drainage. Apply the water at the time and in the quantity approved by the Engineer.

2130.4 METHOD OF MEASUREMENT

The Engineer will measure water for payment by volume. The Engineer may deduct payment for water wasted if the Contractor fails to coordinate the water application with other operations as directed by the Engineer.

2130.5 BASIS OF PAYMENT

The contract unit price for *Water* includes the cost of providing, transporting, and applying the water as directed by the Engineer. The Department will only pay for water applied for dust control for the project as approved by the Engineer.

The Department considers the cost of water used for the following as included in the contract unit prices for the relevant contract pay items:

(1) Water used for sprinkling,
(2) Water used in the construction of concrete pavements,
(3) Water used in the production or curing of concrete,
(4) Water used to maintain plant life,
(5) Water used in compacting soil and aggregate, and
(6) Water used for dust control on Contractor-selected haul roads, detours, or work sites outside of the project, and
(7) Water applied for dust control or pavement cleaning caused by the Contractor's equipment and operations, including abatement of nuisance dust for adjacent landowners and dust conditions detrimental to the safety of the traveling public, as directed by the Engineer.

The Department will pay for water applied to aggregate surfaces for dust control caused by the traveling public on portions of the project open to traffic as directed or approved by the Engineer at a unit price of $20 per 1,000 gal [$5.45 per cu. m] in the absence of the Contract Pay Item 2130.501.

The Department will pay for application of water for dust control on the basis of the following schedule:

Item No.:	Item:	Unit:
2130.501	Water	MGal [cubic meter]

2131 APPLICATION OF CALCIUM CHLORIDE

2131.1 DESCRIPTION

This work consists of applying calcium chloride as a surface treatment or as an admixture while grading or placing aggregate base or surface courses.

2131.2 MATERIALS

A Calcium Chloride.....3911

B Water

Provide water meeting the water quality rules established by the State of Minnesota.

2131.3 CONSTRUCTION REQUIREMENTS

All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.

A Surface Application

Apply a uniform layer of dry or liquid calcium chloride following the rates listed in the Grading and Base Manual.

B Admixture Application

Use one of the following calcium chloride application methods:

(1) Mix the calcium chloride with the aggregate during aggregate production. Use a separate conveyor or metering device to add calcium chloride to the aggregate.
(2) Apply dry calcium chloride as a surface application and mix with the specified layer.
(3) Apply calcium chloride solution as a surface application.

2131.4 METHOD OF MEASUREMENT

The Engineer will measure dry calcium chloride by weight and calcium chloride solutions by volume.

2131.5 BASIS OF PAYMENT

The Department will pay for the application of water used with dry calcium chloride in accordance with 2130, "Application of Water for Dust Control."

2131.5

The Department will pay for the application of calcium chloride on the basis of the following schedule:

Item No.:	Item:	Unit:
2131.501	Calcium Chloride, Type ___	ton [metric ton]
2131.502	Calcium Chloride Solution	gallon [cubic meter]

Base Construction

2211 AGGREGATE BASE

2211.1 DESCRIPTION
This work consists of placing aggregate base.

2211.2 MATERIALS
A Aggregate.....3138

Provide the class of aggregate as required by the contract.

2211.3 CONSTRUCTION REQUIREMENTS
All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.

A General
Remove aggregate base, placed under the contract that saturates subgrade soils, and then dry and re-compact the subgrade.

Compact and shape the aggregate base, to the plan dimensions, before suspending operations.

B Contractor Quality Control (QC) Testing
Test according to the Schedule of Materials Control.

Certify materials on Form G&B-104. Attach all required aggregate test results to Form G&B-104.

Submit results to the Engineer within one hour after sampling.

Submit a preliminary, required before work commences, and final Grading and Base Report (G&B-001), and a weekly summary report of tests completed and retests of failing materials (G&B-003).

Retest corrected base, which fails either QC or Quality Assurance (QA) testing. Correct failing material, before placing the next lift and provide copies to the Engineer before QA testing.

Test for the moisture content in areas that appear least likely to meet specifications.

Test roll, per the Schedule of Materials Control and Contract, the top surface per 2111 using test roller TR10.

Provide the Engineer a copy of the test results on a daily basis.

C Placing and Compacting
Ensure the underlying layer meets QC and QA requirements before the next layer is placed.

Maintain the moisture content per Table 2211-1.

Table 2211-1
Moisture Required for Base Compaction

Classification	Moisture Content (% by dry weight)
Class 3 and 4 (< 2.5% bitumen content)	≥ 7%
Class 5, 5Q and 6 (< 2.5% bitumen content)	≥ 5%
Classes 3, 4, 5, 5Q and 6 ≥ 2.5% bitumen content	3% ≤ moisture content ≤ 7%

Ensure the aggregate material has a uniform consistency before compaction.

Place and compact lifts per Table 2211-2.

Table 2211-2 Rollers Required for Compaction	
Base Lift Thickness / Bitumen Content	**Required Rollers**
≤ 3 in [75 mm] / Any Bitumen Content	Use Pneumatic Rollers only
> 3 in [75 mm] to ≤ 6 in [150 mm] / Bitumen Content ≤ 2.5%	Use both Vibratory and Pneumatic Rollers
> 3 in [75 mm] to ≤ 6 in [150 mm] / Bitumen Content > 2.5%	Use both Vibratory Pad Foot roller weighing at least 25,000 lb. [11,300 kg] and 25 ton [22.7 tonne] Pneumatic Roller

Place and compact the base to support traffic, while allowing no greater than ½ inch [13 mm] of surface displacement, when measured using a straightedge. Construct the aggregate layer to ±0.05 ft [15 mm] of the profile and cross-section as required by the contract in accordance with 2112, "Subgrade Preparation." Maintain the compaction, quality, integrity, and properties of the aggregate material in each lift until the next lift or layer is placed.

Uniformly compact each lift to meet the QA criteria listed in the Contract. Use the 2211.3.D.2.c, "Penetration Index Method".

Correct, blend and re-compact aggregate material represented by failing tests.

D Agency Quality Assurance (QA)

Test according to the Schedule of Materials Control.

D.1 Gradation and Aggregate Quality Sampling and Testing

Sample aggregates from the roadway after spreading but before compaction using the random sampling method in the Grading and Base Manual.

Test the entire lot or area of corrected material with new random samples.

The Engineer will test materials for the contract item *Stockpile Aggregates* before delivery and stockpiling.

D.2 Compaction

The Engineer will test for compaction in the areas with the greatest rutting or deflection.

The Engineer will perform a new test in corrected areas with the greatest rutting or deflection.

The Engineer will test the compacted aggregate material using the Penetration Index Method per 2211.3.D.2.c, "Penetration Index Method", unless designated otherwise in the Contract. Other compaction testing methods include 2211.3.D.2.a, "Specified Density Method" and 2211.3.D.2.b, "Quality Compaction Method" and are listed below.

The requirements of 2211.3.D.2.a, 2211.3.D.2.c and 2211.3.D.2.d include the requirements of Quality Compaction in 2211.3.D.2.b.

D.2.a Specified Density Method

Use the specified density method on virgin aggregates only.

Verify by testing that each lift is compacted to at least 100 percent of maximum density.

D.2.b Quality Compaction Method

Comply with the requirements of 2105.3.F.2.

D.2.c Penetration Index Method

Verify that each lift meets the penetration index and seating value per Table 2211-3.

Table 2211-3 Penetration Index Method — Maximum Seat and DPI				
Grading Number †	**Moisture Content‖**	**Maximum Allowable SEAT, *[mm]***	**Maximum Allowable DPI, *[mm/blow]***	**Test Layer, *in [mm] ****
3.1 – 3.5	< 5.0	40	10	4 – 6
	5.0 – 8.0	40	12	
	> 8.0	40	16	
3.6 – 4.0	< 5.0	40	10	4 – 6
	5.0 – 8.0	45	15	
	> 8.0	55	19	
4.1 – 4.5	< 5.0	50	13	5 – 6
	5.0 – 8.0	60	17	
	> 8.0	70	21	
4.6 – 5.0	< 5.0	65	15	6 – 12
	5.0 – 8.0	75	19	
	> 8.0	85	23	
5.1 – 5.5	< 5.0	85	17	7 – 12
	5.0 – 8.0	95	21	
	> 8.0	105	25	
5.6 – 6.0	< 5.0	100	19	8 – 12
	5.0 – 8.0	115	24	
	> 8.0	125	28	

† As determined by Form G&B-204
‖ Percent of dry weight.
* If layer to be placed is thinner than the Test Layer, use 2211.3.D.2.b, "Quality Compaction Method".
Note: When bitumen content is ≥ 2.5%, compact to achieve a penetration index value of 10 mm and a seating value of 40 mm, as determined by Form G&B-205.
Note that a moisture test is not required, if the material meets the toughest requirements for the Grading Number.

D.2.d Light Weight Deflectometer (LWD) Method

Compact the entire lift to achieve an LWD target value as required per the LWD procedure for 2211 in the Grading and Base Manual.

D.3 Test Rolling

Observe and document all test rolling, per the Schedule of Materials Control and Contract.

E Aggregate for the Contract Item *Stockpile Aggregate*

Produce and certify the class of material required by the contract using form G&B-104.

Deliver and stockpile certified material to the designated sites listed in the contract.

F Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2211.4 METHOD OF MEASUREMENT

The Engineer will measure the aggregate base per 1901, "Measurement of Quantities". The Engineer will not deduct the mass or volume of water and admixtures.

Mass and volume conversion tables are in the Grading and Base Manual.

2211.5 BASIS OF PAYMENT

The contract unit price for the accepted quantities of *Aggregate Base* includes the costs of production, testing, placement and compaction.

The contract unit price for the accepted quantities of *Stockpile Aggregate* includes the costs of production, testing, delivery and stockpiling at the designated site.

Aggregate base placed before the Engineer accepts the Contractor's certification is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

The Engineer may allow the Contractor to accept a monetary price adjustment instead of correcting failing material in accordance with:

- Table 2211-4,
- Table 2211-5,
- Table 2211-6,
- The monetary price adjustment table for aggregate base quality on the Grading and Base website.

The Department will add monetary price adjustments for each failing aggregate quality, crushing, sieve and bitumen content results.

The maximum monetary price adjustment is 50%.

The Department will apply the monetary price adjustment against the entire quantity represented by the failing test or lot. Apply a monetary price adjustment to a Lot failure and an individual failing test within a Lot.

Table 2211-4
Aggregate Gradation Monetary Price Adjustment Schedule
Based on the Average of Four Samples per Lot

Percent Passing Outside Specified Limits for Sieves			Monetary Price Adjustment %
2 in, 1½ in, 1 in, ¾ in, ⅜ in & No. 4 [50, 37.5, 25, 19, 9.5 & 4.75 mm]	No. 10 & No. 40 [2.00 mm & 425 µm]	No. 200 [75 µm]	
3-5	1	0.1	5
—	—	0.2	6
6	—	—	7
7	—	0.3	9
8	—	0.4	11
9	—	—	13
—	—	0.5	14
10	2	0.6	15
> 10	> 2	> 0.6	Corrective action required

Table 2211-5
Aggregate Gradation Monetary Price Adjustment Schedule
Based on an Individual or Average of Two or Three Samples

Percent Passing Outside Specified Limits for Sieves			Monetary Price Adjustment %
2 in, 1½ in, 1 in, ¾ in, ⅜ in & No. 4 [50, 37.5, 25, 19, 9.5 & 4.75 mm]	No. 10 & No. 40 [2.00 mm & 425 µm]	No. 200 [75 µm]	
3-5	1	0.2 – 0.6	1
—	—	0.7	2
6	—	0.8	3
—	—	0.9 – 1.0	4
7	—	1.1	5
—	—	1.2	6
8	—	1.3	7
—	—	1.4	8
9	—	1.5	9
—	2	1.6 – 1.7	10
10	—	1.8	11
—	—	1.9	12
—	—	2.0	13
—	—	2.1	14
—	3	2.2–2.5	15
>10	>3	>2.5	Corrective action required

Table 2211-6 Bitumen Content Monetary Price Adjustment Schedule	
Bitumen Content (Composite Mixture) %	**Monetary Price Adjustment %**
3.7	1
3.8	2
3.9	3
4.0	4
4.1	6
4.2	8
4.3	10
4.4	12
4.5	15
> 4.5	Corrective action required

The Department will pay for aggregate base on the basis of the following schedule:

Item No.:	Item:	Unit:
2211.501	Aggregate Base, Class ___	ton [metric ton]
2211.502	Aggregate Base (LV), Class ___	cubic yard [cubic meter]
2211.503	Aggregate Base (CV), Class ___	cubic yard [cubic meter]
2211.505	Stockpile Aggregate, Class ___	ton [metric ton]
2211.506	Stockpile Aggregate (LV), Class ___	cubic yard [cubic meter]
2211.507	Stockpile Aggregate (SV), Class ___	cubic yard [cubic meter]

2212 DRAINABLE AGGREGATE BASE

2212.1 DESCRIPTION

This work consists of constructing a drainable Aggregate Base on a finished base or filter layer.

2212.2 MATERIALS

Provide the drainable base of the type designated in the Contact.

A Drainable Bases.....3136

2212.3 CONSTRUCTION REQUIREMENTS

All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.

A General

Before placing the drainable base, shape the underlying surface in accordance with the contract and 2112.3.E, "Tolerances."

Maintain a uniform gradation during placement.

B Contractor Quality Control (QC) Testing

Test according to the Schedule of Materials Control.

Certify materials on Form G&B-104, "Certification of Aggregate and Granular Materials". Attach all required aggregate test results to Form G&B-104.

Submit a preliminary, required before work commences, and final Grading and Base Report (G&B-001), and a weekly summary report of tests completed and retests of failing materials (G&B-003).

C Placing and Compacting

Maintain the moisture content from 3 to 7 percent by dry weight during compaction.

Provide placement equipment meeting the following requirements:

(1) Will not rut the in-place surface,
(2) Will not displace or damage any geotextile and
(3) Capable of placing the required thickness without creating segregation.

Vibratory rollers are not allowed. Do not allow traffic on the drainable base after final placement and compaction. Meet the quality compaction requirements of 2105.3.F.2, "Quality Compaction." Maintain drainage.

Construct the aggregate layer to ±0.05 ft [15 mm] of the profile and cross-section as required by the contract in accordance with 2112, "Subgrade Preparation." Maintain the surface, quality, integrity, and properties of the aggregate material in each lift until the next lift or layer is placed.

D Agency Quality Assurance Testing (QA)

Test according to the Schedule of Materials Control.

Sample and test from the roadway after spreading but before compaction using the random sampling method in the Grading and Base Manual.

Test the entire lot or area of corrected material with new random samples.

Verify compaction per 2105.3.F.2, "Quality Compaction."

E Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2212.4 METHOD OF MEASUREMENT

Measure the material in accordance with 1901, "Measurement of Quantities".

2212.5 BASIS OF PAYMENT

The contract unit price for the accepted quantities of Drainable Aggregate Base includes the costs of production, testing, placement and compaction.

Drainable aggregate base placed before the Engineer accepts the Contractor's certification is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

The Engineer may allow the Contractor to accept a monetary price adjustment, instead of correcting failing material in accordance with drainable aggregate gradation and quality monetary price adjustment tables on the Grading and Base website.

The Department will add price adjustments for each failing sieve and quality content result.

The maximum monetary price adjustment is 50%.

The Department will apply the monetary price adjustment against the entire quantity represented by the failing test or lot. Apply a monetary price adjustment to a Lot failure and an individual failing test.

The Department will pay for drainable base on the basis of the following schedule:

Item No.:	Item:	Unit:
2212.501	Drainable Aggregate Base, Type (1) (CV)	cubic yard [cubic meter]

Note (1): Specify Type either OGAB or DSB.

2215 RECLAMATION

The subsections below are designated so an "A" subsection refers to All Reclamation, a "B" subsection refers to Full Depth Reclamation (FDR) and a "C" subsection refers to Stabilized Full Depth Reclamation (SFDR), as illustrated here:

2215.X Topic
A Topic – All Reclamation
B Topic – Full Depth Reclamation (FDR)
C Topic – Stabilized Full Depth Reclamation (SFDR)

2215.1 DESCRIPTION

A Description – All Reclamation

A.1 Definitions

A.1.a Pulverized (un-stabilized) Material

Pulverized material is produced by grinding the bituminous pavement with a portion of the underlying granular material. It may also include additional materials, such as add rock or compaction aids.

A.1.b Bituminous Stabilized Material

Bituminous Stabilized Material is pulverized material that has had a bituminous stabilizing agent (emulsion or foamed asphalt) added to it. It may also include additional materials, such as cement or add rock.

B Description – Full Depth Reclamation (FDR)

This work consists of pulverizing and blending the in-place bituminous pavement with a portion of the underlying material to produce a uniformly mixed aggregate base.

The work includes spreading, watering, compacting, shaping and maintaining the blended reclaim material to the specified profile and cross-section.

If a compaction aid is used, a second pulverization, mixing and compaction occurs after the initial phase.

C Description – Stabilized Full Depth Reclamation (SFDR)

Construct a stabilized full depth reclamation (SFDR) layer by:

Pulverizing and blending the in-place bituminous pavement structure with a portion of the underlying material, mixing it with a specified bituminous material and additional materials, if required, shaping and compacting. The process is performed in two steps: an initial pulverization and compaction, and a final pulverization, mixing and compaction.

2215.2 MATERIALS

A Materials – All Reclamation

A.1 Additional Aggregates

Provide additional aggregates as required by the Contract.

A.2 Water

Provide mixing water that meets 3906, "Water for Concrete and Mortar".

B Materials - Full Depth Reclamation (FDR)

B.1 Modified Aggregate Bases 3135

B.2 Compaction Aids

Provide Compaction aids, if required by the Contract.

C Materials - Stabilized Full Depth Reclamation (SFDR)

C.1 SFDR Design Parameters

The mix design criteria for SFDR in the Grading and Base Manual section 5-692.290. The Agency will provide the mix requirements on Form G&B-408 in the Contract documents.

C.1.a Design Requirements

Meet the mix Design Parameters listed on Form G&B-408.

C.2 Gradation

Meet the gradation requirements of Table 2215-1.

Table 2215-1 Gradation Requirements	
UnStabilized Portion	
Sieve Size	**Percent Passing**
3″	100
2″	90 – 100
Stabilized Portion	
Sieve Size	**Percent Passing**
1.5″	98 – 100

C.3 Bituminous Material

Provide the type and grade of Bituminous Material for Mixture (liquid bituminous material) at the rate in the mix design on Form G&B-408. Meet the requirements of 3151. Note that application rate of bituminous material may need to be varied throughout the project as material properties change.

C.4 Mineral Stabilizing Agent (Cement or Lime)

Provide mineral stabilizing agent(s) at the rate required by the Contract.

- Cement must conform to 3101, "Portland Cement".
-

- Hydrated Lime must conform to 3106, "Hydrated Lime".

2215.3 CONSTRUCTION REQUIREMENTS

A Construction Requirements – All Reclamation

- All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.
- Repair structures damaged by Contractor: operations, neglect or negligence.
- Correct and re-test all failing areas.
- Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

A.1 Contractor Quality Control (QC) Testing

- Test according to the Schedule of Materials Control.
- Submit results to the Engineer within one hour after sampling.
- Submit two Grading and Base Reports (G&B-001) as follows:
  - a preliminary report, required before work commences; and
  - a final report, after completion of grading and base work.
- Submit a weekly summary report of tests completed and retests of failing materials (G&B-003).
- Sample and test for gradation within the first 500 ft [150 m] of production and within 500 ft [150 m] after a failing gradation.
- Correct and retest all failing areas, which fail either Quality Control or Quality Assurance Testing.

A.2 Agency Quality Assurance (QA) - General

Test according to the Schedule of Materials Control.

B Construction Requirements – Full Depth Reclamation (FDR)

B.1 Agency Quality Assurance (QA) – FDR

- Test compaction using the Penetration Index Method.
- Sample for gradation, according to the Grading and Base Manual, after spreading but before compaction.

B.2 General FDR Requirements

Remove all reclaimed pavement pieces that would be retained on a three inch sieve, from the right-of-way.

B.3 Equipment Requirements

B.3.a Reclaiming Machine

Use a road reclaiming machine capable of uniformly pulverizing the pavement and the underlying layer to the specified depth and gradation.

B.4 Rollers

B.4.a Pneumatic-Tired Roller

Use a pneumatic-tired roller weighing at least 25 ton [22.7 tonne] or 616 lb per in [111 kg per cm] of rolling width. Ensure the tire arrangement allows compaction over the full width of the roller with each pass.

B.4.b Pad Foot Vibratory Roller

If required in 2215.3.B.7, use a pad foot roller weighing at least 25,000 lb [11,300 kg].

B.5 Pulverizing Operation

- Before beginning pulverization, remove vegetation and topsoil adjacent to the surface.
- Blend, add water, spread, compact, and shape pulverized material by the end of the workday.
- Protect and avoid damaging Structures during pulverization.
- Correct reclaim sections represented by a failing gradation.

B.6 Incorporation of Additional Aggregates and/or Compaction Aids

- If required of the Contract, uniformly spread additional aggregates across the roadway surface to be reclaimed before incorporating it into the reclaim mixture.
- If required of the Contract, inject and automatically meter compaction aids within the reclaimer using a second reclamation pass.

B.7 Placing and Compacting

- Uniformly mix reclamation material before spreading.
- Spread and compact the reclamation material to the profile and cross section shown on the plans before placing the next layer.
- Maintain the moisture content from 3 to 7 percent by dry weight during compaction.
- Place and compact reclamation materials in maximum 3-inch [75 mm] lifts using a pneumatic-tired roller in compliance with 2215.3.B.4.
- For lifts thicknesses from 3 inches [75 mm] to 6 inches [150 mm] compact using both a pneumatic-tired and pad foot vibratory rollers in compliance with 2215.3.B.4.
- The Engineer may allow the contractor to compact using a lift thickness up to 12 inches [300 mm], as long as passing compaction results are obtained.
- The Contractor may use excess reclamation material from other locations on the project to attain the profile or cross-section as shown on the plans.
- Compact the full thickness to achieve a penetration index value of 10 mm and a seating value of 40 mm as measured by the MnDOT Standard Dynamic Cone Penetrometer (DCP) method, as determined by Form G&B-205.
- Place and compact to support traffic, while allowing no greater than ½ inch [13 mm] of surface displacement, when measured using a straightedge.
- Construct the layer to ±0.05 ft [15 mm] of the profile and cross-section as required by the contract in accordance with 2112, "Subgrade Preparation."

B.8 Workmanship, Quality, Repair and Maintenance

The Engineer will provide staking to re-establish the centerline, when Contractor-staking is not required by the contract.

Maintain the compaction, quality, integrity, and properties of the aggregate material in each lift until the next lift or layer is placed.

Repair ruts, potholes, wash-boarding and other distortions by scarifying to a depth of 2 inches [50 mm] below the deepest distortion and re-compact.

C Construction Requirements – Stabilized Full Depth Reclamation (SFDR)

C.1 General SFDR Requirements

Provide water in order to obtain maximum density.

Stabilize when:

1. The atmospheric temperature is 50°F and rising,
2. It is not foggy or rainy and
3. Freezing temperatures are not predicted within 48 hours after placement of SFDR.

Atmospheric temperature and predicted weather requirements are determined by the Engineer.

C.2 Equipment

C.2.a Reclaiming Machine

Provide a self-propelled reclaiming machine with the ability to:

1. Uniformly pulverize the pavement and the underlying layer to the specified depth and gradation requirements of Table 2215-1.
2. Thoroughly mix the reclaimed pavement while injecting the liquid bituminous material and automatically metering it with a variation of not more than ±0.1 percent by weight. It must be capable of adding an additional 6 percent asphalt by total weight.
3. Automatically control cross-slope and control cutting depth to within ± ¼ inch of the depth shown on the Plans.

4. Maintain the designed asphalt content of overlapped mixtures by adjusting the application of bituminous material for the width of pulverized layer. Automatically maintain the designed asphalt content regardless of machine speed, depth of cut, and number of operating nozzles. Provide means for automatically cleaning nozzles and continual observation and measurement by the operator.

For foamed asphalt applications, the reclaiming machine must also:

1. Accurately foam bituminous material and uniformly add specified water.
2. Provide samples of the foamed bituminous material through a sampling nozzle.

C.2.b Rollers

C.2.b (1) Pneumatic-Tired Roller
Provide at least one Pneumatic Tired Roller that meets the requirements of 2360.3.B.2.e(2) and has a minimum weight of 25 tons.

C.2.b (2) Pad Foot Vibratory Roller
Use a pad foot roller weighing at least 12.5 ton.

C.2.b (3) Steel-Wheeled Roller
Use a double drum vibratory meeting the requirements of 2360.3.B.2.e(1) and is equipped with a water spray system.

C.2.c Bituminous Material for Mixture Supply Tankers
When foaming, tankers must be equipped with a visible thermometer that measures the temperature of the liquid Bituminous Material for Mixture in the bottom third of the supply tank.

C.2.d Vane Feeder
When mineral stabilizing agent is required, provide a vane feeder capable of uniformly spreading mineral stabilizing agents on the road surface prior to reclaiming.

C.2.e Motor Grader
Use a self-propelled motor grader with a minimum 12 foot wide blade

C.3 Pulverization

- Pulverize (grind) and uniformly blend the in-place bituminous pavement with the underlying granular base to the gradation requirements of Table 2215-1.
- If required of the Contract, uniformly spread additional material across the roadway surface to be reclaimed before incorporating it into the reclaim mixture.
- Correct reclaim sections that do not comply with table 2215-1 by re-pulverizing.

C.4 Spreading & Compaction of the Unstabilized Material

- Spread, shape and compact the pulverized material to the profile and cross section shown on the plans.
- Maintain the moisture content from 3 to 7 percent by dry weight during compaction.
- Place and compact pulverized (un-stabilized) materials in maximum 6-inch lifts.
- Compact the initial pulverized layer to a maximum penetration index value of 10 mm as measured by the MnDOT standard Dynamic Cone Penetrometer (DCP) device.
- Blend, add water, spread, compact and shape pulverized material by the end of each workday, and before any significant rainfall event occurs.

C.5 Spreading Mineral Stabilizing Agent

- Spread mineral stabilizing agent using a vane feeder in a manner that minimizes dusting, i.e. do not spread when the wind is strong enough to coat traffic and/or the environment.
- Control the mineral stabilizing agent content to within ± 0.5 pounds/sy, of the mix design target from Form G&B-408.
- Start mixing operations, no longer than ½ hour after spreading stabilizing agent.

C.6 Mixing/Injecting

- Produce the SFDR layer by mixing and injecting the liquid bituminous material into the pulverized pavement.
- Use a minimum 6 inch overlap between passes of the reclaimer.

- Demonstrate that the asphalt stabilizing agent is uniformly blended into the in-place re-cycle pavement. If the first mixing fails to produce uniformity, remix the stabilized layer until it is achieved.
- Maintain bituminous material within ±10^0 F of the optimum temperature recommended by the supplier. If the supplier does not provide a recommendation, maintain the foamed asphalt temperature between 305^0 F & 325^0 F.
- Obtain the Engineer's authorization to apply Bituminous Material for Mixture greater or less than ±0.3% by weight (0.2% for foamed asphalt) compared to the mix requirements on Form G&B-408.

C.7 Compaction of Bituminous Stabilized Material

Complete the initial compaction (i.e. a pad foot compactor "walks out") of the bituminous stabilized material prior to shaping.

C.8 Shaping and Compacting of Bituminous Stabilized Material

Remove any remaining pad foot marks and spread the material.

Place and compact the material to within ±0.05 feet of the profile and so that the cross section has no variations greater than ½ inch within 10 feet.

C.8.a Control Strip

Use a control strip to establish a rolling pattern. The control strip should represent a homogenous roadway section and have the following characteristics:

- Minimum area of 400 square yards
- Remain in-place and become a part of the completed work.

Use the following to establish a rolling pattern after initial breakdown is complete:

1. Randomly select three test points in the control strip and use a nuclear density device (ASTM D2950, in back-scatter mode) to determine a wet density at each point after each finish (steel) roller pass.
2. Ensure that that the nuclear gauge rests on a flat surface. The density at each point is defined as the average of two readings offset 180 degrees.
3. Continue compacting until additional roller coverage does not produce appreciable increase in density. Provide documentation of the growth curve and maximum target density to the Engineer. Use this for QA/QC process.
4. Roll the remainder of that course in accordance with the pattern developed in the control strip for that roller.
5. Discontinue and reevaluate the rolling operation (pattern and timing), if surface cracking or checking occurs.

Use this rolling pattern until a new control strip is performed.

Establish a new rolling pattern by performing a new control strip when there are changes in the mixture that cause the original control strip to no longer be representative; changes may include:

- In-place materials variation, including sections with varying thickness, construction history, etc.
- If vehicles leave indents in the compacted surface.
- Changes in RAP gradation
- 96% of Target Density is not achieved on two consecutive QC or QA readings.
- Changes in the application rate of Bituminous Material for Mixture, greater than 0.2% for foaming or 0.3% for emulsion.

C.9 Workmanship, Quality, Repair and Maintenance

Maintain the compaction, quality, integrity, the profile and cross section to within the criteria of 2215.3.C.8 and properties of the SFDR layer during the curing period until the placement of the next layer.

Immediately prior to placement of the next layer, clean the SFDR surface and remove loose aggregate.

The Engineer will provide staking to re-establish the centerline, when Contractor-staking is not required by the contract.

Repair ruts, potholes, washboarding and other distortions.

C.10 Fog Seal and Bituminous Requirements

Apply a CSS-1h bituminous fog seal per 2355, "Bituminous Fog Seal" at a rate of 0.10 to 0.16 gallons per square yard prior to placing the asphalt pavement.

Place the asphalt pavement a minimum of 3 calendar days after the SFDR has been placed and when the moisture content of each test result is 3.0% or less or has not changed by more than 0.2% in three days and is less than 3.5%. The Engineer may adjust the target moisture content, if field conditions do not result in a moisture of 3.5% or below.

2215.4 METHOD OF MEASUREMENT

A BLANK

B Method of Measurement – Full Depth Reclamation (FDR)
The Engineer will measure the reclamation area by the square yard.

C Method of Measurement – Stabilized Full Depth Reclamation (SFDR)
The Engineer will measure the Bituminous Stabilized Full Depth Reclamation (SFDR) by the square yard.

The Engineer will measure the Bituminous Material for Mixture by the ton.

The Engineer will measure the bituminous fog seal by gallon [liter].

2215.5 BASIS OF PAYMENT

A All Reclamation
The contract unit prices for the reclamation includes the cost of production, testing, placement, occasional variations in the bituminous pavement thickness, removing vegetation and topsoil adjacent to the surface, repair to Structures damaged by Contractor's operations and necessary maintenance.

Payment for any required mineral stabilizing agents, compaction aids, additional aggregate, or other additives designated in the Contract is incidental.

The Agency will pay for the correction of unstable areas through no fault of the Contractor's operations, if directed by the Engineer, per 1402.5, "Extra Work".

The Department will pay for reclamation on the basis of the following schedule:

Item No.:	Item:	Unit:
2215.501	Full Depth Reclamation	square yard [square meter]
2215.502	Haul Full Depth Reclamation (LV)	cubic yard [cubic meter]
2215.501	Stabilized Full Depth Reclamation	square yard [square meter]
2331.509	Bituminous Material for Mixture	Ton [Tonne]
2355.502	Bituminous Material for Fog Seal	Gallon [liter]

2221 SHOULDER BASE AGGREGATE

2221.1 DESCRIPTION
This work consists of placing Contractor-certified aggregate on shoulder base adjacent to pavements.

2221.2 MATERIALS
A Aggregate.....3138
Use the class of aggregate required by the contract.

2221.3 CONSTRUCTION REQUIREMENTS
A General
All forms and the Grading and Base Manual are available on the Grading and Base Website. Unless otherwise designated all test procedures are in the Grading and Base Manual.

Comply with the requirements of 2211.3.A, "Construction Requirements, General."

B Contractor Quality Control (QC) Testing
Comply with the requirements of 2211.3.B, "Contractor Quality Control (QC) Testing."

C Shoulder Preparation
Comply with the requirements of 2211.3.C, "Placing and Compacting"; however, compact the existing material using the Quality Compaction Method as specified in 2105.3.F.2, "Quality Compaction."

Remove vegetation and replace contaminated material as directed by the Engineer.

Shape the bottom of the proposed shoulder aggregate to the grade and cross section as shown on the plans.

Do not place shoulder aggregate on the existing pavement surface.

Immediately sweep spilled material from the pavement surface.

D Agency Quality Assurance Testing (QA)

Comply with the requirements of 2211.3.D, "Agency Quality Assurance Testing". Test according to the Schedule of Materials Control.

E Tolerances

Construct aggregate shouldering in accordance with 2112.3.E, "Tolerances."

F Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2221.4 METHOD OF MEASUREMENT

The Engineer will measure the shoulder aggregate in accordance with 1901, "Measurement of Quantities."

The Engineer will not deduct the mass or volume of water and admixtures.

Mass and volume conversion tables are in the Grading and Base Manual.

2221.5 BASIS OF PAYMENT

The contract unit price for placing shoulder base aggregate includes the costs of the removing vegetation, production, testing, placement, compaction and shaping.

All shoulder base aggregate placed before the Engineer accepts the Contractor's certification is unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

The Engineer may allow the Contractor to accept a monetary price adjustment instead of correcting failing material in accordance with:

- Table 2211-4,
- Table 2211-5,
- Table 2211-6 and
- The monetary price adjustment table for shoulder base aggregate quality on the Grading and Base website.

The Department will add monetary price adjustments for each failing aggregate quality, crushing, sieve and bitumen content results.

The Department will apply the monetary price adjustment against the entire quantity represented by the failing test or lot. Apply a monetary price adjustment to a Lot failure and an individual failing test.

The maximum monetary price adjustment is 50%. The Department will pay for shoulder base aggregate on the basis of the following schedule:

Item No.:	Item:	Unit:
2221.501	Shoulder Base Aggregate, Class ___	ton [metric ton]
2221.502	Shoulder Base Aggregate (LV), Class ___	cubic yard [cubic meter]
2221.503	Shoulder Base Aggregate (CV), Class ___	cubic yard [cubic meter]

2231 BITUMINOUS SURFACE RECONDITIONING

2231.1 DESCRIPTION

This work consists of reconditioning the existing pavement surface before constructing a bituminous overlay or surfacing courses.

2231.2 MATERIALS

A Bituminous Patching Mixture

Provide bituminous patching material matching the type of material used in the first layer of bituminous surfacing placed on the reconditioned surface.

B Mixture for Joints and Cracks

Provide a mixture for joints and cracks consisting of a prepared mix of fine aggregate and bituminous material in accordance with the following requirements:

Table 2231-1 Joint and Cracks Mixture Requirements	
Material	**Requirement, %**
Aggregate gradation*:	
½ in [12.5 mm] sieve	100
No. 8 [2.00 mm] sieve	45 – 80
No. 200 [75 µm] sieve	2.0 – 7.0
Aggregate spall	< 5
Bituminous material ‖	6.5 – 7.0†

* Percent passing requirement.
‖ Match PG grade to grade used on first lift of plant mixed asphalt.
† Percent by weight.

C Joint and Crack Filler
Provide joint and crack filler in accordance with the special provisions.

2231.3 CONSTRUCTION

A Surface Repair
Remove loose, unstable, or deteriorated portions of the existing pavement to provide a stable surface after completion of the patching operation. Remove waste or surplus material from the project. Repair and fill the holes and depressions with mix in accordance with the special provisions. Compact the mix using conventional pneumatic tire roller or mechanical tampers in areas inaccessible to conventional roller equipment.

B Joint Repair

B.1 Concrete Pavement
Clean and refill joints and cracks at least ¼ in [6 mm] wide.

B.2 Bituminous Pavement
Rout and seal cracks ¼ in to ¾ in [6 mm to 20 mm] wide. For cracks greater than ¾ in [20 mm] wide, fill with the mixture for joints and cracks and tamp in place.

2231.4 METHOD OF MEASUREMENT
The Engineer will separately measure the accepted quantities of bituminous patching mixture, mixture for joints and cracks, and joint and crack filler, as provided and placed, by the weight or by the loose volume of material as shown on the plans.

2231.5 BASIS OF PAYMENT
The contract unit prices for *Bituminous Patching Mixture*, for *Mixture for Joints and Cracks*, and for *Joints and Crack Filler* include the cost of removing and disposing of the existing deteriorated materials.

If the contract does not specify a specific contract pay item for removing concrete base or pavement in accordance with 2104, "Removing Pavement and Miscellaneous Structures," the Department will pay for the removal of a concrete base or pavement to full depth and width between existing joints, or by sawing, as extra work in accordance with 1402, "Contract Revisions."

The Department will pay for bituminous surface reconditioning on the basis of the following schedule:

Item No.:	Item:	Unit:
2231.501	Bituminous Patching Mixture	ton [metric ton]
2231.502	Bituminous Patching Mixture	cubic yard [cubic meter]
2231.505	Mixture for Joints and Cracks	pound [kilogram]
2231.507	Joint and Crack Filler	pound [kilogram]

2232 MILL PAVEMENT SURFACE

2232.1 DESCRIPTION
This work consists of removing the existing pavement by cold milling.

2232.2 MATERIALS — (BLANK)

2232.3 CONSTRUCTION REQUIREMENTS

A Equipment

Mill the existing pavement with a power operated, self-propelled cold milling machine capable of removing concrete and bituminous materials to the profile, cross-slope, grade, and elevation uniformly across the pavement surface as shown on the plans. Use automatic controls to control grade, elevation, cross-slope, and profile. Use a machine with ski, matching shoe, or an independent grade control to reference the existing pavement and automatically establish profile grades along each edge of the machine within ±¼ in [6 mm].

B Operations

Mill the pavement surface to the depth, width, grade, and cross-slope as shown on the plans. Perform milling without tearing or gouging the underlying material. Surface irregularities exceeding ½ in [6 mm] under a 10-foot [3-meter] straightedge laid transversely and longitudinally after milling is complete are unacceptable. Reference the milling operation from an independent grade control in areas directed by the Engineer. Establish and maintain grade control as approved by the Engineer.

Mill the entire pavement width to a flush surface at the end of each work period, when the pavement is open to traffic. If uncompleted operations result in a vertical or near vertical longitudinal face, re-slope the longitudinal face to provide a taper, construct a temporary bituminous taper or provide protective measures, as approved by the Engineer. Taper transverse cutting faces at the end of each working period where pavement is open to traffic. Construct temporary bituminous tapers at intersecting streets, around utility appurtenances, and appropriated entrances during the milling operations, as directed by the Engineer.

Mill areas inaccessible to the milling machine using other equipment or methods as approved by the Engineer.

The Contractor may recycle the surfacing removed by the milling operations and use on the project in accordance with 3138, "Aggregate for Base and Surface Courses," or 3139, "Graded Aggregate for Bituminous Mixtures," or dispose of the millings outside the right-of-way in accordance with 2104.3, "Removing Pavement and Miscellaneous Structures, Construction Requirements."

After milling to the depth shown on the plans, sweep or vacuum clean the milled area with equipment approved by the Engineer. Clean the milled area as approved by the Engineer. Dispose of debris from milling and cleaning operations outside of the right-of-way in accordance with 2104.3, "Removing Pavement and Miscellaneous Structures, Construction Requirements," except as otherwise approved by the Engineer.

Mill previously patched areas to the specified depth below the pavement surface that existed before placement of the previous patch, and not from the surface of the patch.

Avoid disturbing or damaging existing drainage or utility structures on the project. Repair damage resulting from the milling operations at no additional cost to the Department.

Keep the milled pavement surface free of all loose materials and dust.

2232.4 METHOD OF MEASUREMENT

The Engineer will measure pavement milling by the area of each type of surface removed. The Engineer will measure areas milled, based on actual finished dimensions of the work.

2232.5 BASIS OF PAYMENT

The contract unit price for pavement milling includes the cost of traffic safety, cleanup, and disposal operations.

The cost of constructing a temporary milled taper and providing, placing, and removing temporary bituminous tapers is included in the contract unit price for other relevant contract items.

The Department will pay for mill pavement surface on the basis of the following schedule:

Item No.:	Item:	Unit:
2232.501	Mill Bituminous Surface ___ in [___mm]	square yard [square meter]
2232.502	Mill Concrete Surface ___ in [___mm]	square yard [square meter]

Pavement Construction

2301 CONCRETE PAVEMENT

2301.1 DESCRIPTION

This work consists of constructing portland cement concrete pavement on a prepared base.

The Department defines paving concrete to include concrete mainline, ramps, loops, integrant curb, shoulders, and curb and gutter placed adjacent to the concrete mainline with the same mixture used in the paving. Integrant curb is a curb constructed monolithically with the pavement.

Use "slipform" as the standard construction method for concrete paving, unless otherwise allowed in the contract or by the Engineer.

2301.2 MATERIALS

A Concrete 2461

A.1 Slipform Placement Mix No. 3A21

A.2 Fixed Form PlacementMix No. 3A41

B Concrete Aggregate Requirements

Test each aggregate fraction proposed for use in accordance with Table 2301-1:

Table 2301-1
Aggregate Testing Requirements

Aggregate Fraction	Testing Required
Tested by Department in the last 3 years	No additional testing *
Not tested by the Department in the last 3 years	Preliminary aggregate testing in accordance with 2301.2.B.1, "Required Preliminary Aggregate Testing."
New source	New source concrete aggregate testing in accordance with 3126, "Fine Aggregate for Portland Cement Concrete," and 3137, "Coarse Aggregate for Portland Cement Concrete."

* Perform additional testing as required by the Engineer in conjunction with the Concrete Engineer.

B.1 Required Preliminary Aggregate Testing

After the Department awards the contract and as soon as coarse and fine aggregates are available for testing, contact the Engineer to coordinate preliminary sampling of aggregate for concrete paving. The Engineer, in conjunction with the Concrete Engineer, will sample and test the aggregate to verify specific gravity, absorption data, and aggregate quality. The Department will perform other tests as determined necessary by the Engineer, in conjunction with the Concrete Engineer.

B.2 Fine Aggregate Requirements

Provide fine aggregates complying with quality requirements of 3126.2.D, 3126.2.E, and 3126.2.F, "Fine Aggregate for Portland Cement Concrete."

B.2.a Fine Aggregate Alkali Silica Reactivity (ASR) Requirements

The Department will routinely test fine aggregate sources for alkali silica reactivity (ASR) in accordance with the following:

(1) Multiple sources of certified portland cement in accordance with ASTM C 1260 MnDOT Modified; and

(2) Multiple combinations of certified portland cement and supplementary cementitious materials in accordance with ASTM C 1567 MnDOT Modified.

The Concrete Engineer, in conjunction with the Engineer, will review the 14-day fine aggregate expansion test results to determine the acceptability of the proposed fine aggregate and cement combination in accordance with the following:

(1) For fine aggregate and cement combinations previously tested by the Department, the Concrete Engineer will use the average of all 14-day unmitigated test results for an individual source to determine necessary mitigation in accordance with Table 2301-2.

(2) If the previously tested proposed fine aggregate and cement combination requires less mitigation than the average 14-day unmitigated test result, the Concrete Engineer will allow mitigation at the lesser rate in accordance with Table 2301-2.

(3) Alkali silica reactivity (ASR) ASTM C1260 and ASTM C1567 MnDOT Modified test results are available on the MnDOT Concrete Engineering Unit website.

Table 2301-2 Fine Aggregate ASR Mitigation Requirements							
14-day Fine Aggregate Unmitigated Expansion Limits	**Class F Fly Ash**	**Class C Fly Ash**	**Slag**	**Slag/Class F Fly Ash**	**Slag/Class C Fly Ash**	**IS(20)/Class F Fly Ash**	**IS(20)/Class C Fly Ash**
≤ 0.150	No mitigation required						
>0.150 –0.200	Minimum 20%	Minimum 20%	35%	20% Slag with a minimum of 15% Class F fly ash	20% Slag and 20% Class C fly ash	Type IS(20) with a minimum of 15% Class F	Type IS(20) with a minimum of 15% Class C
> 0.200 – 0.300	Minimum 20%	Minimum 30%	35%				
> 0.300	The Department will reject the fine aggregate						

The Concrete Engineer may reject the fine aggregate if mortar bar specimens exhibit an indication of external or internal distress not represented by the expansion results. The Concrete Engineer will make the final acceptance of the aggregate.

B.3 Intermediate Aggregate Requirements

Provide intermediate aggregates complying with the quality requirements of 3137.2.D.3, "Coarse Aggregate for Portland Cement Concrete," except as modified in Table 2301-3, for each individual fraction.

The Concrete Engineer classifies intermediate aggregate in accordance with Table 2301-3.

Table 2301-3 Intermediate Aggregate for Use in Concrete			
If the gradation meets the following:	**Classify material type as:**	**Gradation Test Procedures**	**Quality Test Requirements**
100% passing the 1/2″ and ≤90% passing #4	Intermediate Aggregate	Coarse Aggregate (+4 Portion)	Spec. 3137.2.D.3 except 3137.2.D.3(c) modified to maximum 40% carbonate
		Fine Aggregate (-4 Portion)	3126 Shale in Sand (-4 Portion)
100% passing the 1/2″ and >90% passing #4	Intermediate Aggregate	Fine Aggregate (Minimum 1000 g sample)	Shale Content Test by AASHTO T113 MnDOT Modified (+4 Portion)
			3126 Shale in Sand (-4 Portion)
100% passing the 3/8″ and ≤90% passing #4	Coarse Sand	Fine Aggregate	Shale Content Test by AASHTO T113 MnDOT Modified (+4 Portion)
			3126 Shale in Sand (-4 Portion)

For any intermediate aggregate size not previously tested by the Department, the Concrete Engineer reserves the right to test for alkali silica reactivity, in accordance with ASTM C1260, prior to allowing incorporation into the concrete mix design.

B.4 Coarse Aggregate Requirements

Provide coarse aggregates complying with the requirements of 3137.2.D.3, "Coarse Aggregate for Portland Cement Concrete," for each individual fraction.

B.4.a Coarse Aggregate Alkali Silica Reactivity (ASR) Requirements

When using coarse aggregate identified as quartzite or gneiss, the Concrete Engineer will review ASTM C1293 testing to determine the necessary ASR mitigation requirements in accordance with Table 2301-4.

Alkali silica reactivity (ASR) ASTM C1293 test results are available on the MnDOT Concrete Engineering Unit website.

Table 2301-4
Coarse Aggregate ASR Mitigation Requirements

ASTM C1293 Expansion Results	Class F Fly Ash	Class C Fly Ash	Slag	Slag/Class F Fly Ash	Slag/Class C Fly Ash	IS(20)/Class F Fly Ash	IS(20)/Class C Fly Ash
≤ 0.040	No mitigation for coarse aggregate required						
>0.040	Minimum 30%	Not Allowed	35%	20% Slag with a minimum of 15% Class F fly ash	20% Slag and 20% Class C fly ash	Type IS(20) with a minimum of 15% Class F	Type IS(20) with a minimum of 15% Class C

C Cementitious Materials

Provide only cementitious materials from the Approved/Qualified Products List.

C.1 Portland Cement.....3101

Use Type I or Type I/II cement complying with the following:

(a) Total alkalis (Na2Oe) no greater than 0.60 percent in the portland cement, and

(b) Total alkalis (Na2Oe) no greater than 3.0 lb per cu. yd of concrete resulting from the portland cement.

C.2 Slag Cement 3102

C.3 Blended Hydraulic Cement 3103

Use Type IL, IS or IP cement complying with the following:

(a) Total alkalis (Na2Oe) no greater than 0.60 percent in the portland cement, and

(b) Total alkalis (Na2Oe) no greater than 3.0 lb per cu. yd of concrete resulting from the portland cement.

C.4 Fly Ash 3115

The Concrete Engineer defines Class F fly ash for the purposes of ASR mitigation as having a maximum CaO content of 18.0%.

D Concrete Admixtures.....3113

Use air-entraining admixtures and Class A, B, D, and S. Use of Class C, E, and F require approval of the MnDOT Concrete Engineer.

E Reinforcement Bars.....3301

F Dowel Bars 3302

G Concrete Joint Sealers

G.1 Preformed Type.....3721

G.2 Hot-poured, Elastic Type 3725

G.3 Silicone Type 3722

H Preformed Joint Filler.....3702

I Curing Materials

I.1 Burlap Curing Blankets 3751

I.2 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound 3754

I.3 Linseed Oil Membrane Curing Compound 3755

I.4 Plastic Curing Blankets 3756

J Form Coating Material 3902

K Water 3906

L Contractor Concrete Mix Design

The Contractor assumes full responsibility for the mix design and performance of the concrete. The Engineer determines final acceptance of concrete for payment based on satisfactory field placement and performance.

L.1 Concrete Mix Design Requirements

The Department defines the concrete mix design requirements for Grade A concrete in accordance with Table 2301-5.

Based on the estimated quantity of concrete pavement in the contract, calculated by multiplying the planned pavement area by the planned pavement thickness, provide a mix design meeting the following requirements in accordance with Table 2301-5:

Table 2301-5
Concrete Mix Design Requirements

Concrete Grade	Estimated Concrete Contract Quantity (cu. yd)	Mix Number	Maximum w/c ratio		Cementitious Content (lbs/cy) ‖	Gradation Requirements	Minimum Aggregate Size Required	Maximum %SCM (Fly Ash/ Slag/ Ternary) †	Slump Range ‡	3137 Spec.
			Fly Ash	Slag/ Ternary						
A	≥ 3,500	3A21	0.40	0.42	530 – 615	Job Mix Formula	1 1/2″ nominal	33/35/40	½ - 3″	2.D.3
		3A41	0.40	0.42					2 – 5″	
		3A41HE *	0.40	0.42	> 615 – 750				2 – 5″	
	< 3,500	3A21	0.42	0.42	530 – 615	3126 and Table 3137-4 Or Job Mix Formula	3/4″ nominal	33/35/40	½ - 3″	2.D.3
		3A41	0.42	0.42					2 – 5″	
		3A41HE * ‖	0.42	0.42	> 615 – 750				2 – 5″	
	Minor work and fill-ins not provided by the primary paving plant	3A21	0.42	0.42	530 – 615	3126 and Table 3137-4	3/4″ nominal	33/35/40	½ - 3″	2.D.3
		3A41	0.42	0.42					2 – 5″	
		3A41HE * ‖	0.42	0.42	> 615 – 750				2 – 5″	

* The Contractor may use 100% Portland cement for High Early Concrete, provided no mitigation is required for the fine aggregate in accordance with Table 2301-2 or the coarse aggregate in accordance with Table 2301-4. If mitigation is required, the Contractor is required to use a minimum of 15% of any supplementary cementitious material when designing High Early Concrete.
‖ The minimum portland cement content is 400 lb per cu. yd [238 kg per cu. m]; provide additional cementitious material to meet requirements in accordance with this section at no additional cost to the Department.
† Ternary mixes are defined as portland cement and two other supplementary cementitious materials, or blended cement and one other supplementary cementitious material with a maximum replacement of 40% by weight.
‡ Adjust slump in accordance with 2461.3.G.6.a for slipform concrete placement.

L.2 Concrete Mix Design Submittal Requirements

Design Grade A concrete mixes based on an absolute volume of 27 cu. ft [1.0 cu. m] and a target air content of 7.0%.

Submit the concrete mixes using the appropriate MnDOT *Contractor Mix Design Submittal Workbook* available on the Department's website at least 21 calendar days before the initial concrete placement. When required by Table 2301-5, include a Job Mix Formula in accordance with 2301.2.L.3, "Job Mix Formula."

For mix design calculations, the Engineer, in conjunction with the Concrete Engineer, will provide specific gravity and absorption data.

The Concrete Engineer, in conjunction with the Engineer, will review the mix design submittal for compliance with the contract.

L.3 Job Mix Formula

A Job Mix Formula (JMF) contains the following:

(1) Proportions for each aggregate fraction,
(2) Individual gradations for each aggregate fraction; and
(3) Composite gradation of the combined aggregates including working ranges on each sieve in accordance with Table 2301-6.

Table 2301-6
Job Mix Formula Working Range

Sieve Sizes	Working Range, %*
2 in [50 mm]	±5
1½ in [37.5 mm]	±5
1 in [25 mm]	±5
¾ in [19 mm]	±5
½ in [12.5 mm]	±5
⅜ in [9.5 mm]	±5
No.4 [4.75 mm]	±5
No.8 [2.36 mm]	±4
No.16 [1.18 mm]	±4
No.30 [600 µm]	±4
No.50 [300 µm]	±3
No.100 [150 µm]	±2
No.200 [75 µm]	≤ 1.6

* Working range limits of the composite gradation based on a moving average of 4 tests (N=4).

L.3.a Verification of JMF

The Engineer will determine the sampling location by using a random number chart and multiplying the random number by the sampling rate as defined in the Schedule of Materials Control.

(1) Take samples at the belt leading to the weigh hopper or other locations close to the incorporation of the work as approved by the Engineer.
(2) Add fill-in sieves as needed during the testing process to prevent overloading.
(3) If the quantities of concrete produced results in no gradation testing for any given day, include the untested quantity of concrete into the next day's production and include that quantity of concrete in the sampling rate.
(4) If the untested quantity is on the last day of production, add that quantity to the previous day's production.

Test and record the individual gradation results using the *Well-graded Concrete Aggregate Workbook*.

(1) Using the *JMF Moving Average Summary Worksheet*, calculate the moving average of four Contractor aggregate gradation test results during production.
(2) The Engineer will randomly verify Contractor combined aggregate gradation results as defined in the Schedule of Materials Control.
(3) The Engineer will determine the well-graded aggregate optional incentive, if required, in accordance with 2301.2.M.3, "Well-Graded Aggregate Optional Incentive."

L.3.b JMF Adjustments

If the Contractor expects a future JMF adjustment, submit a new mix design including JMF in accordance with 2301.L.3, "Job Mix Formula."

If, during concrete batching, the moving average of four (4) Contractor aggregate gradation tests falls outside the allowable JMF working range:

(1) Make immediate adjustments on the *JMF Adjustment Worksheet*, within the limits specified in Table 2301-7;

(2) Review JMF Adjustments with the Engineer. Provided the adjustments comply with Table 2301-7, both the Contractor and Engineer will sign the *JMF Adjustment Worksheet*. Once signed by both, resume paving.

(3) If the moving average of four tests falls outside of the adjusted allowable working range, stop production and provide a new mix design including JMF to the Concrete Engineer.

Table 2301-7
Allowable JMF Adjustments

Sieve Size	Allowable Adjustment, %
≥ No. 4 [4.75 mm]	±5
No. 8 [2.36 mm] – No.30 [600 µm]	±4
No. 50 [300 µm]	±3
No. 100 [150 µm]	±2

M Concrete Pavement Incentives and Disincentives

The Department will apply concrete mix incentives or disincentives for contracts using at least 3,500 cu. yd [2,900 cu. m] of concrete, calculated by multiplying the planned pavement area by the planned pavement thickness, of paving concrete. The Department will determine payment for the incentives or disincentives for aggregate quality, well-graded aggregate, and water/cement ratio in accordance with 2301.4, "Method of Measurement."

The Department defines a primary concrete plant as the following:

(1) A primary concrete plant providing the majority of the concrete to a paving project.

(2) Only one primary concrete plant per project is allowed unless otherwise approved by the Engineer.

(3) Use either a paving plant or a certified ready-mix plant as the primary concrete plant. Refer to Table 2301-8 to determine if concrete provided by the Primary Concrete Plant is eligible for concrete pavement incentives and disincentives.

(4) The Department will only apply incentives or disincentives for materials provided or produced by the Contractor's primary concrete plant.

Table 2301-8
Designated Primary Concrete Plant Eligibility for Incentives/Disincentives*

Type of Concrete Plant	Method for Hauling Concrete	w/c ratio†‖	Aggregate Quality	Well-graded Aggregate
Paving Plant	Dump Trucks, Agitator Trucks, or Both	Yes	Yes	Yes
Certified Ready-Mix Plant	Dump Trucks, Agitator Trucks, or Both	Yes	Yes	Yes
Paving Plant	Truck Mixers	No	Yes	Yes
Certified Ready-Mix Plant	Truck Mixers	No	Yes	Yes

* A secondary concrete plant providing any minor work or fill-ins not provided by the primary concrete plant is not eligible for any incentives/disincentives.
† High-early mixes are not eligible for w/c ratio incentive payments.
‖ If the Contractor adds water to the pavement surface without approval by the Engineer, the Department will not pay water/cement or ride incentives on sections where the water is added and the Engineer may reject the pavement in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

M.1 Coarse Aggregate Quality Incentive/Disincentive

The Engineer will accept the coarse aggregate for paving concrete by statistical methods and in accordance with all other aggregate quality requirements of 2301, "Concrete Pavement," 2461, "Structural Concrete," and 3137, "Coarse Aggregate for Portland Cement Concrete." Use the *Coarse Aggregate Quality Incentive/Disincentive Workbook* to determine the sampling locations and the incentive/disincentive.

The Coarse Aggregate Quality Incentive/Disincentive for CLASS B and CLASS C Aggregates will comply with the following:

The Engineer will take samples at the belt leading to the weigh hopper or other locations close to the incorporation of the work as determined by the Engineer. The Engineer will determine the number of samples required in accordance with Table 2301-9:

Table 2301-9 Coarse Aggregate Quality Incentive/Disincentive Sampling Rates	
Plan Concrete, cu. yd [cu. m]	**Samples per Fraction (n)**
3,500 – 7,500 [2,900 – 6,250]	3
7,501 – 10,000 [6,251 – 8,500]	5
10,001 – 25,000 [8,501 – 21,000]	10
25,001 – 50,000 [21,001 – 42,000]	15
> 50,000 [42,000]	20

The Engineer will consider the entire project as a single lot for each of the two fractions containing the highest percentage by weight. If the project is planned for construction over multiple years and before placing any concrete pavement, request that the Engineer calculate the incentive/disincentive payment on a yearly basis. The Engineer, in conjunction with the Concrete Engineer, will modify the sampling and testing rates as necessary.

The Engineer will establish a new statistical family for each change in aggregate source, fraction, or both.

The Engineer will randomly choose the acceptance samples.

The Engineer will divide a lot representing the plan cubic yards [cubic meters] of concrete by the number of samples to form sublots. The Engineer will multiply the number of cubic yards [cubic meters] in a sublot by a random number to obtain the position in the sublot for the sample. The Engineer will split the samples and leave half of the sample for the Contractor. The Engineer's laboratory will test the samples and report the individual results. The Engineer will calculate a Quality Index (QI) for each fraction in accordance with the following:

$$QI = X + k(s)$$

Where:

$$\mathrm{X} = \text{mean} = \sum \frac{X_i}{n}$$

X_i = individual test results

$$\mathrm{s} = \text{standard deviation} = \sqrt{\sum \frac{(x_i - x)^2}{(n-1)}}$$

k = Adjustment Factor based on the number of tests as shown in Table 2301-10:

Table 2301-10 Adjustment Factor "k"	
K	**No. of Tests**
1.09	3
1.20	4
1.23	5
1.26	10
1.27	≥ 15

If Class A, Class B, and Class C aggregates meet the requirements as determined by the Engineer, the Department will provide payment based on a per fraction incentive in accordance with Table 2301-11.

Table 2301-11 Coarse Aggregate Quality Incentive/Disincentive		
Aggregate Class	**QI for Fraction, %**	**Structural Concrete per cu. yd [cu. m] Payment Change per Fraction**
Class A (including quartzite and gneiss)	—	$1.00 [$1.30]
Class B (based on % absorption)	≤1.00	$1.00 [$1.30]
	1.01 – 1.45	$0.50 [$0.65]
	1.46 – 1.76	$0.00
	1.77 – 1.85	−$1.00 [$1.30]
	≥ 1.86	As recommended by the Concrete Engineer, with coordination of the Engineer
Class C (based on % carbonate)	≤ 15.0	$1.00 [$1.30]
	15.1 – 24.0	$0.50 [$0.65]
	24.1 – 31.0	$0.00
	31.1 – 35.0	−$1.00 [$1.30]
	≥ 35.1	As recommended by the Concrete Engineer, with coordination of the Engineer

The Department will not pay incentives or disincentives for Class R aggregates.

If the concrete mixture contains at least three fractions of coarse aggregate, the Engineer will consider only the two containing the highest percentage by weight as eligible for incentive.

The Department will pay for Coarse Aggregate Quality Incentive/ Disincentive for all paving concrete, including water/cement ratio concrete, and high-early concrete provided by the Contractor's primary paving plant.

M.2 Water/Cement (w/c) Ratio

Provide and place concrete with a water/cement ratio not to exceed 0.40 when using cement only or fly ash and 0.42 when using slag or ternary. Make any adjustments immediately when the water/cement ratio exceeds 0.40 when using cement only or fly ash and 0.42 when using slag or ternary.

The Department will not make incentive payments for water/cement ratio on high-early mixes.

Do not add water to the surface of the concrete to aid in finishing without the approval of the Engineer. Supply sufficient trucks to ensure a steady forward progress of the paver.

The Department will determine the water/cement ratio for concrete hauled in dump or agitator trucks (concrete hauled in truck mixers are not eligible for w/c ratio incentives) in accordance with the following:

M.2.a Water Content Determination

For a concrete paving batch plant, use an electronic meter approved by the Engineer to record the water, including temper water, added to the mix that is capable of printing the amount of total water on each batch ticket.

For a ready-mix plant, record the total water added to the mix, including temper water, on the computerized Certificate of Compliance.

The Engineer will determine the water content for calculating the water/cement ratio using the average water calculated from 10 batch tickets or Certificates of Compliances surrounding the randomly selected batch ticket sample (four previous tickets, ticket representing the random sample, and the five following tickets).

M.2.b Water Content Verification

The Engineer will use plastic concrete taken at the plant site to verify the water content in the mix as determined in accordance with 2301.2.M.2.a, "Water Content Determination." Sample the plastic concrete as directed by the Engineer.

The Engineer will verify the water content in the plastic concrete mixture using the test procedure specified in AASHTO T 318-02, "Standard Test Method for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying." The Engineer will begin the test within 45 min after the water has contacted the cement. Provide the microwave oven and the ancillary equipment as required by the Engineer to perform this test.

M.2.c Cementitious Content Determination

The Engineer will determine the cementitious content for calculating the water/cement ratio using the average total cementitious calculated from 10 batch tickets or Certificates of Compliance surrounding the randomly selected batch ticket sample (four previous tickets, the ticket representing the random sample, and the five following tickets).

M.2.d W/C Ratio Incentive/Disincentive

The Engineer will base the statistical analysis of acceptance for water/cement ratio in accordance with 2301.2.M.2.a, "Water Content Determination," and 2301.3.M.2.c, "Cementitious Content Determination," at a rate defined in the Schedule of Materials Control. The Engineer will use the *W/C Ratio Calculation Workbook* for moisture testing and determining the incentive/disincentive.

The Engineer will randomly choose acceptance samples. The Engineer will determine the sampling location by using a random number chart and multiplying the random number by the sampling rate as defined in the Schedule of Materials Control.

The Engineer will sample, test, and record the individual results.

If the quantities of concrete produced results in no Department moisture testing for any given day, include the untested quantity of concrete into the next day's production and include that quantity of concrete in the sampling rate. If the untested quantity is on the last day of production, add that quantity to the previous day's production.

Do not place concrete mix not meeting the 0.40 water/cement ratio requirement in accordance with Table 2301-5. The Engineer may accept material not meeting the contract requirements and the Department will pay for the work in accordance with Table 2301-12.

Table 2301-12
W/C Ratio Incentive/Disincentive

When using cement only or fly ash		When using slag or ternary	
W/C Ratio Test Result	**Payment incentive/disincentive per cu. yd [cu. m]**	**W/C Ratio Test Result**	**Payment incentive/disincentive per cu. yd [cu. m]**
≤ 0.37	+$3.00 [$3.90]	≤ 0.39	+$3.00 [$3.90]
0.38	+$1.75 [$2.25]	0.40	+$1.75 [$2.25]
0.39	+$0.50 [$0.65]	0.41	+$0.50 [$0.65]
0.40	$0.00	0.42	$0.00
0.41	−$0.50 [$0.65]	0.43	−$0.50 [$0.65]
0.42	−$1.75 [$2.25]	0.44	−$1.75 [$2.25]
≥ 0.43	Determined by the Concrete Engineer	≥ 0.45	Determined by the Concrete Engineer

The Contractor may remove and replace concrete represented by water/cement ratios greater than 0.40 when using cement only or fly ash and 0.42 when using slag or ternary. For concrete left in place with water/cement ratios greater than 0.40 when using cement only or fly ash and 0.42 when using slag or ternary and the level of payment is not defined in the table, the Engineer, in conjunction with the Concrete Engineer, will evaluate the material based on the adequacy of the material for the use intended. Remove and replace unsatisfactory concrete as determined by the Engineer at no additional cost to the Department.

M.3 Well-Graded Aggregate Optional Incentive

The Engineer will use the Contractor's combined aggregate gradation test results documented in the *Well-Graded Concrete Aggregate Workbook*, as verified by Department verification testing, to determine eligibility for the incentive. Table 2301-13 defines the well-graded concrete aggregate gradation band, on a percent retained per sieve size basis.

Table 2301-13 % Retained Gradation Band	
Sieve Size	**% Retained**
2 in [50 mm]	0%
1½ in [37.5 mm]	≤ 5%
1 in [25 mm]	≤ 16%
¾ in [19 mm]	≤ 20%
½ in [12.5 mm]	4–20%
⅜ in [9.5 mm]	4–20%
No. 4 [4.75 mm]	4–20%
No. 8 [2.36 mm]	≤ 12%
No. 16 [1.18 mm]	≤ 12%
No. 30 [600 µm]	4–20%
No. 50 [300 µm]	4–20%
No. 100 [150 µm]	≤ 10%
No. 200 [75 µm]	≤ 8%

The Engineer will use statistical analysis of the Contractor's combined (averaged) aggregate gradation samples for well-graded aggregate on a per lot basis representing one day's paving. Each combined aggregate gradation is considered a sublot. The lot will represent the cumulative average of the sublot values on each sieve for the gradation band.

An optional incentive is available to the Contractor provided a concrete mixture is designed and produced with a well-graded aggregate gradation that meets the following in accordance with Table 2301-14.

Table 2301-14 Well-Graded Aggregate Optional Incentive
Payment incentive/disincentive per cu. yard [cu. m]
$2.00 per cu. yd [$2.60 per cu. m]

2301.3 CONSTRUCTION REQUIREMENTS

A Notice of Inspection

Notify the Engineer at least 24 h before placing concrete to allow for inspection. Do not place concrete until the Engineer approves preparations for concrete placement. If the Contractor fails to notify the Engineer at least 24 h before concrete placement, the Engineer may not allow concrete placement in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

B Contractor and Equipment Qualifications

B.1 Contractor Organizational Chart

Provide paving operations supervision in accordance with 1506, "Supervision by Contractor." Provide an organizational chart listing names and phone numbers of individuals and alternates responsible for mix design, quality control administration, and inspection to the Engineer. Post the organizational chart in the Contractor's on-site facility.

B.2 Contractor Flatwork Certification

The Concrete Contractor, or Subcontractor, shall have at least two people with a current ACI concrete flatwork technician or flatwork finisher certification, and at least one of them must be onsite for all concrete pours.

B.3 Concrete Paving Plant Certification

Provide notice 16 h in advance of concrete paving production and in conjunction with the Engineer, perform a thorough on-site inspection of the concrete plant and complete MnDOT Form 2164, "Concrete Paving Plant Contact Report." Sign the report to certify compliance with the paving requirements and to certify review of the continual maintenance of the plant. If concrete is provided by a Certified Ready-Mix Plant, complete MnDOT Form 2164, "Contact Report – Addendum Ready-Mix Paving."

Calibrate and correlate the testing equipment in accordance with 2461.3.D, "Batching Requirements."

For projects with greater than 3,500 cu. yd [2,900 cu. m], provide a separate combination plant lab – office for use during concrete paving in accordance with 2301.3.B.3.a, "Combination Plant Lab-Office Requirements."

B.3.a Combination Plant Lab – Office Requirements

The Concrete Paving Contractor QC technicians and the Department QA technicians will equally share a combination plant lab – office during concrete paving.

Provide a separate combination plant lab – office in accordance with 1604, "Plant Inspection – Commercial Facility," except as modified by the following characteristics and requirements:

(1) Located at the plant site within 100 yd [91 m] from the batch plant or other location, as approved by the Engineer,
(2) Plant lab and plant office areas separated and isolated by a wall,
(3) Total plant lab-office floor area, based on exterior dimensions, of at least 224 sq. ft [21 sq. m],
(4) Plant lab floor area, based on exterior dimensions, of at least 144 sq. ft [13.5 sq. m],
(5) Plant office floor area, based on exterior dimensions, of at least 80 sq. ft [7.5 sq. m],
(6) Heating and cooling system capable of maintaining a uniform temperature between 72° and 85° F [22° and 29° C],
(7) Drinking water container or cooler with adequate supply of potable water,
(8) Detached portable toilet conveniently located,
(9) Electrical power supply that provides adequate amperage for all electrical needs,
(10) Water supply (storage tank with a capacity of 50 gal or more, or pressurized water supply) connected to the sink faucet,
(11) Provide a sample storage area to prevent contamination of the samples,
(12) Plant lab furnished in accordance with the following:
  (12.1) One sturdily-built workbench or countertop at least 30 in × 144 in [0.75 m × 3.65 m],
  (12.2) One service sink located near one end of the workbench with a water supply, faucet and an outside drain,
  (12.3) Shelf space above workbench or countertop or at other convenient locations, totaling at least 8 linear ft [2.5 m] × 8 in [0.2 m],
  (12.4) Electronic scales of sufficient size to weigh the samples for all required materials testing, and
  (12.5) A four (4) burner 30″ standard electric stove top or stove and at least two (2) additional electric burners to perform required aggregate testing per the Schedule of Materials Control.
  (12.6) Microwave oven with turntable or wave deflection fan (900 Watt), heat resistant glass pan (approx. 9″x9″x2″), plain weave fiberglass cloth (10 oz/yd^2 and 14 mills thick), metal scrapper and grinding pestle,
  (12.7) Metal bowls of sufficient size to perform all required material testing,
(13) Plant office furnished in accordance with 2031.3.B.1, "Field Office Furnishings," except as modified by the following:
  (13.1) Two desks, one for the Department and one for the Contractor, with total exterior dimensions of at least 30 in × 60 in [¾ m × 1.50 m],
  (13.2) At least six desk chairs,
  (13.3) A telephone capable of providing email, and
  (13.4) A printer with scanning and copying capabilities.

Do not begin concrete paving operations until the Engineer approves the combination plant lab–office.

For concrete paving projects supplied by a Certified Ready-Mix Plant, the separate Combination Plant - Lab Office requirements in 2301.2.B.3.a do not apply, with the exception of the following:

(1) Electrical power supply that provides adequate amperage for all electrical needs,
(2) Water supply (storage tank with a capacity of 50 gal or more, or pressurized water supply) connected to the sink faucet,
(3) Electronic scales of sufficient size to weigh the samples for all required materials testing,
(4) At least six (6) electric burners to perform required aggregate testing per the Schedule of Materials Control.
(5) Metal bowls of sufficient size to perform all required material testing, and
(6) If w/c incentives apply, provide a microwave oven with turntable or wave deflection fan (900 Watt), heat resistant glass pan (approx. 9″x9″x2″), plain weave fiberglass cloth (10 oz/yd^2 and 14 mills thick), metal scrapper and grinding pestle.

B.3.b Paving Plant Sampling and Testing

Provide a MnDOT Certified Concrete Plant Level 2 Technician to oversee testing and plant operations and to remain on-site during concrete production or have cellular phone availability.

Provide technicians with certifications at least meeting MnDOT Concrete Plant Level 1 to perform all of the duties in accordance with section 5-694.500 of the Concrete Manual. The Engineer will provide technicians with certifications at least meeting MnDOT Concrete Plant Level 1 to perform all of the duties in accordance with section 5-694.500 of the Concrete Manual.

Perform testing in accordance with section 5-694.500 of the Concrete Manual and determine testing rates in accordance with the requirements of the Schedule of Materials Control. The Engineer performs testing in accordance with section 5-694.500 of the Concrete Manual and determines testing rates meeting the requirements of the Schedule of Materials Control.

B.4 Contractor Project Documentation

Maintain and keep control charts current using the following MnDOT provided charts:

(1) *JMF Moving Average Summary*
(2) All Contractor plastic air content tests (including before and after consolidation) in the *Air Content Chart*

Provide all batch tickets and test results to the Engineer on a daily basis. The Engineer may suspend plant operations if the Contractor fails to provide daily test results.

Provide all reports, records, and diaries developed during the progress of construction activities to the Engineer.

C Batching and Mixing

Batch and mix the concrete in accordance with 2461, "Structural Concrete," and the following:

C.1 Batching Requirements

Perform the initial spot check of the measuring equipment in accordance with the Concrete Manual for accuracy and sensitivity before starting production operations. Provide a copy of the inspection certificate to the Engineer.

Provide to the Engineer a computerized batch ticket that includes the following:

(1) Date,
(2) State project number (SP) or (SAP),
(3) Time concrete was batched,
(4) Quantity of concrete in this load,
(5) Running total of each type of concrete, each day for each project,
(6) Mix number,
(7) Labels identifying each material that correlates with the contractor mix design, including cementitious and admixture abbreviations or MnDOT 5 digit pit numbers),
(8) Target weight of materials,
(9) Actual batched weights of materials,
(10) Temper water, and
(11) Total water weight.

If satisfactory finishing and curing of the pavement does not occur, as determined by the Engineer, suspend batching and mixing operations.

C.2 Concrete Ingredient Summaries

If delivering bulk cementitious materials directly to the concrete batching plant in railroad cars or sealed transport trucks, submit copies of the bill of ladings to the Engineer on the same day received from the transporting company.

Advise the Engineer of the method and schedule of cementitious material unloading. Do not unload cementitious materials until the Engineer approves the operation.

Each day of concrete pavement production, provide the Engineer with a production summary in an electronic format that includes the following:

(1) Daily total concrete produced in cubic yards for each concrete mixture type.
(2) Daily total ingredient quantities (aggregate, cementitious and water) including the percent overrun/underrun.

Provide final project total quantities for (1) and (2) to the Engineer at the end of the Project using the Concrete Ingredient Summary Worksheet.

The Engineer will verify the following:

(1) Individual daily cement quantity do not show an underrun in cement usage greater than 1.0 percent of the quantity specified,
(2) The final cement quantity summary does not show an overall underrun greater than 1.0 percent, and
(3) If either one or both of these limitations are exceeded, the Engineer will not pay for the concrete represented at the contract unit price.

The Engineer may reject defective concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," or the Department may pay for the defective concrete at an adjusted unit price at the

same ratio to the contract unit price as the quantity of cement used to the quantity of cement required less the allowable underrun. If the cement exceeds the limitations for individual cutoff and final cutoff, the Department may apply the price adjustment to the cutoff value that produces the greatest monetary deduction.

D Subgrade and Aggregate Base Preparations

Prepare the subgrade and aggregate base in accordance with 2105, "Excavation and Embankment," 2112, "Subgrade Preparation," and 2211, "Aggregate Base," and the following:

Fine grade the aggregate base to the shape and grade shown on the plans, allowing construction of the pavement to the thickness and cross section shown on the plans. Use an approved fine grading machine mounted on crawler tracks.

Shape and maintain the shoulders to allow surface water to drain away from the pavement and off the shoulders.

E Concrete Equipment and Paving Operations

Provide self-propelled spreading and finishing machines capable of consolidating and finishing the concrete, and producing a dense and homogenous finished surface meeting the requirements specified in 2301, "Concrete Pavement."

E.1 Consistency

Maintain the concrete at a uniform consistency. The Engineer will not allow an edge slump greater than ⅛ in [3 mm] or irregular edge alignment. Do not allow the edges of the pavement, including longitudinal joints, to deviate from the line shown on the plans by greater than ½ in [13 mm] at any point.

For slipform concrete pavement placement, place the concrete with a slump value that optimizes placement, except ensure the concrete does not slough or slump and is adequately consolidated and meets all other requirements of 2301, "Concrete Pavement."

For fixed form placement, place the concrete with a slump no greater than the maximum allowable slump in accordance with Table 2301-4.

E.2 Slipform Construction

Place concrete using a slipform paver or combination of pavers designed to spread, consolidate, screed, and float-finish the freshly placed concrete with minimum hand finishing. Provide a slipform paver with a non-oscillating extrusion plate with an adjustable angle of entry.

Place the concrete pavement before placing curb and gutter.

If the sequence of operations includes placing the curb and gutter before the concrete pavement, submit a jointing plan to the Engineer for approval. Submit the jointing plan to the Engineer a minimum of seven (7) calendar days before placing the curb and gutter.

Equip the paver with automatic grade control capable of maintaining both the elevation and longitudinal line shown on the plans on both sides of the paver.

Use an erected string line to achieve the line and grade reference. Tightly stretch a string line set parallel to the established grade for the pavement surface to achieve the grade reference. Set the control reference and support the line at intervals to maintain the established grade and alignment.

When constructing concrete overlays, set and use string lines for grade control on both sides of the roadway during paving operations.

Operate the slipform paver with a continuous forward movement coordinating all operations of mixing, providing adequate concrete hauling units, and spreading concrete to provide uniform progress with minimal stopping and starting of the paver.

Consolidate the full width and depth of concrete pavement placed by a single pass of a series of internal vibrators. Operate full-width vibrators from 3,600 VPM to 7,000 VPM [60 Hz to 117 Hz] in concrete, and from 4,150 VPM to 8,000 VPM [70 Hz to 133 Hz] when checked in air. Deliver the vibrator impulses directly to the concrete and operate at an intensity to consolidate the concrete uniformly throughout the entire depth and width of the concrete. The Contractor may increase the vibrator frequency as approved by the Engineer. Perform additional testing as directed by the Engineer at no additional cost to the Department. If the vibrator fails, suspend operations and remove unconsolidated concrete.

Regulate the rate of progress of the vibratory equipment and the duration of the application to fully, but not excessively, vibrate the concrete. If the forward progress of the paver stops, suspend the operation of vibrators.

Attach vibrators to spreading or finishing equipment. Do not allow vibrators to come in contact with preset dowel basket assemblies, the grade, pavement reinforcement, or side forms. Do not allow the operation of vibrators to cause separation or segregation of the mix ingredients, including the downward displacement of large aggregate or the accumulation of laitance on the

concrete surface. The Contractor may reduce the vibration frequency within the specified range if reducing the forward progress of the paver to avoid segregation of the concrete mix. Connect the power to all vibrators so that they cease when the machine motion is stopped. Stop paving operations if a vibrator fails to operate within the range specified above.

E.2.a Electronic Vibration Monitoring Device

For projects with greater than 3,500 cu. yd [2,900 cu. m], provide an electronic monitoring device meeting the following characteristics and requirements to display the operating frequency of each individual internal vibrator for concrete pavement placed by the slipform method:

(1) Contains a readout display near the operator's controls; visible to the paver operator and to the Engineer,
(2) Operates continuously as the paving machine operates,
(3) Displays all the vibrator frequencies with manual and automatic sequencing for each of the individual vibrators, and
(4) Records the following at least every 25 ft [7.62 m] of paving or at least every 5 min of time:
  (4.1) Clock time,
  (4.2) Station location,
  (4.3) Paver track speed, and
  (4.4) Operating frequency of individual vibrators.

Provide an electronic copy containing the record of data after the completion of the concrete paving operation. Provide vibration data daily as directed by the Engineer.

E.3 Fixed Form Construction

E.3.a Setting Forms

Provide forms meeting the following requirements and characteristics:

(1) Steel, straight edge sides,
(2) Depth equal to the pavement thickness shown on the plans,
(3) Smooth and free of localized indentations and deformities,
(4) Top face with deviations no greater than ⅛ in [3 mm] in any 10 ft [3 m] section,
(5) Faces of straight forms with deviations no greater than ¼ in [13 mm] in any 10 ft [3 m] section,
(6) Side forms containing no bends or damaged sides,
(7) Forms containing no damaged joint locks or pin pockets, and
(8) Form lengths at least 10 ft [3 m] long with horizontal joint and base width equal to the depth of the forms.

For pavements with radii no greater than 100 ft [30 m], use flexible or curved forms approved by the Engineer. Provide devices to securely set forms and withstand operation of the paving equipment without springing, settlement, or lateral displacement. Provide forms with joint locks to tightly join the ends of abutting form sections. Connect individual form sections using methods that create a continuous form.

Set the forms to the alignment and grade shown on the plans for a distance equal to at least 3 h ahead of concrete placement.

Compact the foundation before placing the forms in accordance with 2301.3.D, "Subgrade and Aggregate Base Preparations." Ensure the forms have a firm and uniform bearing over the entire base area, are tightly joined and securely staked, and are clean and free of accumulations of hardened concrete. Coat the contact faces of the forms with an approved form coating material in accordance with 3902, "Form Coating Material," before placing the concrete.

During a rain event, remove and reset the forms as necessary to allow drainage.

E.3.b Fixed Form Placement

Place concrete using one or more machines to spread, screed, and consolidate between previously set side forms. Accomplish vibration of these areas using hand-held or machine-mounted internal vibrators.

If not using an electronic monitoring device, use a tachometer or similar device to demonstrate to the Engineer that the paving equipment vibration meets the requirements in this section.

Use hand-held vibrators to consolidate concrete adjacent to side forms and fixed structures. Operate the hand-held vibrators at a speed of at least 3,600 VPM [60 Hz]. Do not allow the vibrator head to contact the joints, load transfer devices, reinforcement, grade, or side forms. If the vibrator fails, suspend operations and remove unconsolidated concrete.

Continue vibration to achieve adequate consolidation, without segregation, for the full depth and width of the area placed.

Provide an adequate number and capacity of machines to perform the work at a rate equal to the concrete delivery rate.

Strike-off concrete with a clary screed, unless otherwise approved by the Engineer. Finish small or irregular areas that are inaccessible to finishing equipment using other methods as approved by the Engineer.

Discontinue any operation that causes displacement of the side forms from the line or grade or causes undue delay, as determined by the Engineer, due to mechanical difficulties.

E.3.c Removal of Forms

Do not remove side forms of pavement and back forms on integrant curb earlier than 12 h after placing the concrete, unless otherwise approved by the Engineer. Remove forms without exerting shock or strain, including temperature variations, on the pavement or curb. Cure concrete in accordance with 2301.3.M.1.a, "Membrane Curing Method."

F Placing Concrete

Construct mainline pavement in a single layer of concrete. Place the concrete pavement in one complete pass of the paving machine to minimize the need for hand finishing.

Coordinate paving operations for mixing, delivering, spreading, and extruding the concrete to provide uniform progress of the paver. Use sufficient trucks to ensure a steady forward progress of the paver. If the forward movement of the paver stops for a period long enough to create a cold joint or honeycombing, construct a header joint in accordance with 2301.3.F.4, "Constructing Headers."

Set manhole and catch basin frames or rings to the elevation shown on the plans during the paving operations. Do not form "box-outs" of castings unless approved by the Engineer.

Dump or discharge concrete without causing grade displacement or damage to the existing asphalt or bond breaker layer. Repair damage to the grade in accordance with 2301.3.D, "Subgrade and Aggregate Base Preparations," existing asphalt or bond breaker layer as approved by the Engineer at no additional cost to the Department. Provide protection for turning concrete trucks.

F.1 Placement on Aggregate Base

Maintain the base in a moist condition until placement of concrete.

F.2 Placement on Asphalt or Asphalt Bond Breaker

When placing concrete on asphalt or asphalt bond beakers, comply with the following:

(1) Do not place concrete on an asphalt surface with an asphalt surface temperature greater than 120 °F [50 °C].
(2) Maintain the asphalt surface in a moist condition and at a surface temperature not greater than 120 °F [50 °C] before placing the concrete. The Engineer will allow the Contractor to apply water, whitewash of hydrated lime and water, or both to cool the asphalt surface, or other methods allowed by the Engineer.
(3) Before placing concrete on a milled asphalt surface, clean the milled surface by sweeping and patch as shown on the plans in accordance with 2231, "Bituminous Surface Reconditioning," or as directed by the Engineer.

F.3 Placement Adjacent to In-Place Concrete Pavement

Stake preformed joint filler material for expansion joints in place to maintain the position shown on the plans during concrete placement.

When placing concrete adjacent to in-place concrete pavement, protect the following:

(1) All ends of transverse joints $^{3}/_{16}$ in [5 mm] or wider to the satisfaction of the Engineer. The Engineer will allow sawing through the existing joint when sawing the newly placed concrete, and
(2) The in-place pavement to prevent damage.

Do not allow the edges of the pavement, including longitudinal joints, to deviate from the line shown on the plans by greater than ½ in [13 mm] at any point.

Set manhole and catch basin frames or rings to the elevation shown on the plans during the paving operations.

F.4 Constructing Headers

Construct construction headers, temporary headers, and permanent headers as shown on the plans.

The Engineer will not allow incorporating any concrete accumulated in the grout box of the paver into the pavement. Construct all headers such that the concrete contained in the grout box is removed from the project. Use any approved construction header method as shown in the Standard Plate 1150.

Use internal vibration to consolidate the concrete along header joints before final finishing.

F.5 Air Content

F.5.a Air Content Before Consolidation

Measure the air content of the plastic concrete after placement on the grade but before consolidation. Maintain the air content of Type 3 paving concrete at the specified target of 7.0 percent (**plus 2.0%** / **minus 1.0%**) of the measured volume. Make adjustments immediately to maintain the desired target air content, in accordance with Specification 1503, "Conformity with Contract Documents."

F.5.b Air Content After Consolidation

If using the slipform paving method, establish an air-loss correction factor (ACF) to determine the air content after consolidation. Apply the ACF to tests taken before consolidation to estimate the air content after consolidation. Place concrete with an air content of at least 5.0 percent after consolidation.

Take the following actions in accordance with Table 2301-15 for air content test results with the ACF applied or a test taken after consolidation:

Table 2301-15
Air Loss Correction Factor (ACF) Required Action

If Contractor or Agency test results in the following:	Contractor Action
5.0 to 5.5%	Test next load and verify the ACF is correct. If the results are still between 5.0 and 5.5%, make immediate adjustments to the concrete or the consolidation process, test any loads that have not been discharged or adjusted at the plant and apply the ACF to determine compliance. Test every load of concrete until the air content test results meet the requirements. Test at least 3 additional trucks to ensure the concrete remains in compliance.
<5.0%	Test next load and verify the ACF. Stop production, test any loads that have not been discharged or adjusted at the plant and apply the ACF to determine compliance. If the results are less than 5.0%, reject the concrete. Test every load of concrete until the air content test results meet the requirements. Test at least 3 additional trucks to ensure the concrete remains in compliance. Perform additional testing on the hardened concrete as required by the Engineer in conjunction with the Concrete Engineer.

F.2.a Non-Conforming Material

Only place Type 3 concrete meeting the air content requirements in the work. If the Contractor places Type 3 concrete not meeting the air content requirements into the work, the Engineer will not accept nonconforming concrete at the contract unit price.

For concrete not meeting the required air content, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the contract unit price for the contract pay item of the concrete in accordance with Table 2301-16. When there is not a separate structural concrete contract unit price for a contract item, the Department will reduce payment based on a concrete price of $60.00 per cu. yd [$78.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2301-16 Paving Concrete	
Air Content Before Consolidation, %	**Adjusted Contract Unit Price**
>10.0	The Engineer, in conjunction with the Concrete Engineer will determine the concrete suitability for the intended use in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work,"
>9.0 – ≤10.0	The Department will pay 75 percent of the Contract unit price for the concrete represented and placed as approved by the Engineer
6.0 – 9.0	The Department will pay 100 percent of the Contract unit price for the concrete represented and placed as approved by the Engineer
>5.0 – <6.0	The Department will pay 75 percent of the Contract unit price for the concrete represented and placed as approved by the Engineer
>4.0 – ≤5.0	The Engineer, in conjunction with the Concrete Engineer will determine the concrete suitability for the intended use in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work,"
≤ 4.0	Remove and replace concrete in accordance with 1503, "Conformity with Contract Documents" and 1512, "Unacceptable and Unauthorized Work" as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain place, the Engineer will not pay for the concrete and if the Engineer determines the surface is exposed to salt-brine freeze-thaw cycling, coat with an epoxy penetrant sealer from the Approved/Qualified Products List.

G Placing Pavement Reinforcement

Provide and place reinforcement meeting the following requirements and characteristics:

(1) Provide epoxy coated reinforcement in accordance with 2472, "Metal Reinforcement," except keyway bars and tie bars are not required to have epoxy coated ends.
(2) Provide and place reinforcement bars including keyway bars, tie bars, taper steel, and stopper bars.
(3) Place keyways as shown on the plans.
(4) Provide and place supplemental pavement reinforcement as shown on the plans.
(5) Provide and place reinforcement bars on chairs, in stakes, utilizing tie bar basket assemblies or by appropriate equipment for depressing the bars to the specified location.
(6) For slipform paving, stake the tie bar steel to the roadbed, or use a mechanical device attached to the spreader or paver to place tie bar steel required for L1T joints as shown on the plans. Space and depress the tie bar steel to the depth and location shown on the plans. Do not place tie bars over a dowel bar assembly.

H Dowel Bar Placement

Place dowel bars parallel to the grade and parallel to the centerline of the pavement.

Space contraction joints at the intervals shown on the plans, except shorten the spacing at the following to provide panel lengths at least 5 ft [1.5 m]:

(1) Adjacent to header joints,
(2) Reinforced panels,
(3) Railroad grade crossings, and
(4) Free ends of pavement.

In accordance with Standard Plate 1103, provide dowel bar assemblies manufactured in single units for the lane widths shown on the plans, unless otherwise approved by the Engineer. For non-typical lane widths, do not (splice) use more than two dowel bar assemblies in any one doweled joint.

Secure dowel bar assemblies with anchors to hold the dowel bars in the correct position and alignment while preventing movement during concrete placement in accordance with Standard Plate 1103 and the following:

(1) Provide a Quality Control Plan for Anchoring Dowel Basket Assemblies in accordance with 2301.3.H.1, "Quality Control Plan for Anchoring Dowel Basket Assemblies."
(2) Fasten the baskets to the substrate surface so that they do not move vertically or horizontally more than 1/4 inch [6 mm].
(3) Type, location, number and length of anchors are dependent upon field conditions;
(4) Before the beginning of concrete pavement placement and each day prior to beginning paving, demonstrate the fastening method to the Engineer for approval.

Within 1 h before covering with concrete, coat the dowel bars with a thin uniform coating of a form coating material in accordance with 3902, "Form Coating Material."

Before placing the concrete, mark the location on both sides of each transverse joint as approved by the Engineer. Transfer the markings to the top surface of the fresh concrete immediately after completing the final finishing operations.

The Contractor may use a mechanical dowel bar inserter to place dowel bars in the pavement as approved by the Engineer, in conjunction with the Concrete Engineer. Immediately before inserting the dowels, coat the dowels with a thin uniform coating of a form coating material in accordance with 3902, "Form Coating Material." If using a dowel bar inserter, initially and on each production day, demonstrate to the Engineer that the inserted dowel bars in the completed concrete pavement are parallel to the surface and centerline slab and are located at mid-depth of the slab thickness.

H.1 Quality Control Plan for Anchoring Dowel Basket Assemblies

At least 7 days prior to the beginning of concrete paving, provide a Quality Control Plan in writing to the Engineer for acceptance that provides a method for keeping the dowel basket assemblies anchored to the subgrade, the existing concrete, or into the asphalt or bond breaker layer and into the underlying concrete. The Quality Control Plan shall include the following at a minimum:

(1) Proposed type and number of fasteners
(2) Proposed installation equipment
(3) Dowel basket assembly anchoring plan (i.e. Anchored all basket assemblies prior to concrete placement, one lane at a time, anchor all basket assemblies during the concrete placement operation, etc.)
(4) Action plan if mis-aligned baskets are identified during concrete pavement placement

The Engineer will suspend paving operations if the Contractor fails to comply with their Quality Control Plan.

I Definition of a Lot and Sublot for Concrete Field Testing

I.1 Lot Establishment

The Engineer will select random locations for locating dowel bars, reinforcement (L1T) steel, pavement texture, and concrete probing testing. The Department defines a lot as all concrete pavement of a single lane added together lineally into a lot. The Engineer will include all doweled pavement, regardless of width as part of the lot.

The Department defines a single lane in accordance with the following:

(1) From the pavement edge to the adjacent longitudinal joint,
(2) From one longitudinal joint to the next, or
(3) In the absence of a longitudinal joint, between pavement edges,
(4) Each ramp and loop ≤ 18 ft [5.5 m] wide.

I.2 Sublot Establishment

Once established, the Engineer will divide the lot into sublots representing 1,000 linear lane ft [300 lineal lane m]. The Engineer will add partial sublots less than 500 lineal lane ft [150 lineal lane m] to the previous sublot. The Engineer will consider partial sublots equal to or greater than 500 lineal lane ft [150 lineal lane m] as individual sublots. If the project results in less than four (4) sublots, the Engineer will divide the project into four (4) sublots of equal length.

The Engineer will provide the sublot testing locations to the Contractor prior to pavement placement. The Engineer will utilize random numbers to locate specific testing locations within the sublots at the minimum rates defined in:

(1) 2301.3.J.2, "Minimum Plastic Concrete MIT-Scan-T2 Testing Rates,"
(2) 2301.3.K.1.a, "Texture Testing," and
(3) Spec 2301.3.L.3, "Contractor Quality Control Probing."

J Verification of Dowel Bar and Tie Bar Placement in Plastic Concrete

For projects with greater than 3,500 cu. yd [2,900 cu. m], provide a MIT-Scan-T2 non-destructive testing device in accordance with this section for concrete pavement placed by the slipform method.

J.1 MIT-SCAN-T2 Non-Destructive Testing Device

The Contractor shall furnish a MIT-SCAN-T2 non-destructive testing device having the ability to locate pavement reinforcement, dowel bars, and measure concrete pavement thickness in a single device. Agency and Contractor personnel shall mutually use this non-destructive testing device to locate dowel bar and tie steel placement in the plastic concrete during pavement construction.

Agency observations do not relieve the Contractor of the requirement to properly place the concrete reinforcement and dowel bars as shown in the plans. In addition, the Department reserves the right to reject the pavement in accordance with 1503, "Conformity with Plans and Specifications" and 1512, "Unacceptable and Unauthorized Work."

The Engineer will not provide additional payment for furnishing the above equipment for the Department's use.

J.2 Minimum Plastic Concrete MIT-Scan-T2 Testing Rates

The Engineer will identify the MIT-SCAN-T2 testing locations in accordance with 2301.3.I, "Definition of Lot and Sublot for Concrete Field Testing," and the following:

(1) Use the MnDOT *Probing Coring Texture MIT-SCAN-T2 Workbook* to determine the random testing locations.

(2) Provide the MIT-SCAN T2 Report generated from the MnDOT *Probing Coring Texture MIT-SCAN-T2 Workbook* to the Contractor prior to the start of paving.
(3) Offset the location of the dowel bar test to the closest contraction joint.

Unless otherwise approved by the Engineer, perform all testing with the MIT-SCAN-T2 device in the presence of the Engineer. If the concrete pavement is constructed utilizing a slip form-paving machine locate dowel bars and machine placed tie bar (L1T) steel in the plastic concrete in accordance with the following:

(1) Locate the entire span of the dowel bar baskets and tie bar (L1T) steel, utilizing a walk bridge that spans the width of the pavement.
(2) Verify the adequacy of the dowel bar basket anchoring by locating both the upstream and downstream edges of the dowel bar baskets. After locating both the upstream and downstream limits of the dowel bar basket, ensure the proposed saw cut is centered on the dowel bars (± 3 inches) and that the dowels remain anchored parallel to the roadway centerline.
(3) Verify the presence and alignment of tie bar (L1T) steel by locating both ends of the tie bar. After locating both ends of the tie bar, ensure the proposed saw cut is centered on the tie bar (± 5 inches).

Locate both the dowel bar baskets and tie bar (L1T) steel in accordance with the following minimum testing rates:

(1) On the first day of pavement placement:
(1.1) Verify the adequacy of the dowel bar anchoring by scanning seven (7) random doweled contraction joints in each sublot.
(1.2) Verify the presence and alignment of tie bar steel by scanning 75 lin. ft. [22.5 m] in each sublot.

(2) If the Engineer determines the first days dowel bar anchoring and tie bar placement processes are acceptable, the Engineer may allow a reduction in scanned joints in each sublot as follows:
(2.1) Verify the adequacy of the dowel bar anchoring by scanning four (4) random doweled contraction joints per sublot.
(2.2) Verify the presence and alignment of tie bar steel by scanning 25 lin. ft. [7.6 m] out of every sublot.

J.3 Non-conforming Placement

If a dowelled contraction joint has dowel bars out of acceptable alignment during placement in accordance with 2301.3.J.2, "Minimum Plastic Concrete MIT-Scan-T2 Testing Rates," and Standard Plate 1103, scan both upstream and downstream from the misaligned transverse doweled joints, from concrete placed in the same operation, until at least three (3) joints comply with Standard Plate 1103.

If a panel along the tied longitudinal (L1T) joint is found to have two (2) or more tie bars missing or out of acceptable alignment tolerances specified in 2301.3.J.2, scan joints on both ends until three (3) consecutive panels meets the correct number of tie bars installed and acceptable tie bar alignment tolerances.

Failure to comply with the alignment tolerances will result in the Engineer, in conjunction with the Concrete Engineer, evaluating the concrete in accordance with 2301.3.Q "Workmanship and Quality."

K Surface Finishing

Use a ⅜ in [10 mm] radius edging tool to finish edges of the pavement. Do not add water to the surface of the concrete to aid in finishing without the approval of the Engineer.

If satisfactory finishing of the pavement does not occur, as determined by the Engineer, suspend batching and mixing operations.

After consolidating, screeding, and floating the concrete, give the pavement surface a final finish texture in accordance with 2301.3.K.1, "Pavement Texture."

K.1 Pavement Texture

Pull a carpet drag or broom drag longitudinally along the pavement before the concrete attains its initial set to obtain the final finish. Mount the drag on a bridge. Provide a drag with the following dimensions:

(1) As wide as the concrete placed, and
(2) Longitudinal length with sufficient surface contact to produce a texture approved by the Engineer.

When using a carpet drag method, provide an artificial grass type carpeting for the carpet drag meeting the following characteristics and requirements:

(1) Molded polyethylene pile face,
(2) Blade length from ⅝ in to 1 in [15 mm to 25 mm], and
(3) Total weight of at least 70 oz per sq. yd [2.35 kg per sq. m].

The Contractor may use manual methods to achieve similar results on ramps and other locations as approved by the Engineer. The Contractor may use other texturing equipment to obtain an equivalent texture as approved by the Engineer.

K.1.a Texture Testing

Test the adequacy of the pavement skid resistance in accordance with ASTM E 965-87, "Test Method for Measuring Surface Macrotexture Depth Using a Sand Volumetric Technique." Provide a texture depth of at least 1.00 mm.

The Engineer will identify the texture testing locations in accordance with 2301.3.I, "Definition of Lot and Sublot for Concrete Field Testing," and the following:

(1) Use the MnDOT *Probing Coring Texture MIT-SCAN-T2 Workbook* to determine the random testing locations.
(2) Provide the Concrete Texture Report generated from the MnDOT *Probing Coring Texture MIT-SCAN T2 Workbook* to the Contractor prior to the start of paving.
(3) Offset the texture test at a point located transversely in the outside wheel path.

Perform surface texture testing of the concrete pavement and provide the test results to the Engineer no later than 48 h after pavement placement unless otherwise approved by the Engineer.

K.1.b Non-conforming Texture

The Engineer will evaluate the texture results in accordance with Table 2301-17.

(1) If any texture test results fall below the minimum required, correct the operation immediately to achieve the minimum required texture.
(2) If the Engineer determines by visual inspection, that areas not represented by random testing appear to not meet the minimum texture required, the Engineer reserves the right to require additional testing in those specific areas to determine compliance.
(3) Run additional tests at 100 ft [30 m] intervals before and after the failing test location to determine the limits of any individual failing test.

Table 2301-17
Pavement Texture Depth

Texture Depth Test Results for Individual Tests	Resolution
≥ 1.00 mm	Meets requirements – No action required
<1.00 mm to ≥0.80 mm	The Engineer will accept the work if the Contractor amends the operation to achieve the required depth of at least 1.00 mm as approved by the Engineer. If the Contractor fails to correct the operation, the Engineer will suspend the paving operation until corrections produce the required results.
< 0.80 mm	Perform concrete grinding of the pavement represented by this test to attain the minimum texture of 1.00 mm as required by the Engineer.

L Pavement Thickness Requirements

Provide pavement with a finished pavement thickness as shown on the plans or as modified, in writing, by the Engineer.

L.1 Thickness Evaluation Procedure

The Department will evaluate each differing concrete pavement thickness required on the project. The Engineer will evaluate the concrete pavement through random probing and core measurements in accordance with the following:

(1) Contractor Quality Control Probe (QCP),
(2) Probe Verification Core (PVC), and
(3) Quality Acceptance Core (QAC).

The Engineer will identify the QCP, PVC, and QAC thickness measurement locations in accordance with 2301.3.I, "Definition of Lot and Sublot for Concrete Field Testing," and the following:

(1) Using the MnDOT *Probing Coring Texture MIT-SCAN-T2 Workbook* to determine the random testing locations.
(2) Adjust the location to ensure the Contractor takes no measurements within 1 ft [0.3 m] of the pavement edge and takes no measurements within 3 ft [0.60 m] of any transverse or longitudinal joint or other obstructions.
(3) Prior to the start of paving, provide the *Field Probing Report* generated from the MnDOT *Probing Coring Texture MIT-SCAN-T2 Workbook* to the Contractor.

L.2 Contractor Quality Control Probing (QCP)

Measure the pavement thickness of freshly finished concrete pavement at a rate of at least one (1) probe measurement per sublot. Notify the Engineer before performing probing thickness measurements in the plastic concrete so they may observe the Contractor's probe tests. Record the probing results on the *Field Probing Report*.

Provide daily summary reports listing the results of the day's QCP thickness measurements and additional probing results to the Engineer.

L.2.a Contractor QCP Probing Equipment and Probing Method

Provide the following equipment as approved by the Engineer to perform probing:

(1) Probing rod meeting the following characteristics and requirements:
- (1.1) Non-flexing,
- (1.2) Length capable of completely penetrating the pavement for measuring,
- (1.3) Utilizes a circular or square top plate,
- (1.4) Contains a centrally located hole in the top plate with a diameter allowing for easy maneuvering along the length of the probing rod, and
- (1.5) Fitted with a locking device fixing the angle between the top plate and the probing rod at 90 degrees when locked.

(2) Base plate meeting the following characteristics and requirements:
- (2.1) 30 cm ± 0.1 mm diameter, 660 µm ± 10 µm thick, steel (US ASTM Standard A653 Type 2 Commercial 1 Grade, G90) circular plate supplied by Kessler Soils Engineering Products, Inc. or approved equal, and
- (2.2) Rigid when in place, allowing the probing rod to be pushed against it without flexing.

(3) Work bridge meeting the following characteristics and requirements:
- (3.1) Spans the full width of the freshly laid concrete,
- (3.2) Supports a person, and
- (3.3) Height above the concrete allows for the use of the probing device.

(4) Tape measure accurate to nearest ⅛ in [even mm] and with a length capable of measuring the depth of penetration of the probing device into the plastic concrete pavement.

Perform probing in accordance with the following:

(1) Place the base plates at the randomly selected locations and anchor the plates to prevent movement during concrete placement. Mark the locations of the base plates to ensure ease of locating the plates after the paver has passed.
(2) Position the bridge at the selected locations to reach and locate each point.
(3) Assemble the probing device. Keeping the probing rod perpendicular to the pavement surface, insert the rod into the plastic concrete until the rod strikes the base plate.
(4) Slide the top plate down the probing rod until it contacts the pavement surface then lock to the probing rod.
(5) Withdraw the probing device.
(6) Measure the length of the probing rod inserted into the plastic concrete from the underside of the top plate to the end of the probing rod. Record this measurement to the nearest ⅛ in [even mm].

L.2.b Individual Deficient Probe

If an individual probe measurement shows a thickness deficiency greater than ½ in [13 mm] from plan thickness, take a core (QCP-Core) at the probe location to determine if the pavement is defective.

L.3 Quality Acceptance Testing – Coring

After concrete pavement placement, the Engineer will mark the core locations identified on the *Field Coring Report* generated from the MnDOT *Probing Coring Texture MIT-SCAN-T2 Workbook*. The Contractor will core the designated PVC and QAC locations.

L.3.a Probe Verification Core (PVC)

Take PVC at the same location as a probe measurement at the rate of one (1) core for every four (4) probe measurements. If the probe measurements are not divided evenly by four (4) for each plan thickness take one (1) additional core in the remaining probes.

The Engineer will compare PVC measurement to the initial probe measurement.

L.3.b Quality Assurance Cores (QAC)

Take one (1) random core every 4,000 lineal lane ft [1220 lineal lane m] for each plan thickness. Add partial segments less than 2,000 lineal lane ft [610 lineal lane m] to the previous 4,000 lineal lane ft [1220 lineal lane m] and take one (1) core. If partial segments are equal to or greater than 2,000 lineal lane ft [610 lineal lane m], take one (1) random core. If the plan thickness for the entire project is less than 4,000 lineal lane ft [1220 lineal lane m], take one (1) random core.

L.3.c PVC and QAC Coring Method

(1) The Engineer will allow coring after the concrete meets the requirement of 2301.3.O, "Opening Pavement to Traffic." Use 3U18 concrete or another concrete mix approved by the Engineer to fill the core holes within 72 h of coring at no additional cost to the Department. Provide traffic control for coring;
(2) Cut 4 in [100 mm] nominal diameter cores at marked locations. Lay the cores next to the holes in a curing condition. Protect the cores. Do not submit cores out of round, not perpendicular, or containing ridges;

(3) The Engineer will field measure the core thickness to the nearest ⅛ in [even mm], verify (Field ID Number) the cores, and record the field measurement on the *Field Coring Report* generated from the MnDOT *Probing Coring Texture MIT-SCAN-T2 Workbook*;
(4) Pick up the cores, accompanied by the Engineer. Store the cores in a water tank heated from 60 °F to 80 °F [15 °C to 25 °C] at the Department field office. The Engineer will not require the storage of cores in a curing condition for concrete older than 28 days;
(5) The Engineer will transport the cores in a curing condition, unless older than 28 days, to the MnDOT Office of Materials and Road Research; and

L.3.d Final Pavement Thickness Core Measurement

The MnDOT Office of Materials and Road Research will determine the final pavement thickness by measuring the length of the PVC and QAC cores in accordance with the following:

(1) Use nine probes interconnected in a hydraulic linkage to obtain the average length of the core in one operation.
(2) Report the lab measured core length to the nearest 0.05 in [1 mm].
(3) After Department thickness verification, the Department will test all of the cores for compressive strength at 60 days of age for information only. The Department will test three (3) of the cores from the entire project for rapid chloride permeability (RCP) in lieu of compressive strength testing for information only.

L.4 Evaluation of Cores to Determine Acceptance

The Department will use lab-measured cores (QCP-Core, PVC and QAC) to determine acceptance and price adjustment based upon the following:
(1) Individual core thickness in accordance with Table 2301-18, and
(2) Final average core thickness for each plan thickness (PT).

Table 2301-18
Acceptable Concrete Pavement Thickness

Individual Lab Measured Core (QCP-Core, PVC or QAC)	Exploratory Coring Required	Resolution
< PT – ½″ [< PT - 13 mm]	No	2301.3.L.7
PT - ½ in to 1 in [PT - 13 mm to 25 mm]	2301.3.L.5	2301.3.L.6.a
> PT - 1″ [> PT - 25 mm]	2301.3.L.5	2301.3.L.6.b

L.5 Exploratory Coring

The Engineer will require an exploratory core in the adjacent lane if placed in the same paving operation. If the length of the exploratory core in the adjacent lane is at least equal to the plan thickness minus ½ in [13 mm], the Engineer will not require additional cores in the adjacent lane.

Take exploratory cores in accordance with the following procedure:
(1) At any location within 10 ft [5 m] on each side of the deficient thickness location and at the same distance from the pavement centerline. If the length of each of the first exploratory cores is at least equal to the plan thickness minus ½ in [13 mm], the Engineer will not require additional cores from this location.
(2) If any cores do not fall within the plan thickness minus ½ in [13 mm], take additional exploratory cores at 25 ft [10 m] intervals and at the same distance from the pavement centerline, as directed by the Engineer.
(3) Perform coring in the direction of the deficiency until obtaining a core with a length at least equal to the plan thickness minus ½ in [13 mm] in each lane separately. The Engineer will use exploratory cores to determine the extent of deficient pavement thickness for adjusting the contract unit price or requiring pavement removal and replacement.

L.6 Non-conforming Thickness

The Department defines the defective pavement area as the entire area surrounding the deficient core within the entire width of the traffic lane and between acceptable cores.

The Department considers the pavement acceptable to remain in place in the remaining areas as the increment where the cores show a thickness deficiency no greater than plan thickness minus ½ in [13 mm].

L.6.a Defective Pavement Area between ½ in and 1 in [13 mm to 25 mm]

For cores showing a pavement thickness greater than the plan thickness minus ½ in to 1 in [13 mm to 25 mm], the Contractor may choose one of the following:
(1) Remove and replace the defective pavement area at no additional cost to the Department, or
(2) Leave the pavement in place with a monetary deduction of $20.00 per sq. yd [$25.00 per sq. m] for the defective pavement area, as approved by the Engineer.

L.6.b Defective Pavement Area > 1 in [25 mm]

For cores showing a pavement thickness greater than 1 in [25 mm] below the plan thickness, the Engineer, in conjunction with the Concrete Engineer, will determine whether the Contractor will do one of the following:

(1) Remove and replace the defective pavement area at no additional cost to the Department, or

(2) Leave the pavement in place at no cost to the Department and apply a monetary deduction of $20.00 per sq. yd [$25.00 per sq. m] for the defective pavement area in accordance with 1503, "Conformity with Contract Documents."

L.7 Final Average Core Thickness

After all coring (including exploratory coring) is completed; the Engineer will use all the cores (QCP-Core, PVC or QAC) to determine the final average core thickness for each plan thickness.

If all of the cores (QCP-Core, PVC or QAC) meet the design plan thickness requirements of the project, the Engineer will consider the final average core thickness for each plan thickness acceptable.

If any of the cores (QCP-Core, PVC or QAC) do not meet the design plan thickness requirements of the project, the Engineer will determine the final average core thickness for each plan thickness, except for the following:

(1) If exploratory cores are taken to identify the defective pavement area, substitute the two outside exploratory cores that are within plan thickness minus ½ in [13 mm] for the deficient PVC or QAC.

(2) If the length of a PVC or QAC exceeds the plan thickness plus 0.30 in [8 mm], the Engineer will limit the core length to the plan thickness plus 0.30 in [8 mm]. If the final average core thickness for each plan thickness is deficient by more than the plan thickness minus 0.10 in [3 mm], the Department will pay for the pavement by the plan thickness at the contract unit price less the monetary deductions in Table 2301-19, excluding areas of defective pavement as indicated above.

Table 2301-19
Monetary Deductions for Final Average Core Thickness
(Each Plan Thickness)

Thickness Deficiency Exceeding Permissible Deviations, in [mm]	Adjusted contract unit price per sq. yd [sq. m] of Payment
0.00 – ≤ 0.10 [≤ 3.0]	None (tolerance)
0.11 – ≤ 0.20 [3.1 – ≤ 5.0]	$0.20 [$0.25]
0.21 – ≤ 0.30 [5.1 – ≤ 8.0]	$0.40 [$0.50]
0.31 – ≤ 0.40 [8.1 – ≤ 10.0]	$0.70 [$0.90]
0.41 – ≤ 0.50 [10.1 – ≤ 13.0]	$1.00 [$1.25]
0.51 – ≤ 1.00 [13.1 – ≤ 25.0]	$20.00 [$25.00]

M Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 minutes of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2301.3.M.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets, unless the contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets in accordance with 2301.3.M.1.b, "Curing Blanket Method," as soon as practical without marring the surface.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions or equipment failures occur, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

Failure to comply with the above provisions will result in the Engineer, in conjunction with the Concrete Engineer, applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents." When there is not a separate contract unit price for Structural Concrete, the Department will apply a monetary deduction of $30.00 per cu. yd [$39.00 per cu. m] or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

M.1 Curing Methods

M.1.a Membrane Curing Method

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound in accordance with the following:

(1) At a minimum rate of 1 gal per 150 sq. ft (1 L per 4 m²) of surface curing area.
(2) Apply curing compound homogeneously to provide a uniform, solid, white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. If using a Department approved curing compound with a non-white base color, apply the compound to provide a uniform, solid, opaque consistency meeting the intent of the requirement in this section.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.
(4) If the Engineer determines that the initial or corrective spraying result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method, at no additional cost to the Department.

Use the fully-automatic, self-propelled mechanical power sprayer approved by the Engineer to apply the curing compound in accordance with the following:

(1) Operate the equipment to direct the curing compound to the surface from two different lateral directions,
(2) Do not allow the sprayer to ride on the pavement surface,
(3) Ensure the sprayer covers the entire lane width and atomizes the curing compound, and
(4) If puddling, dripping, or non-uniform application occurs, suspend the operation to perform corrections as approved by the Engineer.

Use a fully automatic, self-propelled mechanical power sprayer equipped with the following as approved by the Engineer:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle,
(3) Check valve nozzles,
(4) Multiple or adjustable nozzle system that provides for variable spray patterns,
(5) A shield to control loss of material by wind action, and
(6) A spray-bar drive system that operates independently of the wheels or track drive system.

For applying the curing compound on pavements that are 10 ft [3 m] wide or less and irregular shaped surfaces, the Engineer will allow an airless spraying machine that complies with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

M.1.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

M.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of the concrete. Should any damage result, the Engineer will suspend operations until corrective action is taken and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

M.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 36 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, the Contractor shall submit a cold weather protection plan.

Protect the concrete from damage, including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until corrective action is taken and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

M.3.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plans.

M.4 Vibratory and Backfilling Protection

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 h. Resume vibratory and backfilling operations after the concrete has reached a minimum compressive strength of 2,000 psi [13.7 MPa] or a flexural strength of 250 psi [1.7 MPa]. Cast concrete control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens." The Engineer will test the control specimens. If the Engineer discovers evidence of damaged concrete,

the Engineer will suspend work until the Contractor corrects the work. The Engineer may reject damaged concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may use hand-operated concrete consolidation equipment, walk-behind vibratory-plate compactors, rollers in "static" mode, and fine grading machines 24 h after placing the concrete, and other equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

N Joint Construction Operations

Unless otherwise shown on the plans, construct all joints perpendicular to the grade.

N.1 Joint Sawing Equipment

Provide wet-cut saws for joint establishment in the all concrete.

If the Contractor would like to use lighter weight dry-cut saws, commonly referred to as "early entry", submit a Quality Control Plan to the Engineer defining the intended use for the early-entry saws. The Engineer, in conjunction with the Concrete Engineer, will evaluate the QC plan to determine if their use is acceptable.

When using early-entry saws, use saw blades and skid plates specifically designed for the type coarse aggregate used in the concrete in accordance with the saw manufacturer's recommendation.

N.2 Joint Establishment

Provide initial joint sawing as shown on the plans. Perform the initial sawing as soon as the concrete will support the joint sawing operation without raveling and before random cracking occurs. If raveling of joints occurs due to the sawing operations, review the sawing operation and make immediate correction to the sawing operations. The Engineer, in conjunction with the Concrete Engineer, will evaluate the raveled joints in accordance with 2301.3.Q, "Workmanship and Quality."

During sawing of joints, provide one or more backup saws and an adequate supply of blades.

Immediately after completing the joint sawing, use water under nozzle pressure to remove the sawing residue from each joint and the pavement surface.

If widening is necessary, do not widen the joints to full width until the concrete is at least 24 h old, or longer if the sawing causes raveling of the concrete.

Extend transverse joints constructed in the pavement through the integrant curb.

N.3 Joint Sealing

When joint sealing is required by the Contract, provide a joint sealant in accordance with 3725, "Hot-Poured, Extra-Low Modulus, Elastic-Type Joint and Crack Sealer," unless the type of sealant for contraction joints is otherwise specified in the contract.

If the concrete mixture contains Class B coarse aggregate as defined in 3137, "Coarse Aggregate for Portland Cement Concrete," do not seal joints with silicone.

Perform joint sealing as shown on the plans and in accordance with the following:

(1) Seal joints after the Engineer inspects and approves the joints;
(2) Perform joint sealing on surface dry concrete after cleaning the joints of debris, dirt, dust, and other foreign matter, including accumulations of concrete;
(3) Lightly sandblast the joint walls before final compressed air cleaning;
(4) Immediately before sealing the joints, clean the joints with a jet of compressed air under pressure of at least 85 psi [580 kPa];
(5) Seal transverse integrant curb joints with the same joint sealer used to seal the pavement joints;
(6) Seal joints in accordance with the tolerances shown on the plans;
(7) Provide backer rod material compatible with the sealer as shown on the plans; and
(8) Remove and replace sealer at joints filled above the permissible level shown on the plans at no additional cost to the Department.

Handle and place joint sealer material as recommended by the manufacturer and in accordance with the following requirements:

N.3.a Hot-Poured Sealers

Heat hot-poured sealers in a double-boiler type kettle or melter. Fill the space between inner and outer shells with oil or other material as allowed by the manufacturer. Provide heating equipment with automatic temperature control, mechanical agitation, and recirculating pump. Use heating equipment as recommended by the manufacturer of the sealer material. Do not melt quantities of sealer material greater than the quantity used within the same day. After heating the sealer material to the application temperature, maintain the material temperature until placement. Place the sealer material within 4 h after the initial heating to the application temperature.

Apply sealant to the pavement at ambient pavement temperatures greater than 39 °F [4 °C].

N.3.b Silicone Sealers

Install silicone sealers as recommended by the manufacturer.

N.3.c Preformed Sealers

Provide preformed seals in one continuous length for each joint, except the Contractor may use butt splices in transverse joints at longitudinal joints.

Do not stretch the preformed sealer material in the installation process by greater than 5 percent of the joint length.

O Opening Pavement to Traffic

Do not open a new pavement slab to general public traffic or operate paving or other heavy equipment on it for 7 days, or until the concrete has reached a minimum flexural strength meeting the requirements of Table 2301-15, or minimum compressive strength of 3,000 psi [20.6 MPa]; whichever occurs first.

If the pavement joints are widened, seal the joints before operating paving or other heavy equipment and general public traffic on the pavement.

Cast the control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens." Cure the control specimens in the same manner and under the same conditions as the pavement represented. The Engineer will test the control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens."

Table 2301-15
Minimum Strength Requirements for Opening Pavements to Construction and to General Public Traffic

Slab Thickness, *in [mm]*	**Flexural Strength, *psi [MPa]***
≤7.0 [175]	500 [3.4]
7.5 [190]	480 [3.3]
8.0 [200]	460 [3.2]
8.5 [215]	440 [3.0]
9.0 [225]	390 [2.7]
≥ 9.5 [240]	350 [2.4]

Perform operations on new pavement as approved by the Engineer and in accordance with the following:

(1) When moving on and off the pavement, construct a ramp to prevent damage to the pavement slab.

(2) Operate the paving equipment on protective mats to prevent damage to the pavement surface and joints. Before placing the protective mats, sweep the pavement surface free of debris.

(3) Operate equipment on a slab without causing damage. If damage results, suspend operations and take corrective action as approved by the Engineer. Do not operate the equipment wheels or tracks within 4 in [100 mm] of the slab edge.

O.1 Early Opening of Pavement to Traffic

For early use of the pavement as required by the Engineer, construct a section of pavement of high-early strength concrete in accordance with 2301.2.L, "Concrete Mix Design Requirements," at important road crossings, intersections, driveway entrances, or other locations as shown on the plans or directed by the Engineer. Take precautions to satisfactorily finish, cure, and protect high-early strength concrete pavements.

P Pavement Smoothness – IRI (International Roughness Index)

Provide concrete pavement smoothness in accordance with 2399, "Pavement Surface Smoothness."

For any pavement sections not subjected to 2399, "Pavement Surface Smoothness", the Engineer will use a 10 ft [3.05 m] straightedge to evaluate the concrete pavement. The Engineer will measure for surface deviations greater than ¼ in [6.35 mm] in 10 ft [3.05 m]. The Engineer will evaluate transverse joints by centering the straightedge longitudinally across the transverse joint. The Engineer will allow variations less than or equal to ¼ in [6.35 mm] within the span of the straightedge in the longitudinal or transverse direction to remain in place without correction or penalty.

The Engineer will require corrective work on surface deviations greater than ¼ in [6.35 mm] within the span of the straightedge in any direction. For corrected variations, the Engineer will accept deviations less than or equal to ¼ in [6.35 mm] within the span of a 10 ft [3.05 m] straightedge in any direction.

If the Contractor adds water to the pavement surface without approval by the Engineer, the Department will not pay water/cement or ride incentives on sections where the water is added and the Engineer may reject the pavement in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

Q Workmanship and Quality

Q.1 Defective Pavement

The Department will pay for concrete pavement meeting the requirements and tolerances in accordance with this section at the contract unit price. Pavement that fails to meet the minimum requirements when placed and tested in the prescribed manner is considered defective. The Department may reject or adjust the payment for defective concrete pavement in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Engineer will determine the limits of each individual defective pavement area. If adjusting the price for defective payment, the Engineer will measure the area to the nearest whole square yard [square meter], except the Engineer will consider areas less than 1 sq. yd [1 sq. m] as 1 sq. yd [1 sq. m]. The Engineer will determine the condition of each individual defective area of pavement based on the calculation of greatest deficiency within the area.

Q.2 Random or Uncontrolled Cracking

Repair or replace pavement with random or uncontrolled cracks as directed by the Engineer. If repairing the pavement as directed by the Engineer, use a dowel bar load transfer technique in accordance with the MnDOT Concrete Pavement Rehabilitation Details. Submit the intended repair technique to the Engineer for approval. Perform pavement repairs at no additional cost to the Department. If the repair fails, replace the pavement at no additional cost to the Department. The Engineer will accept repairs in accordance with 1516, "Acceptance."

2301.4 METHOD OF MEASUREMENT

A Concrete Pavement

If the contract includes the contract item *Concrete Pavement* or *Concrete Pavement High Early*, the Engineer will measure in accordance with the following:

(1) Measure the concrete pavement placed to a uniform cross-section thickness by the surface area of the pavement as constructed, including integrant curb;
(2) Include measurements for concrete pavement without regard to grade, strength, or type of concrete, width, or thickness of the pavement in a single measurement, except if the plans include a contract item for high-early strength concrete; and
(3) Apply incentive or disincentive for *Concrete Pavement* based on the theoretical volume of concrete used by multiplying the measured square yard [square meter] of concrete by the thickness shown on the plans.

B Place Concrete Pavement

If the contract includes the contract item *Place Concrete Pavement*, the Engineer will measure concrete pavement placed by area based on specified dimensions, including integrant curb. This measurement will represent the surface area of the pavement as constructed.

B.1 Structural Concrete

If the contract includes the contract item *Structural Concrete* or *Structural Concrete High Early*, the Engineer will measure the volume in accordance with the following:

(1) Measure the volume of structural concrete placed to a variable cross-section thickness using the average end-area method.
(2) Verify the volume measurements from the computerized batch ticket printouts from the plant, as verified by 2301.3.C.2, "*Concrete Ingredient Summaries*," and the consideration of any waste as agreed with the Engineer.
(3) Include the volume of all specified concrete pavements into a single item without regard to grade, strength, width, or thickness of the concrete pavement, except if the plans include a contract item for high-early strength concrete.
(4) Apply incentives or disincentives based on the cubic yard [cubic meter] of *Structural Concrete*.

C Supplemental Pavement Reinforcement

The Engineer will measure supplemental pavement reinforcement over culverts, storm sewers, and water mains, by weight.

D Expansion Joints

The Engineer will separately measure dowelled expansion joints of each design designation as shown on the plans by length along the joint line.

E Reinforcement Bars

The Engineer will not separately measure keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars.

F Integrant Curb

The Engineer will separately measure integrant curb of each design by length.

G Dowel Bars

The Engineer will measure dowel bars by the actual number of individual dowels placed. The Engineer will not measure dowels included in the contract linear foot [meter] price for *Dowelled Expansion Joints, Design ___*.

H Concrete Coring

The Engineer will not separately measure the number of cores taken, identified, and delivered as required by the contract or directed by the Engineer.

2301.5 BASIS OF PAYMENT

A Concrete Pavement

Unless the plans include a separate contract item, the Engineer will consider the contract square yard [square meter] price for C*oncrete Pavement* to include the cost of constructing the pavement, including the cost of batch materials and mixing operations; plant-lab office; producing the concrete; fine grading; forming, including all headers; providing and installing keyway and keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars; delivering; depositing; placing; spreading; screeding; vibration monitoring; finishing; curing; protecting; sawing; and sealing the concrete.

If the plans include a separate contract item for *Concrete Pavement High-Early* or if the Contractor requests high-early and the Engineer approves, the Department will not provide extra compensation for the production of high-early strength concrete. The contract square yard [square meter] price for *Concrete Pavement High-Early* includes the cost of constructing the pavement, including the cost of batch materials and mixing operations; plant-lab office; producing the concrete; fine grading; forming, including all headers; providing and installing keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars; delivering; depositing; placing; spreading; screeding; vibration monitoring; finishing; curing; protecting; sawing; and sealing the concrete.

If the plans do not include a separate contract item for *Concrete Pavement High-Early* and the Engineer orders high-early concrete, the Department will pay for the additional cement at a rate of the invoice cost plus 15 percent.

B Place Concrete Pavement

Unless the plans include a separate contract item, the Engineer will consider the contract square yard [square meter] price for *Place Concrete Pavement* to includes the cost of constructing the pavement, including fine grading; forming, including all headers; providing and installing keyway and keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars; placing; spreading; screeding; vibration monitoring; finishing; curing; protecting; sawing; and sealing the concrete.

B.1 Structural Concrete

The Engineer will field calculate the volume of *Structural Concrete* and *Structural Concrete High Early* placed. Due to variations in the asphalt or asphalt bond breaker layer, the Contractor may request additional volume up to 102 percent of the Engineer's field calculated final volume of *Structural Concrete*, *Structural Concrete High Early*¸ or both for the entire project. The Engineer will verify additional volume of concrete from the computerized batch ticket printouts from the plant, with consideration of any waste. If the Engineer finds the Contractor's request for the additional final volume valid, the Engineer will pay for the additional volume up to 102 percent of the calculated quantity for the entire project. The contract cubic yard [cubic meter] price for *Structural Concrete* and *Structural Concrete High-Early* includes the cost of producing, delivering, and depositing the concrete, including the cost of the batch materials, mixing operations, and the plant-lab office. If the plans include a separate contract item for *Structural Concrete High-Early* or if the Contractor requests high-early and the Engineer approves, the Department will not provide extra compensation for the production of high-early strength concrete.

If the plans do not include a separate contract item for *Structural Concrete High-Early* and the Engineer orders high-early concrete, the Department will pay for additional cement at a rate of the invoice cost plus 15 percent.

C Other Concrete Items

The contract pound [kilogram] price for *Supplemental Pavement Reinforcement* includes the cost of providing and placing the metal reinforcement, including tie wires, supporting devices, and splicing.

The contract linear foot [meter] price for *Dowelled Expansion Joints, Design ___* includes the cost of constructing the joints complete in place as shown on the plans, including the costs of providing and placing dowel bar assemblies, filler, and sealer materials.

The contract linear foot [meter] price for *Integrant Curb, Design ___* includes the cost of forming and finishing the curb and protecting and curing the concrete.

The relevant contract unit price for *Concrete Pavement* or *Place Concrete Pavement* includes the cost of coring, including the cost of material, labor, equipment, delivery, core hole filling, and traffic control.

The Department will pay for concrete pavement on the basis of the following schedule:

Item No.:	Item:	Unit:
2301.504	Concrete Pavement ___ in [___ mm]	square yard [square meter]
2301.504	Concrete Pavement ___ in [___ mm] High-Early	square yard [square meter]
2301.504	Place Concrete Pavement ___ in [___ mm]	square yard [square meter]
2301.511	Structural Concrete	cubic yard [cubic meter]
2301.513	Structural Concrete High-Early	cubic yard [cubic meter]
2301.508	Supplemental Pavement Reinforcement	pound [kilogram]
2301.503	Dowelled Expansion Joints, Design ___	linear foot [meter]
2301.538	Dowel Bar	Each
2301.541	Integrant Curb, Design ___	linear foot [meter]

2353 ULTRATHIN BONDED WEARING COURSE (UTBWC)

2353.1 DESCRIPTION

This work is the construction of an ultrathin bonded wearing course on a prepared pavement. An ultrathin bonded wearing course is the application of a polymer modified emulsion membrane followed immediately with an ultrathin wearing course mixture.

2353.2 MATERIAL REQUIREMENTS

A Bituminous Materials

A.1 Polymer Modified Emulsion Membrane

Provide a polymer modified emulsion membrane meeting the requirements of 3151.2.G

A.2 Asphalt Binder

Use a Performance Graded binder, PG 64-34 that meets Mn/DOT 3151.2.A.

B Aggregate

Meets MnDOT 3139.4.

B.3 Mineral Filler

Mineral filler shall meet the requirements in AASHTO M 17.

C Mix Design.

It is the Contractor's responsibility to design the UTBWC mixture that meets the requirements of this specification.

At the optimum binder content the mixture must meet the requirements in Table 2353- 1, "UTBWC Mixture Requirements".

Each design shall include the additional design trial points that bracket the optimum AC content and with at least one point at 0.4 above and below the optimum AC content. Draindown testing and adjusted AFT determinations are required on these trial points.

D. Mix Design Submittal

Submit a proposed job mix formula (JMF) in writing to the Department Bituminous Engineer for review as specified meeting the requirements in Table 3139-9, "UTBWC Aggregate Gradation Broadband" and Table 2353-1, "UTBWC Mixture Requirements" and include the following:

(1) Source, pit ID and description of the materials used.
(2) The proportion and gradation of each material in the JMF.
(3) The composite gradation of the design blend.
(4) Bulk and apparent specific gravities and water absorption (by % weight of dry aggregate). Both coarse and fine aggregate, for each product used in the mixture (including RAP/RAS). Use Mn/DOT Laboratory Manual Method 1204 and 1205. The tolerance allowed between the Contractor's and the Department's specific gravities are Gsb (individual) = 0.040 [+4 and -4] and Gsb (combined) = 0.020.
(5) Test results and worksheets for all properties required in Tables 2353-1, "UTBWC Mixture Requirements" and Tables 3139-7 to 9.
(6) Testing results and worksheets for the additional design points that bracket the optimum AC point.

Table 2353-1 UTBWC Mixture Requirements		
Test	**Criteria**	**Test Reference**
Asphalt Content	4.8-6.0	Mn/DOT Laboratory Manual 1853 or 1852
Adj. AFT (Calculated)	10.5 µm minimum	Mn/DOT Laboratory Manual 1854
Draindown Test	0.10% max	AASHTO T 305
Lottman (TSR)	80% min, 7-8% Voids	Mn/DOT Laboratory Manual 1813

D.1 Job Mix Formula Properties

Base gradation, asphalt binder content and adjusted AFT on the current Department reviewed Mixture Design Report. The JMF limits are the target plus or minus the limits in accordance with table 2353-2, "UTBWC JMF Limits." Use JMF limits as the criteria for acceptance of materials based on individual sample testing. Stop production if the test results vary from the JMF by more than the limits in Table 2353-2, "UTBWC JMF Limits". Identify the cause and document, in detail the corrective action. The JMF may only be adjusted if the revised JMF meets the mixture requirements in Tables 2353-1, "UTBWC Mixture Requirements" and Table 3139-9, "UTBWC Aggregate Gradation Broadbands". Do not resume paving until brought back into specification limits.

Table 2353-2 UTBWC JMF Limits	
Gradation	Broad Band Limits
Asphalt Content	±0.4*
Adj. AFT	-0.5*
*Note: The above limits shall not exceed the "Mixture Requirements" in Table 2353-1	

D.1 JMF Adjustments

The Contractor may make a request to the Bituminous or District Materials Engineer for a JMF adjustment if the QC test results indicate a necessary change to the design. A Certified Level II Bituminous QM Mix Designer will review the requested change for the Department. If the request meets the requirements in Table 3139-9, "UTBWC Aggregate Gradation Broadband" and Table 2353-1, "UTBWC Mixture Requirements", a revised Mixture Design Report will be issued.

2353.3 CONSTRUCTION REQUIREMENTS

A Weather Restrictions

The pavement surface temperature and ambient air temperature shall be at least 50 °F [10 °C]. A damp pavement surface is acceptable, if it is free of standing water and favorable weather conditions are expected.

B Surface Preparation

Complete the following incidental work prior to the paving operations. Remove thermoplastic and tape traffic markings greater than 0.2-in [5-mm] thick. Protect manhole covers, drain, grates catch basins, and other utility structures with plastic or building felt. Clean the pavement surface.

C Equipment

Use a paver, designed and built for the purpose of applying the ultrathin bonded wearing course. The paving machine shall incorporate a receiving hopper, feed conveyor, a storage tank for polymer modified emulsion membrane, polymer modified emulsion membrane spray bar and a variable width, heated, tamper bar screed. The screed shall have the ability to crown the pavement at the center both positively and negatively and have vertically adjustable extensions to accommodate the desired pavement profile.

D Paving

Mixture must be produced by a certified plant.

Apply the polymer modified emulsion membrane and the ultrathin bonded wearing course in one pass. Spray the polymer modified emulsion membrane so it is not driven on, immediately prior to the application of the UTBWC. Use a metered mechanical pressure spray bar at a temperature of 120 – 180 °F [50 – 80 °C]. Accurately and continuously monitor the rate of spray and provide a uniform application across the entire pavement width. Use a spray rate in the range of 0.20 gal/yd² ± 0.07 gal/yd² [0.85 l/m² ± 0.3 l/m²]. Make adjustments based upon the existing pavement surface conditions and recommendations of the polymer modified emulsion membrane supplier. Apply the UTBWC at a temperature of 290 – 330 °F [143 – 165 °C] as measured in front of the screed. No wheel or other part of the paving machine shall come in contact with the polymer modified emulsion membrane before the UTBWC is applied. Use a heated, combination vibratory-tamping bar screed. Open the new pavement to traffic after the rolling operation is complete and the material has cooled below 158 °F [70 ° C].

E Thickness

The minimum finished wearing course thickness is 5/8-in [16-mm] with a maximum ½ inch [12.5 mm] vertical edge at the adjacent shoulder pavement edge.

F Rolling

Roll the wearing course a minimum of two passes, before the material temperature has fallen below 185 °F [85 °C].

Use steel double drum asphalt rollers with a minimum weight of 11 tons [10 tonnes]. Do not allow the roller(s) to remain stationary on the freshly placed UTBWC. Roll in static mode only immediately following the placement of the UTBWC in order to seat the mix.

G Pavement Smoothness

Conduct paving operations to produce a smooth UTBWC. The UTBWC surface will show no variation greater than 1/8 inch [3 mm] from the edge of a 10 foot [3 m] straightedge laid parallel to or at right angles to the centerline.

Pavement Surface Smoothness 2399 is required to be followed except for the following changes.
Replace section 3.C.2 with the following:

For UltraThin Bonded Wearing Course projects, ALR will be collected only on asphalt pavement laid during this project before the UTBWC. No smoothness will be paid for on the asphalt pavement. Identify ALR using the ProVAL "Smoothness Assurance" analysis, calculating IRI with a continuous short interval of 25 ft [7.62 m] with the 250 mm filter.

Replace the first paragraph in section 3.D.1 with the following:

Evaluate smoothness requirements after the UTBWC is laid using equations and criteria in accordance with the following tables:

(1) Table 2399-4 for bituminous pavements,
(2) Table 2399-6 for percent improvement projects.

No ALR will be measured on the UTBWC.

Replace the second and third paragraphs in section 3.E with the following:

Perform corrective work for ALR on the asphalt pavement before placing the UTBWC. No corrective work is allowed on the UTBWC. Any Mean Roughness Index (MRI) values for the 0.1 mile segments on the UTBWC indicating corrective work will be assessed a deduct of $400 for each 0.1 mile segment.

H Quality Control

The Contractor is responsible for obtaining all the quality control (QC/QA) sampling and testing as per the Materials Control Schedule.

I Polymer Modified Emulsion Membrane

Verify the application rate of the polymer modified emulsion membrane by dividing the volume of polymer modified emulsion membrane used by the area of paving for that day.

J Quality Assurance

The Engineer is responsible for all quality assurance (QA) sampling according to Materials Control Schedule (MCS). The QA sample is the Department's companion sample to the Contractor's QC sample and tested as required.

J.1 Verification Sampling and Testing

The Department will test at a minimum one (1) verification sample per day to assure compliance of the Contractor's QC program. The Department will decide daily, which QC/QA companion samples are to be submitted and tested as the verification sample. The verification sample can be any one or all of the QC/QA split samples.

In addition the Engineer may obtain additional verification samples at any time and location during production to determine quality levels of the mixture. When additional verification samples are taken, the Department will provide the Contractor a verification companion. The contractor is required to test and use this verification companion sample as part of the QC program. Use the verification companion sample to replace the next scheduled QC sample.

Compare the verification companion sample to the verification sample for compliance with allowable tolerances in Table 2353-3, "UTBWC Allowable Difference between Contractor and Department Test Results". The Department's verification test results will be available to the Contractor within 2 working days from the time the sample is delivered to the District Laboratory.

If the tolerances between the Contractor's verification companion and the Department's verification sample do not meet the requirements of Table 2353-3, "UTBWC Allowable Difference between Contractor and Department Test Results", the Department will retest the material. If the retests fail to meet tolerances, the Department will substitute the Department's verification test results for the Contractor's results in the QC program and use those results for acceptance. The Department will only substitute the out-of-tolerance parameters.

The Department will test the previously collected QA samples until they meet the tolerances or until the Department has tested all of the remaining samples. After testing the samples, the Department will test QA samples subsequent to the verification sample until tolerances are met.

If the adj. AFT calculation does not meet the tolerance in table 2353-3, equalize the Departments adj. AFT result by increasing the original Department value by 0.5 microns. The increased Department adj. AFT will be the basis for acceptance.

The Department will base acceptance on QC data with substitution of Department test results for those parameters that are out of tolerance. Cease mixture production and placement if reestablished test results do not meet tolerances within 48 h. Resume production and placement only after meeting the tolerances.

Table 2353-3 Allowable Differences between Contractor and Department Test Results

Test	Item	Allowable Difference
Asphalt Binder	Chemical Extraction Incinerator Oven	0.4 0.3
Mixture max gravity (Gmm)	Rice Test	0.019
Adj. AFT (Calculated)		1.2
Gradation	**% Passing**	
	3/8 inch (9.5mm)	6%
	No. 4 (4.75mm)	5%
	No. 8 (2.36mm) No.16 (1.18mm) No. 30 (.060mm)	4%
	No. 50 (0.30mm)	3%
	No. 100 (0.150mm)	2%
	No. 200 (0.075mm)	1.2%

K Failures

The Department will base material acceptance on individual test results and those exceeding the JMF limits as failing.

The Department will reduce payment for failing tests in accordance to Table 2353-4, "UTBWC Reduced Payment Schedule." The Department will calculate the quantity of unacceptable material on the tonnage placed from the sample point of the failing test to the sample point when the testing result is back within the JMF. If the failure occurs at the first test after the start of daily production, the Department will include tonnage from the start of production that day with the tonnage subjected to reduced payment.

If an individual failing test for % Asphalt Binder Content, adjusted AFT, or Gradation exceeds the limits in Table 2353-1, "UTBWC Mixture Requirements" or Table 3139-9, "UTBWC Aggregate Gradation Broadband then the mix will be subject to an assessment according to Table 2353-4, "UTBWC Reduced Payment Schedule"

Table 2353-4
UTBWC Reduced Payment Schedule

Item	Pay Factor ,% *
Asphalt Content, %	80
Adjusted AFT <10.5- 10.0	75 or ** (as determined by the Engineer)
Adjusted AFT <10.0	R & R**
Gradation	95
* Lowest Pay Factor applies when there are multiple reductions on a single test. ** Remove and replace at no expense to Department	

The Department will reduce payment if the mat thickness is less than 5/8 inch [16 mm], or greater than 1 inch [25mm], or the pavement edge is greater than ½ inch [12.5 mm]. Any mixture placed outside of this requirement will be assessed a 50% pay reduction or remove and replaced, as determined by the Engineer, full width, by station.

2353.4 METHOD OF MEASUREMENT

Measure the Ultrathin Bonded Wearing Course by area of pavement surfaced.

2353.5 BASIS OF PAYMENT

Payment for the accepted quantity of Ultrathin Bonded Wearing Course at the Contract unit price of measure will be compensation in full for all costs of furnishing and applying all materials required in this specification. The unit price includes all labor, materials, and equipment necessary to complete the work.

Item No.:	Item:	Unit:
2353.504	Ultrathin Bonded Wearing Course	Square yard [square meter]

2354 MICRO-SURFACING

2354.1 DESCRIPTION

This work consists of constructing micro-surfacing on a prepared pavement.

2354.2 MATERIALS

Micro-surfacing is a mixture of polymer modified asphalt emulsion, well-graded crushed mineral aggregate, mineral filler, water and other additives.

A Bituminous Material

Provide a polymer modified CQS-1P or CQS-1hP for bituminous material for micro-surfacing in accordance with 3151.2H, "Micro Surfacing Emulsified Asphalt".

B Aggregate

Provide aggregate in accordance with 3139.5, "Micro-Surfacing Requirements" and as specified in the Contract.

C Mineral Filler

Provide portland cement or hydrated lime, based on the mix design results and in accordance with the following:

(1) Portland cement, Type I in accordance with 3101, "Portland Cement," and
(2) Hydrated lime in accordance with 3106, "Hydrated Lime."

D Water

Provide potable water in accordance with 3906, "Water for Concrete and Mortar."

E Mixture Requirements

E.1 Mix Design

Submit a complete mix design 10 business days before beginning production. List the source of materials used for the mix design. Show that the individual proportions of each of the materials, when combined, meet the mix design requirements of Table 2354-1. Testing procedures may be obtained from the International Slurry Surfacing Association (ISSA).

Table 2354-1
Mix Design Test Requirements

Test	Description	Specification
ISSA TB-114	Wet stripping	≥ 90
ISSA TB-100	Wet track abrasion loss, 1 h soak	≤ 1.8 oz/sq. ft [538 g/sq. m]
ISSA TB-100	Wet track abrasion loss, 6 day soak	≤ 2.6 oz/sq. ft [807 g/sq. m]
ISSA TB-144	Saturated abrasion compatibility	≤ 3 g loss
ISSA TB-113	Mix time at 77 °F [25 C]	Controllable to ≥120 s
ISSA TB-113	Mix time at 100 °F [37.4 C]	Controllable to ≥35 s

Provide a Job Mix Formula (JMF) containing from 5.5 percent to 10.5 percent of residual asphalt by dry weight of aggregate and 0.25 percent to 3.0 percent mineral filler by dry weight of aggregate.

Submit a new mix design to the Engineer, if aggregate source, aggregate blend, or asphalt emulsion sources is changed.

E.2 Mix Design Format

Submit the final mix design with information in the following format:

(1) Source of each individual material.
(2) Aggregate:
    (2.1) Gradation,
    (2.2) Sand equivalent,
    (2.3) Abrasion resistance and
    (2.4) Soundness.

(3) Field simulation tests:
  (3.1) Wet stripping test,
  (3.2) Wet track abrasion loss (1 hour & 6 day),
  (3.3) Saturated abrasion compatibility and
  (3.4) Trial mix time at 77 °F [25 °C] and 100 °F [37.4 °C].
(4) Interpretation of results and the determination of a JMF:
  (4.1) Minimum and maximum percentage of mineral filler,
  (4.2) Minimum and maximum percentage of water, including aggregate moisture,
  (4.3) Percentage of mix set additive (if necessary),
  (4.4) Percentage of modified emulsion,
  (4.5) Residual asphalt content of modified emulsion and
  (4.6) Percentage of residual asphalt.
(5) Signature and date.

2354.3 CONSTRUCTION REQUIREMENTS

A Equipment

A.1 Mixing Machine

Provide a continuous micro-surfacing lay down machine. Provide a positive connection conveyer belt aggregate delivery system and an inter-connected positive displacement, water-jacketed gear pump to accurately proportion aggregate and asphalt emulsion. Locate the mineral filler feed to ensure that the proper amount of mineral filler drops on the aggregate before discharging into the pugmill. Provide a pugmill meeting the following characteristics:

(1) Capable of providing a continuous flow,
(2) Twin shaft,
(3) Multi-blade,
(4) At least 4 ft [1.2 m] long and
(5) Blade size and side clearance meeting the equipment manufacturer's recommendations.

Introduce the asphalt emulsion within the first third of the mixer length to ensure proper mixing of materials before exiting from the pugmill.

Use a self-propelled front feed and continuous loading machine with duel driving stations. Provide a remote forward speed control at the back mixing platform for the back operator to control forward speed and the level of mixture in the spreader box. Use sufficient transport units to assure a continuous operation during mix production and application.

Provide individual volume or weight controls for proportioning each material. Position the controls for access at any time. Use the controls to calibrate the operation before production and to determine the amount of each material used at any time.

Provide a water pressure system and nozzle type spray bar to spray water ahead of and outside the spreader box, if necessary. Dampen the surface. Do not create free flowing water ahead of the spreader box.

A.2 Spreader Box

Spread the mix uniformly, using a mechanical type spreader box, attached to the mixer and equipped with spiral augers mounted on adjustable shafts. Continually agitate and distribute the mixture to prevent stagnation, excessive material build-up, or lumps. Equip the spreader box with front and rear flexible seals to achieve direct contact with the surface of the road. Use a secondary strike off attached to the spreader box to provide a smooth finished surface texture. Do not use burlap drags.

A.3 Rut Filling Box

Provide a rut filling box meeting the following characteristics:

(1) Steel V-configuration screed rut box,
(2) Commercially designed and manufactured to fill ruts,
(3) Capable of spreading the mixture at a width from 5 ft to 6 ft [1.5 m to 1.8 m], and
(4) Strike off to control crown.

A.4 Weighting Equipment

Use portable scales to weigh material certified in accordance with 1901.8, "Mass," and as modified as follows:

(1) Re-certify the scale after any change in location and
(2) Randomly spot check the scale once a week or once per project, whichever is greater.

B Operations

B.1 Micro-surfacing Types

B.1a Rut Fill ..... Type 3, per 3139.5

Rut fill pavement segments longer than 1,000 ft [300 m], if the average rut depth is greater than ½ in [13 mm]. Provide a rut box for each designated wheel track. Provide a clean overlap and straight edges between wheel tracks. Construct each rutted wheel track with a crown ¼ in [0.25 cm] per inch [centimeter] of rut depth to allow for proper consolidation by traffic.

B.1.b Scratch Course.....Type 2 or Type 3 per 3139.5, as shown on the plans

Apply full lane width in one course. Use a metal strike off bar on the spreader box. Do not allow excess buildup or uncovered areas.

B.1.3 Surface Course.....Type 2, per 3139.5

Apply full lane width in one course. Do not allow excess buildup or uncovered areas.

B.2 Pre-Paving Meeting

Hold a pre-paving meeting with the Engineer on-site before beginning work to discuss the following:

(1) JMF,
(2) Equipment condition,
(3) Equipment calibration,
(4) Test strips,
(5) Detailed work schedule and
(6) Traffic control plan.

B.3 Calibration

Calibrate each mixing machine before use. Maintain documentation showing individual calibrations of each material at various settings relating to the machine's metering devices. Supply materials and equipment, including scales and containers for calibration (ISSA MA 1). Recalibrate machines on the job after a change in aggregate, asphalt emulsion source, or repairs are made to the aggregate feeding belt, gate or emulsion pump.

B.4 Test Strip

Construct a test strip in a location approved by the Engineer.

For each machine used, construct a one-lane wide test strip 1,000 ft [300 m] long. Begin construction after dark, at least 1 hr after sunset and at least 1 hr before sunrise. Compare the machines for variances in surface texture and appearance.

Do not construct the test strip until the emulsion temperature falls below 122 °F [50 °C].

If any of the follow elements of the system used with a job mix change or field evidence shows that the system is out of control, construct a new test strip:

(1) Type of emulsion,
(2) Type and size of aggregate,
(3) Type of mineral filler and
(4) The lay down machine.

Allow traffic on the test strip within 1 hr after application; the Engineer will evaluate whether any damage occurs. The Engineer will inspect the completed test strip again after 12 hr of traffic to determine if it is acceptable. The Contractor may begin full production after the Engineer accepts a test strip.

The Engineer may waive the test strip requirement, if the Contractor submits evidence of the successful construction of a test strip on another project constructed during the same construction season, using the same mix design.

B.5 Surface Preparation

Clean the surface immediately before placing the micro-surfacing.

B.6 Fog Seal

Apply fog seal to surfaces before the first course of micro surfacing. Provide and apply a CSS-1 or CSS-1h emulsion in accordance with 2355, "Bituminous Fog Seal," and the following:

(1) Apply the diluted emulsion at a rate of 0.05 gal per sq. yd to 0.10 gal per sq. yd [0.23 L per sq. m to 0.45 L per sq. yd].

Limit the daily application of fog seal to the pavement area receiving micro surfacing that day. Do not open fog sealed areas to traffic until after applying and curing the first course of micro surfacing. Allow the fog seal to cure before applying micro surfacing.

Protect drainage structures, monument boxes and water shut-offs during the application of the fog seal and during micro-surfacing.

B.7 Surface Quality

Except for areas within 12 in [300 mm] of the edge line, lane line, or center line, ensure the transverse cross section of the restored pavement surface is no greater than ⅜ in [10 mm] if measured using a 10 ft [3 m] straight edge or $^{3}/_{16}$ in [5 mm] if measured with a 6 ft [2 m] straight edge.

Construct the surface course without excessive scratch marks, tears, rippling, and other surface irregularities. Repair tear marks wider than ½ in [13 mm] and longer than 4 in [100 mm] and tear marks wider than 1 in [25 mm] and longer than 1 in [25 mm]. Repair transverse ripples or streaks deeper than ¼ in [6 mm] if measured by a 10 ft [3 m] straight edge.

Construct longitudinal joints with no greater than ¼ in [6 mm] overlap thickness if measured with a 10 ft [3 m] straight edge, and less than 3 in [75 mm] overlap on adjacent passes. Locate longitudinal construction joints and lane edges to coincide with the proposed painted lane lines shown on the plans. Place overlapping passes on the uphill side to prevent water from ponding.

Construct transverse joints with no greater than ⅛ in [3 mm] difference in elevation across the joint if measured with a 10-foot [3-meter] straight edge.

Construct edge lines along curbs and shoulders, with no greater than 2 in [50 mm] of horizontal variance in any 100 ft [30 m] length. Do not allow runoff in these areas.

Stop micro-surfacing work, if the system is out of control and cannot meet the requirements of this section. Correct the micro-surfacing system, as approved by the Engineer, before re-starting the work.

Protect drainage structures, monument boxes and water shut-offs.

Make repairs to micro-surfacing defects to the full width of paving pass with spreader box. Do not perform hand repairs after micro surfacing mix has set.

B.8 Open to Traffic

Do not open the micro-surface to traffic until the micro-surface cures sufficiently to prevent pickup by vehicle tires. The Department considers properly constructed micro-surface as micro-surface capable of carrying normal traffic within 1-hour of application without damage. Protect the new surface from potential damage at intersections and driveways. Repair damage to the surface caused by traffic at no additional cost to the Department.

Confirm that the micro-surface cured within 1-hour on the first day of production, after the construction of the test strip. The Engineer will conduct three 1-hour spot checks. If a spot check fails, stop work and construct a new test strip. The Department will consider any spot check or test strip failure as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work".

After successful completion of three, one-hour spot checks on the first day of production, the Engineer will perform spot checks once a day. If a 1-hour spot check fails, the Department will require the construction of a new test strip. After a test strip, the Engineer will perform the first day of production procedure.

B.9 Weather and Time Limitations

Begin construction when the air and pavement surface temperatures are at least 50 °F [10 °C] and rising. Do not place micro-surfacing during rain, or if the forecast indicates a temperature below 32 °F [0 °C] within 48-hour of the planned micro-surfacing. Do not start work after September 15.

C Contractor Quality Control (QC) Testing and Documentation

Perform Quality Control (QC) sampling and testing.

C.1 Emulsion

Provide a material Bill of Lading (BOL) for each batch of emulsion used. Include the supplier's name, plant location, emulsion grade, residual asphalt content, volume (gross and net, gallons) and batch number.

C.2 Aggregate

Sample and test according to the Schedule of Materials Control. Provide QC test results daily to the Engineer and a summary upon completion of the work.

C.2.a Gradation and JMF Tolerance

Provide companion samples to the Engineer. The QC tolerances for the JMF are listed in Table 3139-10. The tolerance range may not exceed the limits set per 3139.5.

C.2.b Sand Equivalent Test

The Sand Equivalent quality control tolerance is ±7 percent of the value established in the mix design (60 percent minimum). Run the sand equivalent test at the stockpile site.

C.2.c Moisture Content

Determine the moisture content of the aggregate. Perform additional testing upon a visible change in moisture. Use the average daily moisture to calculate the oven dry weight of the aggregate.

C.3 Asphalt Content

Randomly calculate and record the percent asphalt content of the mixture from the equipment counter readings. The asphalt tolerance is ±0.5 percent residual asphalt.

C.4 Design Application Rate

The design application rate shall be the total amount of micro-surfacing material placed to meet the requirements for cross section and surfacing. This amount will be the combination of all courses placed.

C.5 Documentation

Provide a daily report containing the following information to the Engineer within one working day:

(1) Date and air temperature at work start up,

(2) Beginning and ending locations for the day's work,

(3) Length, width, total area (square yard [square meter]) covered for the day,

(4) Application rate (pounds per square yd [kilograms per square meter], pounds [kilogram]) of aggregate,

(5) Daily asphalt spot check reports, gallons [liters] of emulsion, weight of emulsion (pounds per gallon [kilogram per liter]),

(6) Asphalt emulsion bill of lading,

(7) Beginning, ending, and total counter readings,

(8) Control settings, calibration values, percent residue in emulsion,

(9) Percent of each material, percent of asphalt cement,

(10) Calibration forms,

(11) Aggregate certification or shipment of tested stock report and

(12) Contractor's authorized signature.

D Agency Quality Assurance (QA) Testing

Sample and test the following according to the Schedule of Materials Control.

1. Asphalt Emulsion,
2. Aggregate Gradation
3. Moisture Content of the Aggregate

E Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2354.4 METHOD OF MEASUREMENT

The Engineer will measure the *Bituminous Material for Micro-Surfacing* and undiluted *Bituminous Material for Fog Seal* by volume at 60 °F [15 °C].

The Engineer will measure the Micro-Surfacing Rut Fill, Micro-Surfacing Scratch Course and Micro-Surfacing Surface Course by weight [mass] of oven dry weight of aggregate.

2354.5 BASIS OF PAYMENT

The contract gallon [liter] price for the accepted quantity of *Bituminous Material for Micro-surfacing* includes the costs of additives as indicated above and constructing the micro-surfacing as shown in the plans.

The Department will pay for bituminous material for fog seal in accordance with 2355.5, "Basis of Payment."

A Monetary Price Adjustments

The Department will deduct $5,000 from the contract amount for each spot check failure and anytime there is evidence of the system being out of control per 2354.3.B.4 or 2354.3.B.7. If the test strip fails, the Department will deduct $5,000 from the contract amount.

The Department will calculate price reductions for failing gradations based on 2 percent of the unit price per ton [metric ton] for each 1 percent passing result outside of a QC tolerance requirement as specified in Table 2354-1 or outside of a gradation range for all sieves. The Department will apply this price reduction schedule for micro surfacing construction to non-warranty work.

The Department will pay for seal coat — micro-surfacing on the basis of the following schedule:

Item No.:	Item:	Unit:
2354.503	Bituminous Material for Micro-Surfacing	gallon [liter]
2354.504	Micro-Surfacing Rut Fill	ton [metric ton]
2354.504	Micro-Surfacing Scratch Course	ton [metric ton]
2354.504	Micro-Surfacing Surface Course	ton [metric ton]

2355 BITUMINOUS FOG SEAL

2355.1 DESCRIPTION

This work consists of constructing a fog seal on a prepared surface as shown on the plans.

2355.2 MATERIALS

Bituminous Material

Provide bituminous emulsion as shown in the plans meeting the following requirements:

(1) CSS-1h (3151.2.D.1), or
(2) CFS-1h (3151.2.D.2), or
(3) CRS-2Pd (3151.E.2).

Dilute during manufacture. Do not dilute in the field.

2355.3 CONSTRUCTION REQUIREMENTS

A Weather Limitations

Perform fog seal operations only during daylight hours and not during foggy weather. Begin fog seal operations when the pavement and air temperatures are 60° F [15.5° C] and rising. The Contractor may perform fog sealing on a damp road surface, but not on a road surface with standing water.

B Road Surface Preparation

Clean pavements, including depressions, before fog sealing.

Cover metal surfaces to prevent adherence of the bituminous material. Remove the protective coverings before opening the road to traffic.

C Application of Bituminous Material

Begin using the rate of application for bituminous fog seal as shown in Table 2355-1, Fog Seal Application Rates, and within the temperatures specified in Table 2355-3, Fog Seal Application Temperatures.

Demonstrate a uniform application of asphalt emulsion producing 100 percent coverage of the surface after curing, as approved by the Engineer. Stop operations if the application demonstration does not meet the coverage requirements. Minimize the amount of overspray during the fog seal operation.

Using a distance of 1,000 feet [300 meter] perform a yield check at the beginning of each project to verify the application rate is correct. The Engineer may require additional yield checks be performed if the application rate is questioned. The Engineer may also require the Contractor to verify application is within 10% of the intended application rate by ASTM D 2995 test method A.

Table 2355-1
Fog Seal Application Rates

Application Rates -- gallons/square yard **[liters/square meter]**	
CSS-1h	CRS-2Pd
0.05 to 0.20 **[0.23 to 0.91]**	0.05 to 0.20 **[0.23 to 0.91]**

Table 2355-2
Fog Seal Application Temperatures

Bituminous Material	Minimum Temperature	Ideal Temperature
CRS-2Pd	140 °F [60 °C]	170 °F – 180 °F [76.6 °C – 82.2 °C]
CSS-1h	100 °F [37.7 °C]	100 °F –140 °F [37.7 °C – 60 °C]

D Protection of the Surface

Do not allow traffic on the fog sealed surface until after the bituminous material has set and will not pick up on vehicle tires.

E Equipment

E.1 Distributor
Use a distributor in accordance with 2360.3.B.2.d, "Distributor."

E.2 Brooms
Provide motorized brooms with a positive means of controlling vertical pressure and with the capability to clean the road surface prior to spraying bituminous material.

2355.4 METHOD OF MEASUREMENT
The Engineer will measure the diluted bituminous material for fog seal by volume, at 60° F [15° C].

2355.5 BASIS OF PAYMENT
The Department will pay for fog seal on the basis of the following schedule:

Item No.:	Item:	Unit:
2355.502	Bituminous Material for Fog Seal	gallon [liter]

2356 BITUMINOUS SEAL COAT

2356.1 DESCRIPTION
This work consists of applying bituminous material, a single layer of aggregate, and a fog seal on a prepared surface.

2356.2 MATERIALS
A Bituminous Material
Provide CRS-2P bituminous material for seal coat meeting the requirements of 3151, "Bituminous Material":

Provide Cationic Emulsified Asphalt for fog seal meeting 3151.2.D.1 or 3151.2.D.2.

B Seal Coat Aggregate
Provide aggregate meeting the gradation, job mix formula tolerance and quality requirements of Tables 3127-1 and 3127-2, for the gradation specified in the Contract. If no requirements are specified in the Contract, provide aggregate meeting the requirements of Tables 3127-1 and 3127-2 for FA-3.

C Blank

D Water
Use potable water compatible with the seal coat and meeting the requirements of 3906, "Water for Concrete and Mortar".

E Seal Coat Design
Use the Minnesota Seal Coat Handbook, MN/RC-2006-34 available on the MnDOT website, to design the seal coat and determine the starting application rate for the bituminous material and seal coat aggregate. Base the mix design on the traffic volume and pavement conditions.

Provide the following to the Engineer at least 2 weeks before beginning construction:
(1) Gradation and quality test results as specified in 3127.3,
(2) Seal coat aggregate design application rate,
(3) Bituminous material design application rate and
(4) 150 lb [70 kg] sample of aggregate from each proposed aggregate source.

The Department may postpone the start of work until receipt of the design and approval by the Engineer in accordance with the requirements of this section.

The Department considers the seal coat's design aggregate application rate as a target amount.

2356.3 CONSTRUCTION REQUIREMENTS
Any failure of QC or QA in the mix design submittal, pre-production and production gradation or quality tests constitute a Hold Point per 2356.3N. This includes test results, which are outside the job Mix formula tolerance of Tables 3127-1 and 3127-2.

Provide a remediation plan for all failures originating by any cause including a failing stockpile or poor handling procedures. Bucket blending of a stockpile to remediate for failing material is not acceptable. The remediation plan must be accepted by the Engineer.

A Weather, Time and Date Limitations
Apply the bituminous seal coat in accordance with the following:

(1) From May 15 to August 10, if located in the North or North-Central Road Spring Restriction Zone (Zones are defined on the MnDOT Pavement Design Website),
(2) From May 15 to August 31, if located south of the North and North-Central Spring Road Restriction Zone,
(3) Work only during daylight hours,
(4) Begin work when the pavement and air temperatures are 60º F [15.5º C] and rising.
(5) The road surface may be damp, but ensure that the road is free of standing water and
(6) Do not perform work during foggy weather.

B Equipment

B.1 Distributor
Use a distributor in accordance with 2360.3.B.2.d, "Distributor."

B.2 Aggregate Spreader
Use a self-propelled mechanical type aggregate spreader, mounted on pneumatic-tired wheels, capable of distributing the aggregate uniformly to the width required by the contract and at the design application rate.

B.3 Pneumatic-Tired Rollers
Provide at least three self-propelled pneumatic-tired rollers in accordance with 2360.3.B.2.e(2), "Pneumatic Tired Rollers."

B.4 Brooms
Provide motorized brooms with the following characteristics:
(1) Positive means of controlling vertical pressure,
(2) Capable of cleaning the road surface before applying bituminous material and
(3) Capable of removing loose aggregate after seal coating.

C Road Surface Preparation
Clean pavements, including depressions, before seal coating.

Cover iron fixtures in or near the pavement to prevent adherence of the bituminous material.

Remove the protective coverings before opening the road to traffic.

D Application of Bituminous Material
Begin the rate of application for the bituminous material as determined by the mix design. Construct a test strip 200 ft [60 m] long to ensure the bituminous material application rate is adequate given the field conditions. After applying the bituminous material to this test strip, place the seal coat aggregate at the design application rate. Inspect the aggregate in the wheel paths for proper embedment. Make adjustments to the rate of application, if necessary. Construct one full lane width at a time. Make additional adjustments to the rate of application, if necessary.

Apply the bituminous material in accordance with Table 2356-2:

Table 2356-2
Recommended Application Temperatures

Bituminous Material	Minimum Temperature
CRS-2P	140 F [60 C]*
CSS-1h	100 F [38 C]

* Intended for uniform lay down of emulsion

E Application of Seal Coat
Before construction, calibrate the aggregate spreader to meet the requirements of ASTM D 5624, in the presence of the Engineer. Maintain the aggregate application rate within ±1 lb per square yard [±0.5 kg/m²] of the design.

Provide uniformly moistened aggregates at the time of placement. Place aggregate within 1 min after applying the bituminous material. Do not use previously applied aggregates.

F Rolling Operations
Complete the initial rolling within 2 min after applying the aggregate at a speed no greater than 5 mph [8 km/h] to prevent turning over aggregate. Make at least three complete passes over the aggregate. Roll the aggregate so the entire width of the treatment area is covered in one pass by all the rollers.

G Sweeping
Remove surplus aggregate on the same day as the seal coat construction. Re-sweep areas the day after the initial sweeping. Dispose of the surplus seal coat aggregate as approved by the Engineer.

H Protection of the Surface

Do not allow traffic on the seal coated road surface until after rolling is completed and the bituminous material has set.

I Protection of Motor Vehicles

The Contractor is responsible for claims of damage to vehicles until the roadways and shoulders have been swept free of loose aggregate and permanent pavement markings have been applied. If the Department applies the permanent pavement markings, the Contractor's responsibility ends after completion of the fog seal and placement of temporary pavement markings.

J Application of Bituminous Material for Fog Sealing

Apply fog seal to seal coated areas, after sweeping and before placement of permanent pavement markings.

Apply the fog seal in accordance with 2355, "Bituminous Fog Seal," and as modified as follows:

(1) Construct a 200 ft [60 m] test strip,
(2) Review the application of diluted bituminous material and adjust the application rate as necessary to yield a uniform and full coverage of the underlying seal coat,
(3) Apply from 0.07gal to 0.18 gal per sq. yd [0.3 L to 0.8 L per sq. m] diluted,
(4) Apply the fog seal to minimize the amount of overspray and
(5) Do not allow traffic on the fog seal until it has cured.

K Progress of Work

Allow the seal coat to cure for at least one day before fogging. Place interim pavement markings after the fog seal cures and before removal of traffic control. Do not place permanent pavement markings using latex paint before three days after placing the fog seal. Place all other types of permanent pavement markings at least 14 days after placement of the fog seal.

L Contractor Quality Control Testing

Sample and test according to the rates in the Schedule of Materials Control.

Submit test results to the Engineer within 24 hours of test completion.

Verify and report the average daily bituminous material application rate by dividing the volume used by the area covered.

If gradations fall outside of the Job Mix Formula Tolerance of Table 3127-1, but within specifications, stop placement and submit a new mix design.

M Agency Quality Assurance (QA) Sampling and Testing

Sample and test according to the rates in the Schedule of Materials Control.

N Hold Point

Any failing test creates a Hold Point, whereby no additional material may be placed until Corrective action and passing retest(s) have occurred, or accepted by the Engineer. All additional material placed before corrective action and passing retest(s) occur constitutes Unauthorized Work per 1512.2.

2356.4 METHOD OF MEASUREMENT

The Engineer will measure the bituminous material for fog seal by volume, at 60° F [15° C], undiluted. Conversion factors are located in the MnDOT Bituminous Manual. Dilute the material at a ratio of 1:1 before application at place of manufacture.

The Engineer will measure the bituminous material for seal coat by volume at 60° F [15° C].

The Engineer will measure the seal coat by area of pavement surfaced.

2356.5 BASIS OF PAYMENT

The Department will pay for bituminous material for fog seal in accordance with 2355.5, "Basis of Payment."

The contract gallon [liter] price for accepted quantities of *Bituminous Material for Seal Coat,* including necessary additives, includes the costs of providing and applying the material as required by the contract.

The contract square yard [square meter] unit price for *Bituminous Seal Coat* includes the cost of providing and applying the material as required by the contract. The contract square yard [square meter] price for *Bituminous Seal Coat* includes the cost of all applied aggregate.

A Monetary Price Adjustments

The Engineer may allow the Contractor to accept a monetary price adjustment instead of removing and replacing failing materials in accordance with the following:

1) The Department will reduce the Contract price by 10 percent for each failing quality test per Table 3127-2.

2) The Department will reduce the contract unit price for bituminous seal coat by 0.5 percent for each 1 percent passing outside of the requirements for any sieve as specified in 3127, "Fine Aggregate for Bituminous Seal Coat", except for the #200 sieve, as determined by QA testing.
3) The Department will reduce the contract unit price for bituminous seal coat by 2 percent for each 0.1 percent passing outside of the requirements for the #200 sieve as specified in 3127, "Fine Aggregate for Bituminous Seal Coat", as determined by QA testing.
4) The maximum monetary price adjustment is 50%. Material placed that has a cumulative monetary price adjustment greater than 50% is subject to remove and replace per 1512.1 Unacceptable Work.

The monetary price adjustment for 2356.5.A.2 and 2356.5.A.3 are based upon the contract bid price for bituminous seal coat, however if the contract bid price is less than 75% of the Department's average bid price for Bituminous Seal Coat, the Engineer may use the average bid price to assess the monetary price adjustment.

The Department will add the monetary price adjustments for all failing test results together.

The Department will pay for Bituminous Seal Coat on the basis of the following schedule:

Item No.:	Item:	Unit:
2356.505	Bituminous Material for Seal Coat	gallon [liter]
2356.506	Bituminous Seal Coat	square yard [square meter]

2357 BITUMINOUS TACK COAT

2357.1 DESCRIPTION

This work consists of applying bituminous material (emulsion or cutback asphalt) on a bituminous or concrete pavement prior to paving a new lift of Plant Mixed Asphalt.

2357.2 MATERIALS

A Bituminous Material 3151

The bituminous material for tack coat will be limited to one of the following kinds of emulsified asphalt. Use of medium cure cutback asphalt (MC-250) is allowed during the early and late construction season when it is anticipated the air temperature may drop below 32 degrees Fahrenheit.

Allowable grades are as follows:

Emulsified Asphalt

AASHTO 208 Dilution of the emulsion to 7 parts emulsion to 3 parts water is only allowed by the supplier. **No field dilution is allowed.** The storage tank for diluted emulsion must have a recirculation system or agitator that will prevent settlement or separation of the material.

Table 2357-1
Residual Asphalt Content

	Minimum Residual Asphalt Content	
Emulsion	Undiluted	Diluted (7:3)
CSS-1 or CSS-1h	57%	40%

Cutback Asphalt

Medium Cure Liquid Asphalt MC-250

Only Certified Sources are allowed for use. MnDOT's Certified Source List is located at the following link: http://www.dot.state.mn.us/products/index.html.

2357.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Conduct tack coat operations in a manner that offers the least inconvenience to traffic. Maintain movement in at least one direction at all times without pickup or tracking of the bituminous material.

Do not apply the tack coat when the road surface or weather conditions are unsuitable as determined by the Engineer. Limit the daily application of tack coat to approximately the area on which construction of the subsequent bituminous course can reasonably be expected to be completed that day.

B Equipment

Apply the bituminous material with a distributor meeting the requirements of 2360.3.B.2.d.

C Road Surface Preparations

Apply the bituminous tack coat material to a dry and clean roadway surface. All necessary repairs or reconditioning must have been completed as provided for in the Contract and approved by the Engineer.

Remove all foreign matter on the road surface before applying tack coat and dispose of as approved by the Engineer.

Before placing an abutting bituminous course, provide a uniform coating of liquid asphalt or emulsified asphalt to the contact surfaces of all fixed structures and at the edge of the in-place mixture in all courses at transverse joints and in the final wearing course at longitudinal joints.

D Application of Bituminous Tack Coat Material

Unless otherwise indicated in the Plans or provisions, apply the bituminous tack coat material within the application rates shown below in Table 2357-2, Tack Coat Application Rates, as based on pavement type or condition and type of bituminous material. **Dilution of asphalt emulsion in the field is not allowed.**

All tack must break, turn from brown to black, before paving the subsequent lift or course. Do not allow vehicles to drive on tack that has not broken.

Apply a uniform tack coat to the existing asphalt or concrete surface and to the surface of each course or lift constructed, except for the final course or lift. Tack each lift when placing multiple lifts in the same day. Uniform application will not have streaks (corn rows), bare spots, puddles, or other irregular patterns. The Engineer will compare the freshly sprayed emulsion to a brown sheet of construction paper or a black sheet of construction paper for broken tack to determine conformance with tack application uniformity.

Using a distance of 1,000 feet [300 meter] perform a yield check at the beginning of each project to verify the application rate is correct. The Engineer may require additional yield checks be performed if the application rate is questioned.

The Engineer may also require the Contractor to verify application is within 10% of the intended application rate by ASTM D 2995 test method A.

Table 2357-2
Tack Coat Application Rates

	Application Rates -- gallons/square yard **[liters/square meter]**		
Surface Type	Undiluted Emulsion	Diluted Emulsion (7:3) [1]	MC Cutback[2]
New Asphalt	0.05 to 0.07 **[0.23 to 0.32]**	0.08 to 0.10 **[0.36 to 0.45]**	0.05 to 0.07 **[0.23 to 0.32]**
Old Asphalt[3] and PCC	0.08 to 0.10 **[0.36 to 0.45]**	0.13 – 0.15 **[0.59 to 0.68]**	0.09 to 0.11 **[0.41 to 0.50]**
Milled Asphalt and Milled PCC	0.07 to 0.11 **[0.41 to 0.50]**	0.10 – 0.13 **[0.45 to 0.59]**	0.09 to 0.11 **[0.41 to 0.50]**

1- As provided by the asphalt emulsion supplier (see 2357.2.A)
2- Use when approved by the Engineer
3- Older than 1 year

E Bituminous Temperature

The application temperature of the bituminous material will be:

CSS-1, CSS-1H 70 to 160° F (**21 to 71°C**)
MC-250 165 to 220° F (**74 to 104°C**)

F Bituminous Sampling

Sample asphalt emulsion from either the spigot or a nozzle on the distributor according to the schedule of materials control.

G Pedestrian Crossings

Spread sand on newly tacked surfaces at regularly utilized and open for public use pedestrian crossings.

H Acceptance of Tack Material

Assess a monetary deduction of 5% of the mix price for failures related to 3151 or workmanship/application, as determined by the Engineer. The basis of measurement for deficiencies related to material and workmanship/application is full with of the lane by station.

2357.4 METHOD OF MEASUREMENT
Bituminous material used for tack coat will be measured by volume at 15°C (**60° F)**.

2357.5 BASIS OF PAYMENT
Payment for the accepted quantity of asphalt emulsion and cutback shall be at the Contract price per unit of measure. The Department will include the cost of providing and applying sand at pedestrian crossings with other relevant contract items.

Payment for the tack coat will be made on the basis of the following schedule:

Item No.:	Item:	Unit:
2357.502	Bituminous Material for Tack Coat	gallon [liter]

If the contract does not contain Bituminous Material for Tack Coat, the Department will include the cost of providing and applying bituminous tack coat material with other relevant pay items.

2358 BITUMINOUS PRIME COAT

2358.1 DESCRIPTION
This work consists of treating a prepared base with bituminous material prior to placing a bituminous pavement.

2358.2 MATERIALS
A Medium Curing Liquid Asphalt
Provide Medium Curing Liquid Asphalt in accordance with 3151.2.B, "Medium Curing Liquid Asphalt," for MC-30 or MC-70.

2358.3 CONSTRUCTION REQUIREMENTS
A Restrictions

A.1 Base Moisture Content
Place bituminous prime coat on a prepared base when the base moisture content of the upper 3 in [80 mm] is less than 65 percent of optimum moisture content.

A.2 Traffic
If road is open to traffic, maintain traffic in at least one direction and only close a portion of the traveled way for construction, not to exceed 50 percent.

B Equipment
Use a distributor in accordance with 2360.3.B.2.d, "Distributor."

C Application
Apply the bituminous prime coat at a continuous uniform spread rate of 0.1 gal per cu. yd to 0.3 gal per cu. yd [0.45 L per cu. m to 1.35 L per cu. m].

D Bituminous Temperature
Apply MC-30 bituminous prime coat at temperatures from 85 °F to 145 °F [29 °C to 63 °C]. Apply MC-70 bituminous prime coat at temperatures from 120 °F to 180 °F [49 °C to 82 °C].

2358.4 METHOD OF MEASUREMENT
The Engineer will measure bituminous material for prime coat by volume at 60 °F [15 °C].

2358.5 BASIS OF PAYMENT
The contract gallon [liter] price for *Bituminous Material for Prime Coat* includes the costs of providing and applying the material as required by the contract.

The Department will pay for bituminous prime coat on the basis of the following schedule.

Item No.:	Item:	Unit:
2358.501	Bituminous Material for Prime Coat	gallon [liter]

2360 PLANT MIXED ASPHALT PAVEMENT

2360.1 DESCRIPTION
This work consists of constructing plant mixed asphalt pavement on a prepared surface.

Plant mixed asphalt pavement designed according to a gyratory mix design method for use as a pavement surface.

A Mixture Designations

The Department will designate the mixture for asphalt mixtures in accordance with the following:

(1) The first two letters indicate the mixture design type:
  (1.1) SP = Gyratory Mixture Design.
(2) The third and fourth letters indicate the course:
  (2.1) WE = Wearing and shoulder wearing course, and
  (2.2) NW = Non-wearing Course.
(3) The fifth letter indicates the maximum aggregate size:
  (3.1) A = ½ in [12.5mm], SP 9.5,
  (3.2) B = ¾ in [19.0mm], SP 12.5,
  (3.3) C = 1 in [25.0mm], SP 19.0, and
  (3.4) D = ⅜ in [9.5mm], SP 4.75.
(4) The sixth digit indicates the Traffic Level (ESAL's × 10^6) in accordance with Table 2360-1, "Traffic Levels."

Table 2360-1
Traffic Levels

Traffic Level	20 Year Design ESALs
2 *	< 1
3 ‖	1 – < 3
4	3– < 10
5	10 – ≤ 30
6	>30 (See SMA Provision)

NOTE: The requirements for gyratory mixtures in this specification are based on the 20 year design traffic level of the project, expressed in Equivalent Single Axle Loads (ESAL's) 1 × 10^6 ESALs
* AADT < 2,300
‖ AADT > 2,300 to < 6,000

(5) The last two digits indicate the air void requirement:
  (5.1) 40 = 4.0 percent for wear mixtures, and
  (5.2) 30 = 3.0 percent for non-wear and shoulder.
(6) The letter at the end of the mixture designation identifies the asphalt binder grade in accordance with Table 2360-2, "Asphalt Grades."

Table 2360-2
Asphalt Grades

Letter	Grade
A	PG 52 – 34
B	PG 58 – 28
C	PG 58 – 34
E	PG 64 – 28
F	PG 64 – 34
H	PG 70 – 28
I	PG 70 – 34
L	PG 64 – 22
M	PG 49 – 34

Ex: Gyratory Mixture Designation -- SPWEB540E (Design Type, Lift, Aggr. Size, Traffic Level, Voids, Binder)

2360.2 MATERIALS

A Aggregate

Use aggregate materials in accordance with 3139.2.

B Asphalt Binder Material **3151**

C Additives

The Department defines additives as material added to an asphalt mixture or material that does not have a specific pay item.

Do not incorporate additives into the mixture unless approved by the Engineer. Add anti-foaming agents to asphalt cement at the dosage rate recommended by the manufacturer. The Contractor may add mineral filler in quantities no greater than

5 percent of the total aggregate weight. The Contractor may add hydrated lime in quantities no greater than 2 percent of the total aggregate weight. Do not add a combination of mineral filler and hydrated lime that exceeds 5 percent of the total aggregate weight. Use methods for adding additives as approved by the Engineer.

C.1 Mineral Filler.....AASHTO M 17

C.1.a Mineral Filler – Hydrated Lime

Provide hydrated lime for asphalt mixtures with no greater than 8 percent unhydrated oxides (as received basis) and meeting the requirements of AASHTO M 216. Use a method to introduce and mix hydrated lime and aggregate as approved by the Engineer before beginning mixture production.

C.2 Liquid Anti-Stripping Additive (Contractor Added)

If adding a liquid anti-strip additive to the asphalt binder, complete blending before mixing the asphalt binder with the aggregate. Only use liquid anti-strip additives that ensure the asphalt binder meets the Performance Grade (PG) requirements in 3151. The Contractor may use asphalt binder with liquid anti-strip added at the refinery or the Contractor may add liquid anti-strip at the plant site. If using asphalt binder with liquid anti-strip added at the refinery, ensure the supplier tests the binder and additive blend to confirm compliance with the AASHTO M 320. If an anti-strip agent is added at the plant, the plant mixed asphalt producer is considered a supplier and the binder must conform to the requirements of 3151. Do not pave until the asphalt binder and additive blend testing results meet the criteria in 2360.2.B, "Asphalt Binder Material."

C.2.a Mixture Requirements at Design

Design the mixture with the same asphalt binder supplied to the plant site using mixture option 1, "Laboratory Mixture Design" or mixture option 2, "Modified Mixture Design."

Provide documentation with either design option and include the amount of anti-strip needed to meet the minimum tensile strength requirements. Verify that the binder with the anti-strip meets the PG binder requirements for the mixture.

C.2.b Contractor Production Testing Requirements

Sample and test the asphalt binder and anti-strip blend daily. The Contractor may test the blend by viscosity, penetration, or dynamic sheer rheometer (DSR) of the blend. If the contract requires the use of a polymer modified asphalt binder in the mixture, use the DSR as the daily QC test.

Send the Engineer and MnDOT Chemical Laboratory Director a weekly QC report summarizing the results of the daily testing.

Perform at least one test bi-weekly per project to ensure the binder and anti-strip blend meets the requirements of AASHTO M 320. Send the test results to the Engineer and MnDOT Chemical Laboratory Director.

Provide asphalt binder and anti-strip blend field verification samples in accordance with 2360.2.G.7, "Production Test."

C.2.c Liquid Anti-Strip Additive Metering System

Include a liquid anti-strip flow meter and an anti-strip pump with the metering system. Connect the flow meter to the liquid anti-strip supply to measure and display only the anti-strip being fed to the asphalt binder.

Position the meter readout so that the inspector can easily read it.
Provide means to compare the flow meter readout with the calculated output of the anti-strip pump.

Provide a system that displays the accumulated anti-strip quantity being delivered to the mixer unit in gallons [liters] to the nearest gallon [liter] or in units of tons [metric tons] to the nearest 0.001 ton [0.001 tonne].

Calibrate and adjust the system to maintain an accuracy of ± 1 percent.

Calibrate each plant set-up before producing the mixture.

"Stick" the anti-strip tank at the end of the day's production to verify anti-strip usage quantities. The Engineer may require "sticking" on a daily basis.

Ensure the system has a spigot for sampling the binder and anti-strip after blending.

Use alternative blending and metering systems only when pre-approved by the Engineer.

C.3 Coating and Anti Stripping Additive 3161

C.4 Warm Mix Asphalt (WMA)

WMA is allowed on all projects. Any mix that is produced at temperatures 30°F or lower than typical HMA mixing temperature of the asphalt binder, as defined by the asphalt supplier, is considered as WMA. The WMA can be manufactured through use of foamed asphalt and/or chemical additive processes. Notify the Engineer in advance of using any WMA additive or

process. When chemical additives are used, provide the plant mixing and the laboratory mixing and compaction temperatures as recommended by the manufacturer of the additive.

D Bituminous Tack Coat.....2357

E Mixture Design

E.1 Submittal Location
Submit documentation and sample aggregate materials for review to the District Materials Laboratory.

E.2 Aggregate Quality
Provide aggregate in accordance with 3139.2.

E.3 Restrictions
Do not add aggregates and materials not included in the original mixture submission unless otherwise approved by the Engineer.

E.4 Responsibility
Design a gyratory mixture that meets the requirements of this specification in accordance with the following:

(1) MnDOT Laboratory Manual Method 1820,
(2) The Asphalt Institute's Superpave Mix Design Manual SP-2 (Use a 2 h short term aging period for volumetric), and
(3) The Laboratory Manual.

E.5 Type of Mixture Design Submittal

E.5.a Option 1 — Laboratory Mixture Design

E.5.a(1) Aggregate
Submit the aggregate samples for option 1, at least 15 working days before beginning production samples for quality testing. At least 30 calendar days before beginning asphalt production, submit samples of aggregates that require the magnesium sulfate soundness test to the District Materials Laboratory. Test the samples for quality of each source, class, type, and size of virgin and non-asphaltic salvage aggregate source used in the mix design. Retain a companion sample of equal size until the Department issues a Mixture Design Report. Provide 24 h notice of intent to sample aggregates to the Engineer. Provide samples in accordance with the following:

Table 2360-4
Aggregate Sample Size

Classification	Sieve	Weight
Virgin	Retained on No. 4 [4.75 mm]	80 lb [35 kg]
Virgin	Passing No. 4 [4.75 mm]	35 lb [15 kg]
Recycled asphalt pavement (RAP)	—	80 lb [35 kg]
Recycled asphalt shingles (RAS)	—	10 lb [5 kg] sample of representative RAS material

E.5.a(2) Mixture Sample
At least 7 working days before the start of asphalt production, submit the proposed Job Mix Formula (JMF) in writing and signed by a Level II Quality Management mix designer for each combination of aggregates to be used in the mixture. Include test data to demonstrate conformance to mixture properties as specified in Table 2360-7, "Mixture Requirements," and 3139.2, "Bituminous Aggregates." Use forms approved by the Department for the submission.

Submit an uncompacted mixture sample plus briquettes, in conformance with the JMF, compacted at the optimum asphalt content and required compactive effort for laboratory examination and evaluation. Provide a mixture sample size and the number of compacted briquettes and in accordance with the following:

Table 2360-5
Mixture Sample Requirements

Item	Gyratory Design
Uncompacted mixture sample size	75 lb [30 kg]
Number of compacted briquettes	2

E.5.a(3) Tensile Strength Ratio Sample
At least 7 days before actual production, submit sample to the District Materials Laboratory for verification of moisture sensitivity retained tensile strength ratio (TSR). The Engineer may test material submitted for TSR verification for maximum specific gravity G_{mm} compliance in addition to TSR results. The Engineer will reject the submitted mix design if the tested material fails to

meet the G_{mm} tolerance. If the Engineer rejects a mix design, submit a new mix design in accordance with 2360.2.E, "Mixture Design." The Contractor may use one of the following options to verify that the TSR meets the requirements in Table 2360-7, "Mixture Requirements."

E.5.a(4) Option A

Batch material at the design proportions including optimum asphalt. Split the sample before curing and allow samples to cool to room temperature, approximately 77 °F [25 °C]. Submit 80 lb [35 kg] of mixture to the District Materials Laboratory for curing and test verification. Use a cure time of 2 h ±15 minutes at 290 °F [144 °C] cure time for both groups and follow procedures Laboratory Manual Method 1813.

E.5.a(5) Option B

Batch and cure in accordance with Option A. Compact, and submit briquettes and uncompacted mixture in accordance with Table 2360-6, "Option B Mixture Requirements."

Table 2360-6
Option B Mixture Requirements

Item	Gyratory Design
Un-compacted mixture sample size	8,200 g
Number of compacted briquettes*	6
Compacted briquette air void content	6.5 % – 7.5 %

* 6 in [150 mm] specimens.

For both options, cure for 2 h ±15 min at 290° F [144° C] meeting the requirements in the MnDOT Laboratory Manual Method 1813.

E.5.a(6) Aggregate Specific Gravity

Determine the specific gravity of aggregate in accordance with Laboratory Manual Methods 1204 and 1205.

E.5.b Option 2 — Modified Mixture Design

The Contractor may use the modified mixture design if testing shows that the aggregates meet the requirements of 3139.2 in the current construction season and if the Level II mix designer submitting the mixture design has at least 2 years' experience in mixture design. The Department will not require mixture submittal.

E.5.b(1) Mixture Aggregate Requirements

Size, grade, and combine the aggregate fractions in proportions that are in accordance with 3139.2.

E.5.b(2) JMF Submittal

At least 2 working days before beginning asphalt production, submit a proposed JMF in writing to the District Materials Laboratory signed by a Level II Quality Management mix designer for each combination of aggregates. For each JMF submitted, include documentation in accordance with 2360.2.E.5.a, "Option1 – Laboratory Mixture Design," to demonstrate conformance to mixture properties as specified in Table 2360-7, "Mixture Requirements," and Table 3139-3, "Mixture Aggregate Requirements." Submit the JMF on forms approved by the Department.

E.5.b(3) Initial Production Test Verification

The Department will take a mix verification sample within the first four samples at the start of production of each mix type. The Engineer will notify the Contractor electronically when a sample is to be taken and tested for tensile strength ratio (TSR). Initial production testing will be done within the first 5,000 tons [4500 tonnes] of the start of production.

E.6 Mixture Requirements

The Department will base mixture evaluation on the trial mix tests and in accordance with Table 2360-7, "Mixture Requirements."

Table 2360-7 Mixture Requirements				
Traffic Level	**2**	**3**	**4**	**5**
20 year design ESALs	< 1 million	1 – 3 million	3 – 10 million	10 – 30 million
Gyratory mixture requirements:				
Gyrations for N_{design}	40	60	90	100
% Air voids at $N_{design,}$ wear	4.0	4.0	4.0	4.0
% Air voids at N_{design}, Non-wear and all shoulder	3.0	3.0	3.0	3.0
Adjusted Asphalt Film Thickness, minimum µ	8.5	8.5	8.5	8.5
TSR*, *minimum %*	75‖	75‖	80†	80†
Fines/effective asphalt	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2

* Use 6 in [150 mm] specimens in accordance with 2360.2.I, "Field Tensile Strength Ratio (TSR)."
‖ MnDOT minimum = 65
† MnDOT minimum = 70

E.7 Minimum Ratio of Added Asphalt Binder to Total Asphalt Binder

Control recycled materials used in mixture by evaluating the ratio of new added asphalt binder to total asphalt binder as show in Table 2360-8.

Table 2360-8 Requirements for Ratio of Added New Asphalt Binder to Total Asphalt Binder[1] min%:			
Specified Asphalt Grade[2]	Recycled Material		
	RAS Only	RAS + RAP	RAP Only
PG XX-28, PG 52-34, PG 49-34, PG 64-22			
Wear	70	70	70
Non-Wear	70	70	65
PG 58-34, PG 64-34, PG 70-34			
Wear & Non-Wear	80	80	80

[1] The ratio of added new asphalt binder to total asphalt binder is calculated as (added binder/total binder) x 100
[2] The Contractor can elect to use a blending chart to verify compliance with the specified binder grade. The Department may take production samples to ensure the asphalt binder material meets the requirements. The blending chart is on the Bituminous Office Website.

E.8 Adjusted Asphalt Film Thickness (Adj. AFT) MnDOT Laboratory Manual Method 1854

Ensure the adjusted asphalt film thickness (Adj. AFT) of the mixture at design and during production meets the requirements of Table 2360-7,"Mixture Requirements." Base the Adj. AFT on the calculated aggregate surface area (SA) and the effective asphalt binder content.

E.9 Documentation

Include the following documentation and test results with each JMF submitted for review:

(1) Names of the individuals responsible for the QC of the mixture during production,
(2) Low project number of the contract on which the mixture will be used,
(3) Traffic level and number of gyrations,
(4) The following temperature ranges as supplied by the asphalt binder supplier:
  (4.1) Laboratory mixing and compaction,
  (4.2) Plant discharge, and
  (4.3) Field compaction.
(5) The percentage in units of 1 percent (except the No. 200 sieve [0.075 mm] in units of 0.1 percent) of aggregate passing each of the specified sieves (including the No. 16, No. 30, No. 50, and No. 100) for each aggregate to be incorporated into the mixture. Derive the gradation of the aggregate from the RAP after extracting the residual asphalt.
(6) Source descriptions of the following:
  (6.1) Location of material,
  (6.2) Description of materials,
  (6.3) Aggregate pit or quarry number, and
  (6.4) Proportion amount of each material in the mixture in percent of total aggregate.
(7) Composite gradation based on (5) and (6) above. Include virgin composite gradation based on (6) and (7) above for mixtures containing RAP/RAS.

(8) Bulk and apparent specific gravities and water absorption (by % weight of dry aggregate). Both coarse and fine aggregate, for each product used in the mixture (including RAP/RAS). Use Mn/DOT Laboratory Manual Method 1204 and 1205. The tolerance allowed between the Contractor's and the Department's specific gravities are G_{sb} (individual) = 0.040 [+4 and -4] and G_{sb} (combined) = 0.020.

(9) FHWA 0.45 power chart represented by the composite gradation plotted on Federal Form PR-1115

(10) Test results from the composite aggregate blend at the proposed JMF proportions showing compliance with Table 3139-3:
- (10.1) Coarse Aggregate Angularity,
- (10.2) Fine Aggregate Angularity, and
- (10.3) Flat and Elongated

(11) Extracted asphalt binder content for mixtures containing RAP/RAS with no retention factor included.

(12) Asphalt binder percentage in units of 0.1 percent based on the total mass of the mixture and the PG grade.

(13) Each trial mixture design includes the following:
- (13.1) At least 3 different asphalt binder contents (with at least 0.4 percent between each point), with at least one point at, one point above and one point below the optimum asphalt binder percentage.
- (13.2) Maximum specific gravity for each asphalt binder content calculated based on the average of the effective specific gravities measured by using at least two maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt binder content.
- (13.3) Test results on at least two specimens at each asphalt binder content for the individual and average bulk specific gravities, density, and heights.
- (13.4) Percent air voids of the mixture at each asphalt binder content.
- (13.5) Adj. AFT for each asphalt binder content.
- (13.6) Fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent.
- (13.7) TSR at the optimum asphalt binder content.
- (13.8) Graphs showing air voids, adjusted AFT, Gmb, Gmm and unit weight vs. percent asphalt binder content for each of the three asphalt binder contents submitted with trial mix.
- (13.9) Evidence that the completed mixture will conform to design air voids (Va), Adj. AFT, TSR, F/Ae (Fines to effective asphalt ratio).
- (13.10) Gyratory densification tables and curves generated from the gyratory compactor for all points used in the mixture submittal.
- (13.11) % new asphalt binder to total asphalt binder.

(14) The Contractor has the option of augmenting the submitted JMF with additional sand or rock. When using this option, provide samples of the aggregate for quality analysis in accordance with 2360.2.E.5, "Type of Mixture Design Submittal." Also provide mix design data for two additional design points per add-material. Provide one point to show a proportional adjustment to the submitted JMF that includes 5 percent, by weight, add-material at the JMF optimum asphalt percent. Provide a second point to show a proportional adjustment to the submitted JMF that includes 10 percent, by weight, add material at the JMF optimum asphalt percent. Report the following information for each of these two points:
- (14.1) The maximum specific gravity determined by averaging two tests,
- (14.2) Test results showing the individual and average bulk specific gravity, density, and height of at least two specimens at the optimum asphalt binder content,
- (14.3) Percent air voids for the mixture for each point,
- (14.4) Fines to Effective Asphalt ratio calculated to the nearest 0.1 of a percent,
- (14.5) Crushing of the coarse and fine aggregate,
- (14.6) Adj. AFT, and,
- (14.7) Up to two add materials will be allowed.

F Mixture Design Report

The Department will provide a Mixture Design Report consisting of the JMF. Include the following in the JMF:

(1) Composite gradation,
(2) Aggregate component proportions,
(3) Asphalt binder content of the mixture,
(4) Design air voids,
(5) Adj. asphalt film thickness, and
(6) Aggregate bulk specific gravity values.

Show the JMF limits for gradation control sieves in accordance with aggregate gradation broadbands shown in Table 3139-2, percent asphalt binder content, air voids, and Adj. AFT. If the Department issues a Mixture Design Report, this report only confirms that the Department reviewed the mixture and that it meets volumetric properties shown in Table 2360-7 and Table 2360-8. The Department makes no guaranty or warranty, either express or implied, that compliance with volumetric properties ensures specification compliance regarding placement and compaction of the mixture.

Provide materials meeting the requirements of the aggregate and mixture design before issuing a Mixture Design Report. The Department will review two trial mix designs per mix type designated in the plan per contract at no cost to the Contractor. The Department will verify additional mix designs at a cost of $2,000 per design.

Provide a Department - reviewed Mixture Design Report for all paving except for small quantities of material as described in 2360.3.G, "Small Quantity Paving."

For city, county, and other agency projects, provide the District Materials Laboratory a complete project proposal, including addenda, supplemental agreements, change orders, and plans sheets, including typical sections, affecting the mix design before the Department begins the verification process.

G Mixture Quality Management

G.1 Quality Control (QC)

The Contractor will perform Quality Control (QC) as part of the production process. QC is the process control of the operations related to mixture production and determining the quality of the mixture being produced. The QC sample is the Contractor's sample taken and tested during production and used to control the production process. Provide and maintain a QC program for plant mix asphalt production, including mix design, process control inspection, sampling and testing, and adjustments in the process related to the production of an asphalt pavement.

G.1.a Certification

Provide the following to obtain certification:

(1) Completed and submitted request form application for plant inspection.
(2) Site map showing stockpile locations.
(3) Signed asphalt plant inspection report showing the plant and testing facility passed as documented by Asphalt Plant Inspection Report (TP 02142-02, TP 02143-02). The inspection report must also include documentation showing plant and laboratory equipment has been calibrated and is being maintained to the tolerance shown in the Bituminous Manual and sections 1200, 1800, and 2000 of the Mn/DOT Laboratory Manual.
(4) A Department-signed Mixture Design Report (MDR) before mixture production.

G.1.b Maintaining Certification

Maintain plant certification by documenting the production and testing of the certified plant asphalt mixtures. Sample and test asphalt mixtures in accordance with this section and meeting the requirements of the Schedule of Materials Control.

G.1.b(1) Annual Certification

Perform annual certification after winter suspension.

G.1.b(2) Sampling Rate

Sample at the rate in accordance with 2360.2.G.6 and the requirements of the Schedule of Materials Control.

G.1.b(3) Plant Moved

Recertify the plant if the plant moves to a new or previously occupied location.

G.1.c. Plant Certification Revocation

The Engineer may revoke certification for any of the following reasons:

(1) If the mix does not meet the requirements of 2360.2.E.6, 2360.2.E7,and 3139.2,
(2) If there is a failure to meet the testing rates, or
(3) If it is determined records were falsified.

If the Engineer revokes plant certification, the Department may revoke the Technical Certification of the individual or individuals involved. The Department will maintain a list of companies with revoked certifications.

G.2 Quality Assurance (QA)

The Engineer will perform Quality Assurance (QA) as part of the acceptance process. QA is the process of monitoring and evaluating various aspects of the Contractor's testing as described below. The QA sample is the Department's companion sample to the Contractor's QC sample. QA testing is performed to accept the work. The Engineer will perform the following:

(1) Conduct QA and verification sampling and testing,
(2) Observe the QC sampling and tests,
(3) Monitor the required QC summary sheets and control charts,
(4) Verify calibration of QC laboratory testing equipment,
(5) Communicate Department test results to the Contractor's personnel on a daily basis, and
(6) Ensure Independent Assurance (IA) sampling and testing requirements are met.

If the Engineer observes that the Contractor is not performing sampling and quality control tests in accordance with the applicable test procedures, the Engineer may stop production until the Contractor takes corrective action. The Engineer will notify the Contractor of observed deficiencies promptly, both verbally and in writing.

The Engineer may obtain additional samples, at any time and location during production, to determine quality levels in accordance with 2360.2.G.3, "Verification Sample."

The Department will post a chart with the names and telephone numbers for the personnel responsible for QA.

The Engineer will calibrate and correlate laboratory testing equipment in accordance with the Bituminous Manual and Laboratory Manual.

Table 2360-9
Allowable Differences between Contractor and Department Test Results*

Item	Allowable Difference
Mixture bulk specific gravity (G_{mb})	0.030
Mixture maximum specific gravity (G_{mm})	0.019
Adjusted AFT (calculated)	1.2
Fine Aggregate Angularity, uncompacted voids (U) %	1
Coarse Aggregate Angularity, % fractured faces (%P)	15
Aggregate Individual Bulk Specific Gravity (**+** No. 4 [+4.75 mm])	0.040
Aggregate Individual Bulk Specific Gravity (**-** No. 4 [-4.75mm])	0.040
Aggregate combined blend Specific Gravity (G_{sb})	0.020
Tensile strength ratio (TSR), %	Table 2360-7
Asphalt binder content:	
Meter method, %	0.2
Spot check method, %	0.2
Chemical extraction methods, %	0.4
Incinerator oven, %	0.3
Chemical vs. meter, spot check, or incinerator methods	0.4
Incinerator oven vs. spot check	0.4
Gradation sieve, *% passing:*	
1 in [25.0 mm], ¾ in [19.0 mm], ½ in [12.5 mm], ⅜ in [9.5 mm]	6
No. 4 [4.75 mm]	5
No. 8 [2.36 mm], No. 16 [1.18 mm], No. 30 [0.60 mm]	4
No. 50 [0.30 mm]	3
No. 100 [0.15 mm]	2
No. 200 [0.075 mm]	1.2

* Test tolerances listed are for single test comparisons.

G.3 Verification Sample

The Department will test a minimum of one of the companion samples to the Contractor's QC samples and identify this as a verification sample. The Department's verification sample is used to assure compliance of the Contractor's QC program. The verification samples can be any one or all of the splits to the Contractor's QC samples. Additionally, the Department can take a random sample at any time from behind the paver or from the truck box and will consider this a verification sample. The split of this sample, given to the Contractor, must be tested by the Contractor and will replace the next scheduled QC sample. The Department recommends sampling enough material to accommodate retesting in case the samples fail.

The Department will perform verification testing on at least one set of production tests in accordance with 2360.2.G.6.b, "Production," and 2360.2.G.7, "Production Test," on a daily basis per mix type. Use the verification companion sample to verify the requirements of Table 3139-2, Table 3139-3, and Table 2360-7. Compare the verification companion sample to the verification sample for compliance with allowable tolerances in Table 2360-9, "Allowable Differences between Contractor and Department Test Results." These include the mixture properties of G_{mm} (mixture maximum gravity), G_{mb} (mixture bulk gravity), asphalt binder content, Adjusted AFT (calculated), Coarse and Fine Aggregate crushing, and gradation. Perform one test per week on a verification companion for coarse and fine aggregate crushing meeting the requirements of 2360.2.G.7.g "Coarse Aggregate Angularity" and 2360.2.G.7.h, "Fine Aggregate Angularity." These do not include the aggregate bulk specific gravity G_{sb}, fines to effective asphalt, or the tensile strength ratio (TSR). Determine the asphalt binder content and gradation in accordance with the extraction method specified in 2360.2.G.7.a, "Asphalt Binder Content," or 23602.G.7.b, "Gyratory Bulk Specific Gravity.

The Contractor may access the Department's verification test results for G_{mm} (mixture maximum gravity), Gmb (mixture bulk gravity), air voids (calculated), asphalt binder content, within 2 working days from the time the sample is delivered to the District Laboratory. The Department will provide the gradation, crushing, and Adj. AFT (calculated) results to the Contractor within three working days. The Department will include the verification test results on the test summary sheet. The Department will compare the results with the Contractor's verification companion for the allowable tolerances in Table 2360-9, "Allowable Differences between Contractor and Department Test Results." The Department will consider the verification process complete if the Contractor's verification companion meets the tolerances in Table 2360-9.

If the tolerances between the Contractor's verification companion and the Department's verification sample do not meet the requirements of Table 2360-9, the Department will retest the material. If the retests fail to meet tolerances, the Department will substitute the Department's verification test results for the Contractor's results in the QC program and use those results for acceptance. The Department will only substitute the out-of-tolerance parameters and will recalculate volumetric properties if applicable.

If the Adj. AFT calculation does not meet the tolerance, equalize the Department Adj. AFT result by increasing the original Department value by 0.5 microns. Use the increased Department Adj. AFT for the Individual Adjusted AFT result and to calculate the Moving Average Adj. AFT results. The increased Department Adj. AFT will form the basis for acceptance.

If the verification sample retests do not meet tolerances, the Department will immediately investigate the cause of the difference that will include a review of testing equipment, procedures, worksheets, gyratory specimen height sheets, and personnel to determine the source of the problem. The Engineer may require both the Department and Contractor to perform at least one hot-cold comparison of mixture properties.

To perform a hot-cold comparison, split the sample into three representative portions. The Engineer will observe the Contractor testing. Immediately compact one part while still hot. Apply additional heating to raise the temperature of the sample to compaction temperature if necessary. Allow the second and third part to cool to air temperature. Retain the second part and transport the third part to the District Materials Laboratory. On the same day and at the same time as the District Materials Laboratory, heat samples to compaction temperature and compact. Develop a calibration factor to compare the specific gravity of the hot compacted samples to reheated compacted samples. Use at least two gyratory specimens for each test. The Engineer or the Contractor may request that this test be repeated.

Reheat mix samples to 160° F [70° C] to allow splitting of the sample into representative fractions for the various tests. Do not overheat the mixture portions used for testing maximum specific gravity test.

The Department will test the previously collected QA samples until they meet the tolerances or until the Department has tested all of the remaining samples. After testing the samples, the Department will test QA samples subsequent to the verification sample until tolerances are met. The Department will base acceptance on QC data. The Department will base acceptance on QC data with substitution of Department test results for those parameters out of tolerance. Cease mixture production and placement if reestablished test results do not meet tolerances within 48 h. Resume production and placement only after meeting the tolerances. The process for dispute resolution is available on the Bituminous Office website.

If the Engineer analyzes the data using methods for determination of bias on file in the Bituminous Office and finds a bias in the test results, the Engineer will specify which results to use. If through analysis of data, it is determined that there is a bias in the test results, the Engineer will determine which results are appropriate and will govern.

G.4 Contractor Quality Control

G.4.a Personnel

Submit an organizational chart listing the names and phone numbers of individuals and alternates responsible for the following:

(1) Mix design,
(2) Process control administration, and
(3) Inspection.

Provide QC technicians certified as a Level I Bituminous Quality Management (QM) Tester meeting the requirements of the MnDOT Technical Certification Program for QC testing and Level II Bituminous QM Mix Designer to make process adjustments. Provide at least one person per paving operation certified as a Bituminous Street Inspector.

Provide a laboratory with equipment and supplies for Contractor quality control testing and maintain with the following:

(1) Up-to-date equipment calibrations and a copy of the calibration records with each piece of equipment,
(2) Telephone,
(3) Fax and copy machine; however, the Engineer may waive the requirement to have a fax machine if internet and email are available,
(4) Internet and Email,
(5) Computer,
(6) Printer, and
(7) Microsoft Excel, version 2010 or newer

Laboratory equipment need to meet the requirements listed in Section 400 of the Bituminous Manual, Laboratory Manual, and these specifications, including having extraction capabilities. Before beginning production, the laboratory equipment needs to be calibrated and operational.

Calibrate and correlate all testing equipment in accordance with the Bituminous Manual and Laboratory Manual. Keep records of calibration for each piece of testing equipment in the same facility as the equipment.

G.4.b Sampling and Testing

Take QC samples at random tonnage or locations, quartered from a larger sample of mixture. Sample randomly and in accordance with the Schedule of Materials Control. Determine random numbers and tonnage or locations using the Bituminous Manual; Section 5-693.7 Table A or ASTM D 3665, Section 5, or, an Engineer approved alternate method of random number generation. Sample either behind the paver or from the truck box at the plant site. Other sampling locations can be approved by the Engineer. The Contractor must decide and notify the Engineer where samples will be taken before production begins. The Contractor and Engineer must both agree to a change of sampling location once production has begun. The procedure for truck box sampling is on the Bituminous Office website. The Contractor will obtain at least a 130 pound [60 kg] sample. Split the sample in the presence of the Inspector. The Inspector will retain possession of the Agency portion of each split sample that is taken and randomly submit a minimum of one sample, on a daily basis, to the District Laboratory for Verification testing (see 2360.2.G.3). Store compacted mixture specimens and loose mixture companion samples for 10 calendar days. Label these split companion samples with companion numbers.

If coarse and fine aggregate angularity are not evaluated for every QC sample retain the extracted gradation samples for the respective QC samples for additional testing. Keep the aggregate samples in containers with field identification labels for a period of 10 calendar days. The Engineer will identify which extracted gradation sample is the Verification Companion and whether it is to be tested for coarse and fine aggregate angularity.

G.5 Production Test Requirements

Determine the planned tonnage [metric tons] for each mixture planned for production during the production day. Divide the planned production by 1,000 and round to the next highest whole number. The result is the number of production tests required for the mixture. Table 2360-11, "Production Testing Rates" shows the required production tests.

Split the planned production into even increments and select sample locations as described above. If actual tonnage is greater than the planned tonnage, repeat the calculation above and provide additional tests if the calculation results in a higher number of production tests. During production, the Department will not require mixture volumetric property tests if mix production is no greater than 300 ton [270 tonne]. Provide production tests if the accumulative weight on successive days is greater than 300 ton [270 tonne].

If there is a choice of more than one MnDOT approved test procedure, select one method at the beginning of the project with the approval of the Engineer and use that method for the entire project. The Contractor and Engineer may agree to change test procedures during the construction of the project.

G.5a Establishing an Ignition Oven Correction Factor MnDOT Lab. Manual 1853 Appendix

On the first day of production, for each mixture type, both the Contractor and the Agency will establish an ignition oven correction factor from the produced mixture. Re-establish correction factors when:

There are aggregate or RAP substitutions

There are 3 or more tolerance failures on the extracted asphalt content between the Agency and the Contractor as defined by Table 2360-9, "Allowable Differences between Contractor and Department Test Results".

G.6 Production Testing Rates

G.6.a Start –Up

At the start of production, for the first 2,000 ton [1,800 tonne] of each mix type, perform testing at the following frequencies:

Table 2360-10
Production Start-Up Testing Rates

Production Test	Testing Rates	Laboratory Manual Method	Section
Bulk Specific Gravity	1 test per 500 ton [450 tonne]	1806	2360.2.G.7.b
Maximum Specific Gravity	1 test per 500 ton [450 tonne]	1807	2360.2.G.7.c
Air Voids (calculated)	1 test per 500 ton [450 tonne]	1808	2360.2.G.7.d
Asphalt Content	1 test per 500 ton [450 tonne]	1853	2360.2.G.7.a
Add AC/Total AC Ratio (calculated)	1 test per 1000 ton [900 tonne]	1853	2360.2.G.7.a
Adj. AFT (Calculated)	1 test per 500 ton [450 tonne]	1854	2360.2.E.6.b
Gradation	1 test per 500 ton [450 tonne]	1203	2360.2.G.7.f
Coarse Aggregate Angularity	1 test per 1,000 tons [900 tonne]	1214	2360.2.G.7.g
Fine Aggregate Angularity (FAA)	1 test per 1,000 ton [900 tonne]	1206	2360.2.G.7.h
Fines to Effective Asphalt Ratio (calculated)	1 test per 500 ton [450 tonne]	1203 & 1853	2360.2.G.7.f & 2360.2.G.7.a

G.6.b Production

After producing the first 2,000 ton [1,800 tonne] of each mix type test at the following frequencies:

Table 2360-11
Production Testing Rates

Production Test	Sampling and Testing Rates	Test Reference	Section
Bulk Specific Gravity	Divide the planned production by 1,000. Round the number to the next higher whole number	Laboratory Manual 1806	2360.2.G.7.b
Maximum Specific Gravity	Divide the planned production by 1,000. Round the number to the next higher whole number.	Laboratory Manual 1807	2360.2.G.7.c
Air Voids (calculated)	Divide the planned production by 1,000. Round the number to the next higher whole number	Laboratory Manual 1808	2360.2.G.7.d
Asphalt Content	Divide the planned production by 1,000. Round the number to the next higher whole number	Laboratory Manual 1853	2360.2.G.7.a
Add AC/Total AC Ratio (calculated)	Divide the planned production by 1,000. Round the number to the next higher whole number	Laboratory Manual 1853	2360.2.G.7.a
Adj. AFT (Calculated)	Divide the planned production by 1,000. Round the number to the next higher whole number	Laboratory Manual 1854	2360.2.E.7.e
Gradation	1 gradation per 1,000 tons [900 tonne], or portion thereof (at least one per day)	Laboratory Manual 1203	2360.2.G.7.f
Coarse Aggregate Angularity	2 tests per day for at least 2 days, then 1 per day if CAA is met. If CAA >8% of require-ment, 1 sample per day but test 1 per week.	Laboratory Manual 1214	2360.2.G.7.g
Fine Aggregate Angularity (FAA)	2 tests per day for at least 2 days, then 1 per day if FAA is met. If FAA >5% of require-ment, 1 sample per day but test 1 per week.	Laboratory Manual 1206	2360.2.G.7.h
Fines to Effective Asphalt Ratio (calculated)	Divide the planned production by 1,000. Round the number to the next higher whole number	Laboratory Manual 1203 & 1853	2360.2.G.7.f & 2360.2.G.7.a
TSR	As directed by the Engineer	Laboratory Manual 1813	2360.G.7.i
Aggregate Specific Gravity	As directed by the Engineer	Laboratory Manual 1204, 1205, and 1815	2360.G.7.j
Mixture Moisture Content	Daily unless otherwise required by the Engineer	Laboratory Manual 1855	2360.G.7.k
Asphalt Binder	Sample first load (each grade), then 1 per 250,000 gal sample size 1 qt [1,000,000 L]	MnDOT Bituminous Manual 5-693.920	2360.G.7.l

G.7 Production Tests

G.7.a Asphalt Binder Content

Spotchecks are required only when the Engineer has waived the requirements of 2360.2G8 relating to furnishing a computerized printout of the plant blending control system. A minimum of 1 spotcheck per day per mixture blend is required to determine the new added asphalt binder.

Use an incinerator oven meeting the requirements of the Laboratory Manual Method 1853. Do not use the incinerator oven if the percentage of Class B material is greater than 50 percent within the composite blend, unless the Contractor determines a correction factor approved by the Engineer.

Perform chemical extraction meeting the requirements of Laboratory Manual Method 1851 or 1852.

G.7.b Gyratory Bulk Specific Gravity, Gmb

Use two specimens to determine gyratory bulk specific gravity meeting the requirements of Laboratory Manual Method 1806. Set Gyratory to an internal angle of 1.16° ± 0.02° according to AASHTO TP 71.

G.7.c Maximum Specific Gravity, Gmm

Determine maximum specific gravity meeting the requirements of Laboratory Manual Method 1807.

G.7.d Air Voids – Individual and Isolated (Calculation)

Calculate the individual and isolated air voids meeting the requirements of Laboratory Manual Method 1808. Use the maximum mixture specific gravity and corresponding bulk specific gravity from a single test to calculate the isolated air voids. Use the maximum specific gravity moving average and the bulk specific gravity from a single test to calculate the individual air voids.

Compact gyratory design to N_{design} in accordance with Table 2360-7, "Mixture Requirements" for the specified traffic level.

G.7.e Adjusted Asphalt Film Thickness (AFT) (Calculation)

Calculate the Adj. AFT meeting the requirements of the Laboratory Manual Method 1854.

G.7.f Gradation – Blended Aggregate

Determine the gradation of blended aggregate sample, from an extracted bituminous mixture, meeting the requirements of Laboratory Manual Method 1203.

G.7.g Coarse Aggregate Angularity

Test the Coarse Aggregate Angularity (CAA) meeting the requirements of Laboratory Manual Method 1214 to determine the CAA on composite blend from aggregates used in production of hot mix asphalt. Ensure CAA test results meet the requirements in accordance with Table 3139-3.

The Contractor may test mixtures containing virgin aggregates from composite belt samples. Test mixtures containing RAP from extracted aggregates taken from standard production samples. Test the percentage of fractured faces of the composite aggregate blend less than 100 percent twice a day for each mixture blend for at least two days, then one test per day if the test samples meet the CAA requirements. If the CAA crushing test results are greater than 8 percent of the requirements, take one sample per day and perform one test per week.

Report CAA results on the test summary sheet. The Department may reduce payment in accordance with Table 2360-15, "Reduced Payment Schedule for Individual Test Results," for mixture placed and represented by results below the minimum requirement in accordance with Table 3139-3. The Department will calculate tonnage subjected to reduced payment as the tons placed from the sample point of the failing test to the sampling point where the test result meets the specifications.

G.7.h Fine Aggregate Angularity

Use Laboratory Manual Method 1206 to test the composite blend from aggregates used in production of asphalt mixtures for Fine Aggregate Angularity (FAA) meeting the requirements of Table 3139-3. The Contractor may test mixtures that contain virgin aggregates from composite belt samples. Test mixtures that contain RAP from extracted aggregates taken from standard production samples. Perform two tests per day for each mixture blend for at least two days to test the percentage of uncompacted voids from the composite aggregate blend, then one test per day if the samples meet FAA requirements. If FAA test results are greater than 5 percent of the requirement, take one sample per day and one test per week.

Report FAA results on the test summary sheet. The Department may reduce payment in accordance with Table 2360-16, "Reduced Payment Schedule for Individual Test Results," for mixture placed and represented by results below the minimums in accordance with Table 3139-3. The Department will calculate tonnage subjected to reduced payment as the tons placed from the sample point of the failing test to the sampling point where the test result meets the specifications.

G.7.i Field Tensile Strength Ratio (TSR) – Laboratory Manual Method 1813

If the Engineer requires sampling and testing of the mixture to verify tensile strength ratio (TSR), both the Contractor and the Department will be required to test these samples within 72 h after sampling. The Contractor shall obtain a sample weighing at

least 110 lb [50 kg] and split the sample in half to provide a sample for the Department and the Contractor. Label the Department companion of this split with the following information:

(1) Date,
(2) Time,
(3) Project number, and
(4) Cumulative tonnage to date.

After the sample is split and labeled, give the Department's companion sample to the Department Street Inspector or Plant Monitor or to the Materials Engineer within 24 h of sampling as directed by the Engineer. When using Option 2, obtain the sample within the first 5,000 ton [4,500 tonne] of plant mixed asphalt produced or by the second day of production, whichever comes first, to verify tensile strength ratio (TSR).Take mixture samples from the windrow or truck box. Provide a 6 in [150 mm] specimen for gyratory design. The Contractor may test the sample at a permanent lab site or a field lab site.

Refer to Table 2360-12, "Mixture Type, Minimum TSR," for the minimum acceptable TSR values for production. Stop production immediately if the material does not meet minimum TSR requirements. Do not resume production until after adding anti-strip to the asphalt binder. Determine the responsible party for the cost of the anti-strip in accordance with the Department and Contractor TSR values in Table 2360-13. If the Department is responsible for the cost of the anti-strip, the Department will only pay for the cost of the anti-strip for mixtures placed on that project. The Department will not pay for delay costs associated with making changes related to this testing.

Table 2360-12
Mixture Type, Minimum TSR

Traffic Level 2 – 3, %		Traffic Level 4 – 5, %	
Contractor	**MnDOT**	**Contractor**	**MnDOT**
75	65	80	70

Table 2360-13
Anti-Strip Cost Responsibility

Gyratory Level	Contractor TSR	MnDOT TSR	Responsibility
2 – 3	≥ 75	≥ 65	No anti-strip required
		< 65	Contractor
	< 75	≥ 65	Department
		< 65	Contractor
4 – 5	≥ 80	≥ 70	No anti-strip required
		< 70	Contractor
	< 80	≥ 70	Department
		< 70	Contractor

Take another sample and test within the first 500 ton [450 tonne] after production resumes. Stop production if the re-test fails to meet the minimum specified value. Discuss a proposal to resolve the problem with the Engineer before resuming production. Do not operate below the specified minimum TSR if at least 2 successive tests fail the TSR requirements.

A new sample and retest is automatically required if a proportion changes by greater than 10 percent from the currently produced mixture for a single stockpile aggregate or the Engineer directs the Contractor to sample and retest.

G.7.j Aggregate Specific Gravity(Gsb)..... Laboratory Manual Methods 1204, 1205, 1815

Sample and test aggregate stockpiles to verify aggregate specific gravity if directed by the Engineer in conjunction with the District Materials Engineer. Provide 90 lb [40 kg] representative stockpile samples for each aggregate component. Split samples in half to provide material for both the Department and the Contractor. Label the Department companion with the following information:

(1) Date,
(2) Time,
(3) Project number, and
(4) Approximate cumulative tonnage to date.

Give the Department companion to the Department Street Inspector or Plant Monitor immediately after splitting or to the Materials Engineer within 24 h of sampling as directed by the Engineer. The Materials Engineer will compare the aggregate specific gravity results to the Contractor's values on the current Mix Design Report. If the results deviate beyond the tolerance in accordance with Table 2360-16, "Allowable Differences between Contractor and Department Test Results," the Materials Engineer will notify the Contractor and issue a new Mix Design Report with the current specific gravity results. Base new mixture placed after receiving notification of new specific gravity values on the Department results. The Engineer will notify the Contractor regarding new specific gravity values. The dispute resolution procedure for aggregate specific gravity is on the Bituminous Office website.

G.7.k Moisture Content Laboratory Manual Method 1855

Provide a mixture with moisture content no greater than 0.3 percent. Measure moisture content in the mixture behind the paver or, if approved by the Engineer, in the truck box. Sample and test as directed by the Engineer. Store the sample in an airtight container. Do not perform microwave testing.

Do not provide plant mixed asphalt with a moisture content greater than 0.3 percent.

G.7.l Asphalt Binder Samples

Obtain asphalt binder samples from a sampling valve located between the pump and the drum. Sample each type of asphalt binder used in mixture production after 50 tons of mixture has been produced, then sample at a rate of one per 250,000 gal [1,000,000 L. A minimum of 1 gallon of binder must be drawn and wasted from the sampling valve before the actual sample is drawn. For batch plants, obtain the asphalt binder sample from the weigh pod. Provide a 1 qt [1.0 L] sized sample. The Inspector will monitor the sampling the Contractor performs. Record sample information on an Asphalt Sample Identification Card. Submit the sample to the Central Materials Laboratory. Contact the Department Chemical Laboratory Director for disposition of failing asphalt binder samples.

G.8 Documentation

Maintain documentation, including test summary sheets and control charts, on an ongoing basis. Maintain a file of gyratory specimen heights for gyratory compacted samples and test worksheets. File reports, records, and diaries developed during the work as directed by the Engineer. These documents become the property of the Department.

Number test results in accordance with the MDR and record on forms approved and provided by the Department.

Send production test results on test summary sheets to the District Materials Laboratory and to other sites as directed by the Engineer by 11 AM of the day following production by facsimile, or e-mail when approved by the Engineer.

Include the following production test results and mixture information on the Department approved test summary sheet:

(1) Percent passing on all sieves in accordance with Table 3139-2 (including No. 16, No. 30, No. 50, No. 100),
(2) Coarse and fine aggregate crushing,
(3) Maximum specific gravity (G_{mm}.),
(4) Bulk specific gravity (G_{mb}),
(5) Percent total asphalt binder content (P_b),
(6) New added asphalt binder content,
(7) Ratio of % new added asphalt binder to total asphalt binder,
(8) Calculated production air voids (V_a),
(9) Calculated adjusted AFT (Adj. AFT),
(10) Composite aggregate specific gravity (Gsb) reflecting current proportions,
(11) Aggregate proportions in use at the time of sampling,
(12) Tons where sampled,
(13) Tons represented by a test and cumulative tons produced,
(14) Fines to effective asphalt ratio (F/A_e),
(15) Signature Line for MnDOT and Contractor Representative,
(16) Mixture Moisture Content, and
(17) MnDOT verification sample test result.
(18) Identify, when used, the WMA additive or process and dosing rates.

Submit copies of failing test results to the Engineer on a daily basis.

Provide the Engineer with asphalt manifests or bill of lading's (BOL) on a daily basis.

Provide a daily plant diary, including a description of QC actions taken. Include changes or adjustments on the test summary sheets.

Provide weekly truck scale spot checks.

Provide a Department approved accounting system for mixes and provide a daily and final project summary of material quantities and types.

Provide a final hard and electronic copy of QC test summary sheets and control charts, and density worksheets at completion of bituminous operations on the project to the Engineer.

Provide an automated weigh scale and computer generated weigh ticket. Ensure the ticket indicates the following information:

(1) Project number,
(2) Mix designation, including binder grade,
(3) Mixture Design Report number,

(4) Truck identification and tare,
(5) Net mass, and
(6) Date and time of loading.

Do not include deviations from the minimum information on the computer generated weigh ticket unless otherwise approved by the Engineer in writing.

Continue test summary sheets, charts, and records for a mixture produced at one plant site from contract to contract. Begin new summary sheets and charts annually for winter carry-over projects. Begin new summary sheets and charts when an asphalt plant is re-setup in the same location after it has moved out.

Furnish an electronic printout (long form recordation) from an automated plant blending control system at 20 minute intervals when the plant is producing mixture. The Engineer may waive this requirement if the plant does not have the capability to produce the automated blending control information; however, the Contractor must then perform daily spotchecks to determine percent new asphalt added.

Include the following information on the plant control printout for Drum Plants:

(1) Both the virgin and recycle belt feed rates (tons/hr),
(2) Feeder bin proportions (%),
(3) Total % asphalt cement in the mixture,
(4) Virgin asphalt cement added (%)
(5) Mixture Temperature °F [°C],
(6) Mixture code,
(7) Date and time stamp, and
(8) Current tons of mixture produced and daily cumulative tons of mixture produced at time of printout.

Provide a daily electronic printout of the plant calibration (SPAN) numbers for each bin and meter.

Include the following information on the plant control printout for Batch Plants:

(1) Both the virgin and recycle belt feed rates (tons/hr),
(2) Feeder bin proportions (%),
(3) Mixture Temperature °F [°C],
(4) Mixture code,
(5) Date and time stamp, and
(6) Current tons of mixture produced and daily cumulative tons of mixture produced at time of printout.

Provide a daily electronic printout of the plant calibration (SPAN) numbers for each bin and meter.

G.9 Control Charts

Provide control charts and summary sheets computer generated from software approved by the Engineer.

The Contractor may use software available at the Bituminous Office. Record the following data on standardized control charts:

(1) Blended aggregate gradation, include sieves in accordance with Table 3139-2 for specified mixture;
(2) Percent asphalt binder content (P_b);
(3) Maximum specific gravity (G_{mm});
(4) Production air voids (V_a); and
(5) Adj. AFT.

Unless otherwise directed by the Engineer, plot individual test results for each test point and connect individual points with a solid line. Plot the moving average for each test variable starting with the fourth test and connect with a dashed line. Plot the Department's QA and verification test results with triangles. Plot the specification JMF limits on the control charts using a dotted line.

G.10 JMF Limits

Base the production air voids and Adj. AFT on the minimum specified requirements in accordance with Table 2360-7, "Mixture Requirements." Base gradations and asphalt binder content limits on the current Department reviewed Mixture Design Report. Provide gradation control sieves in accordance with Table 3139-2. Refer to the Mixture Design Report for the mixture production targets. JMF limits are the target plus or minus the limits in accordance with Table 2360-14, "JMF Limits (N=4)." Use JMF limits as the criteria for acceptance of materials based on the moving average.

Table 2360-14 JMF Limits (N=4)	
Item	**JMF Limits**
Adj. AFT	- 0.5
Production air voids, *%*	± 1.0
Asphalt binder content, *%*	- 0.4
Sieve, *% passing:*	
1 in [25.0 mm], ¾ in [19.0 mm], ½ in [12.5 mm], ⅜ in [9.5 mm], No. 4 [4.75 mm]	Broad band limits
No. 8 [2.36 mm]	Broad band limits
No. 200 [0.075 mm]	Broad band limits

G.11 Moving Average Calculation

Calculate a moving average as the average of the last four test results. Continue the calculation without interruption, except begin new summary sheets and charts annually for winter carry-over projects and if an asphalt plant is re-setup in the same site after it has been moved out.

G.12 JMF Bands

JMF Bands are the area between the target, as identified on the Mixture Design Report, and the JMF limits.

G.13 JMF Adjustment

Begin mixture production with aggregate proportions within 5 percent of the design proportions and mixture parameters in Table 2360-14 within the JMF limits shown. Use all the aggregate proportions included on the Mixture Design Report unless the aggregate proportion is shown as 0 percent. If the Contractor provides the District Materials Laboratory with prior documented production data showing how production affects the mixture properties or if the Contractor provides the District Materials Laboratory with a written justification or explanation of material changes since the original mixture submittal waive the preceding requirements.

G.13.a JMF Request for Adjustment

The Contractor may make a request to the Bituminous Engineer or District Materials Engineer for a JMF adjustment to the mix design if the QC test results indicate a necessary change to achieve the specified properties. Do not use aggregates or materials not part of the original mix design to make adjustments unless otherwise approved by the Engineer, in conjunction with the District Materials Engineer or the Department Bituminous Engineer.

A Certified Level II Bituminous QM Mix Designer will review the requested change for the Department. If the request meets the design requirements in Table 3139-2,"Aggregate Gradation Broad Bands", Table 3139-3,"Mixture Aggregate Requirements", and Table 2360-7, "Mixture Requirements," the Department will issue a revised Mixture Design Report. Each trial mixture design submittal in accordance with 2360.2.E, "Mixture Design" may have three JMF adjustments per mixture per project without charge. The Department will charge the Contractor $500 for each additional JMF adjustment requests.

Perform an interactive process with the Engineer before making JMF adjustments. Make JMF adjustments only within the mixture specification gradation design broadbands in accordance with Table 3139-2. Submit a new JMF if redesigning the mixture. Only reduce the JMF asphalt content if the moving average Adj. AFT is 8.5µ or more and Individual Adjusted AFT is at least 7.5 µ.

The department will not allow consecutive requests for a JMF adjustment without production data. Continue calculation of the moving average after the approval of the JMF.

G.13.b JMF Request for Adjustment for Proportion Change > 10%

If requesting a JMF adjustment for a proportion change greater than 10 percent from the currently produced mixture for a single stockpile aggregate, provide supporting production test data from at least four tests run at an accelerated testing rate of one test per 500 ton [450 tonne] with the adjustment request. The Department will base acceptable verification and approval of the requested JMF on individual and moving average test results in addition to the requirements listed above. Individual test results must be within twice the requested JMF limits for percent
asphalt binder, production air voids, and Adj. AFT. Individual gradations must be within the Broad Bands. The moving average values must be within the control limits in accordance with Table 2360-14. Continue to calculate the moving average after the change in proportions.

If the mixture meets the design requirements as discussed in G.13.a, the District Materials Laboratory will sign the request for JMF adjustment effective from the point of the proportion change. If the mixture fails to meet the design requirements, the Department will either reduce the payment or direct the Contractor to remove and replace. Do not make consecutive requests for JMF adjustments without production data.

G.13.c JMF Request for Adjustment When Cumulative Proportion Changes > 10%

Submit a request for JMF adjustment when the cumulative change on any one product exceeds 10% from the original MDR. The Department will issue a revised MDR provided the mixture meets the requirements in Table 3139-2,"Aggregate Gradation Broad Bands", Table 3139-3,"Mixture Aggregate Requirements", and Table 2360-7, "Mixture Requirements".

G.14 Failing Materials

The Department will base material acceptance on individual and moving average test results. The Department will use isolated test results for acceptance of air voids at the start of mixture production. The Department will consider individual test results greater than two times the JMF bands as failing. The Department will fail moving average test results exceeding the JMF limits. Begin new summary sheets annually for winter carry-over projects.

Stop production and make adjustments if the moving average values exceed the JMF limits. Restart production after performing the adjustments and notifying the Engineer. Resume testing at the accelerated rates and for the tests listed in Table 2360-10, "Production Start-Up Testing Rates," for the next 2,000 ton [1,800 tonne] of mixture produced. Continue calculating the moving average after the stop in production.

The Department will consider mixture produced where the moving average of four exceeds the JMF limits as unsatisfactory in accordance with 2360.2.G.14.d, "Moving Average Failure at Mixture Start-Up – Production Air Voids," 2360.2.G.14.e, "Moving Average Failure at Mixture Start-Up — Adjusted AFT," 2360.2.G.14.f, "Moving Average Failure - Production Air Voids," and 2360.2.G.14.g, "Moving Average Failure — Percent Asphalt Binder Content, Gradation, and Adj. AFT."

If the total production of a mixture type for the entire project requires no greater than four tests the Department will accept the material in accordance with 2360.2.G.14.b, "Isolated Failures at Mixture Start-Up — Production Air Voids," and 2360.2.G.14.c, "Individual Failure — Gradation, Percent Asphalt Binder, Production Air Voids, and Adj. AFT."

If the Contractor's testing data fails to meet the tolerances in accordance with Table 2360-9, "Allowable Differences between Contractor and Department Test Results," the Department will substitute QA and verification data to determine the payment factor.

G.14.a Ratio of New Added Asphalt Binder to Total Asphalt Binder – Acceptance Criteria

Minimum design ratio of new added asphalt binder to total asphalt binder is shown in Table 2360-15 below. During production the ratio must meet individual and moving average requirements as listed in Table 2360-15,"Ratio of New Added Asphalt Binder to Total Asphalt Binder Acceptance Criteria". If the individual or moving average ratio drops below the minimum requirement, the Contractor must stop production and make adjustments to correct the process. Restart production only after notifying the Engineer of the adjustments made. The calculation of the moving average will continue after the stop in production.

Table 2360-15
Ratio of New Added Asphalt Binder to Total Asphalt Binder Acceptance Criteria

Specified Asphalt Grade	Recycled Material		
	RAS Only	RAS + RAP	RAP Only
PG XX-28, PG 52-34, PG 49-34, PG 64-22			
Wear (ind./moving average)	66/70	66/70	66/70
Non-Wear (ind./moving average)	66/70	66/70	61/65
PG 58-34, PG 64-34, PG 70-34			
Wear & Non-Wear (ind./moving average	76/80	76/80	76/80

G.14.b Isolated Failures at Mixture Start-Up – Production Air Voids

At the start-up of mixture production, use the first three isolated test results for production air voids before establishing a moving average of four. Calculate isolated production air voids using the maximum mixture specific gravity and the corresponding bulk specific gravity from that single test. After testing four samples and establishing a moving average of four, the Department will base acceptance on individual and moving average production air voids.

The Department will not accept the material if any of the first three isolated test results for production air voids exceeds twice the JMF bands from the target listed on the Mixture Design Report at the start of production. The Department will reduce payment for unacceptable material in accordance with Table 2360-16, "Reduced Payment Schedule for Individual Test Results." The Department will calculate the quantity of unacceptable material on the tonnage placed from the sample point of the failing test to the sample point when the isolated test result is back within twice the JMF bands. If the failure occurs at the first test after the start of production, the Department will calculate the tonnage subject to reduced payment as described above, including the tonnage from the start of production.

If isolated air voids are less than 1.0 percent or greater than 7.0 percent, the Engineer will either reduce the payment or order the material removed and replaced at no additional cost to the Department. The Engineer may require the Contractor to test in-place mixture to better define the removal and replacement limits. The Engineer may require the Contractor to test in-place mixture placed before the failing test result. If the Engineer reduces the payment, the Department will pay for the material at 50 percent of the contract unit price.

G.14.c Individual Failure – Percent Asphalt Binder, Production Air Voids, and Adj. AFT

Table 2360-16 Reduced Payment Schedule for Individual Test Results	
Item	**Pay Factor, % ***
Coarse and fine aggregate crushing	90
Asphalt binder content	90
Production air voids, individual‖ and isolated†	80

* Apply the lowest pay factor when using multiple reductions on a single test.
‖ Calculate individual air voids using the moving average maximum specific gravity and the bulk specific gravity from that single test.
† Calculate the isolated air voids from the maximum specific gravity and the bulk specific gravity from that single test. The Engineer will only use isolated void test results for acceptance for the first three tests after mixture production start-up.

If the individual test result for adjusted AFT is less than 7.5μ, the Department may either reduce payment in accordance with Table 2360-17, "Reduced Payment Schedule for Individual Test Results, Adjusted AFT," or order the material removed and replaced represented by the individual test. This tonnage includes all material placed from the sample point of the failing test to the sample point when the test result meets specification requirements. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subject to reduced payment or removal and replacement.

Table 2360-17 Reduced Payment Schedule for Individual Test Results, Adjusted AFT	
Individual Adjusted AFT, *μ*	**Pay Factor, %**
≥ 7.5	100
7.4 – 7.0	90
6.9 – 6.1	75
≤ 6.0	R&R(*)

* Remove and replace at no expense to the Department.

The Department will not accept material if the individual tests for percent asphalt binder content or production air voids exceeds twice the JMF bands from the target listed on the Mix Design Report. The Department will reduce payment in accordance with Table 2360-16, "Reduced Payment Schedule for Individual Test Results." The Department will calculate the material subject to reduced payment as the material placed from the sample point of the failing test until the sample point when the test result is back within twice the JMF limits. If the failure occurs at the first test after the start of daily production, the Department will include tonnage from the start of production that day with the tonnage subjected to reduced payment.

The Department will not accept material if individual air voids are less than 1.0 percent or greater than 7.0 percent, Remove and replace unacceptable material at no additional cost to the Department as directed by the Engineer. Test in-place mixture to better define the area to be removed and replaced as directed by the Engineer. Test mixture placed before the failing test result as directed by the Engineer. The Department may reduce payment for unacceptable material at 50 percent of the relevant contract unit price.

G.14.d Moving Average Failure at Mixture Start-Up — Production Air Voids

If a moving average failure occurs within any of the first three moving average results after mixture start-up (tests 4, 5, 6), the Department will accept the mixture if the individual air void, corresponding to the moving average failure meets the JMF limits. The Department will not accept material if the individual air void fails to meet the JMF limit. The Department will reduce payment for unacceptable material unless the Engineer determines that the isolated air void corresponding to the individual air void meets the JMF limit. The Department will pay for unacceptable material at 70 percent of the relevant contract unit price. The Department will calculate the quantity of material subject to reduce payment as the tons placed from the sample point of the failing moving average result and corresponding individual air void beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit. If the failure occurs at the first test after the start of daily production, the Department will include tonnage from the start of production that day with the tonnage subjected to reduced payment.

G.14.e Moving Average Failure at Mixture Start-Up — Adj. AFT

The Engineer will calculate the Moving Average (n=4) Adj. AFT during the sixth test after the beginning of mixture production of that specific mixture. The Engineer will include the individual results of calculations for tests No. 3, No. 4, No. 5, and No. 6 with this calculation.

G.14.f Moving Average Failure — Production Air Voids

A moving average production air void failure occurs when the individual production air void moving average of four exceeds the JMF limit. The Department will consider the mixture unacceptable and subject to reduced payment. The Department will pay for unacceptable mixture at 70 percent of the contract unit price. The Department will calculate the quantity of mixture

subject to reduced payment as the tons placed from the sample point of all individual test results beyond the JMF limits, which contributed to the moving average value that exceeded the JMF limit, to the sampling point where the individual test result meets the JMF limits. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subject to reduced payment.

Table 2360-18
Reduced Payment Schedule for Moving Average Test Results

Item	Pay Factor, % *
Gradation	90
Coarse and fine aggregate crushing	NA (individual failures only)
Adjusted AFT	80
Asphalt binder content	80
Production air voids	70

*Lowest Pay Factor applies when there are multiple reductions on a single test.

G.14.g Moving Average Failure - Percent Asphalt Binder Content, Gradation, and Adj. AFT

The Engineer will consider the mixture unacceptable and subject to reduced payment for mixture properties, including asphalt binder content and gradation, where the moving average of four exceeds the JMF limits. The Department may reduce payment for unacceptable mixture properties in accordance with Table 2360-18, "Reduced Payment Schedule for Moving Average Test Results." The Department will calculate the quantity of material subject to replacement or reduced payment as the tons placed from the sample point of all individual test results beyond the JMF limits, which contributed to the moving average value that exceeded the JMF limit, to the sampling point when the individual test result is back within the JMF limits. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subjected to reduced payment.

The Engineer will calculate the Moving Average (n=4) Adjusted AFT during the sixth test after the beginning of mixture production of that specific mixture. The Engineer will include the individual results of calculations for tests No. 3, No. 4, No. 5, and No. 6 with this calculation. The Department will consider material with the Moving Average (n=4) of the Adjusted AFT is less than 8.0 µ as unsatisfactory and will pay for the material at 80 percent of the relevant contract unit price. The Department will calculate the quantity of material subject to replacement or reduced payment as the tons placed from the sample point of all Individual Adjusted AFT results less than 8.0µ, which contributed to the Moving Average value that was less than 8.0µ, to the sample point where the Individual Adjusted AFT is at least 8.0µ. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subject to reduced payment.

G.14.h Coarse and Fine Aggregate Crushing Failure

If any CAA or FAA test results do not meet the requirements specified in Table 3139-3, the Department may reduce payment for the placed material in accordance with Table 2360-16, "Reduced Payment Schedule for Individual Test Results." The Department will calculate the quantity of material subject to reduced payment as the tons placed from the sample point of the failing test until the sampling point where the test result meets the specifications. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subjected to reduced payment.

2360.3 CONSTRUCTION REQUIREMENTS

A Restrictions

A.1 Asphalt Release Agents

Do not use petroleum distillates to prevent adhesion of asphalt mixtures to equipment. An asphalt release agent must meet the criteria for "Effect on Asphalt" as described in the most recent Asphalt Release Agent on file in MnDOT's Office of Environmental Services.

A.2 Edge Drop Off

When construction is under traffic, the requirements of 2221.3.D will apply.

A.3 Surge and Storage Bins

Store the asphalt mixture for no more than 18 h at storage facilities that prevent segregation of the mix and drainage of asphalt from the mix. Maintain the mixture at within 9 °F [5 °C] of the temperature when discharged from the silo or mixer and prevent excessive cooling or overheating.

A.4 Weather Limitations and Paving Date

Do not perform work within the roadway in the spring until removal of seasonal load restrictions on roads in the vicinity unless otherwise approved by the Engineer.

Do not place asphalt mixtures when weather or roadbed conditions or moisture conditions of the roadway surface are judged unfavorable by the Engineer.

Do not place asphalt pavement final wearing course lift after October 15 north of an east-west line between Browns Valley and Holyoke, or after November 1 south of an east-west line between Browns Valley and Holyoke.

The Engineer may waive these restrictions when:

(1) The Contractor is not placing asphalt mixture on the traveled portion of the roadway,
(2) The roadway involved is closed to traffic during the following winter, or
(3) The Engineer provides written direction to place the mixture.

A.5 Mixing and Discharge of Materials

Notify the Engineer of the recommended plant mixing temperatures as provided from the asphalt supplier. Unless authorized by the Engineer, do not produce the mixture more than 30°F above the recommended maximum mixing temperature. Use the automated plant control printout to monitor discharge temperature. The Department will not pay for or allow placement of any mixture produced at more than 30°F above the recommended maximum mixing temperature unless the higher mixing temperatures have been approved by the Engineer.

B Equipment

B.1 Plant

B.1.a Segregation

Provide plant mixed asphalt from a plant capable of producing a uniform mix free of segregation.

B.1.b Scales

Test and calibrate scales in accordance with 1901.

B.1.c Mineral Filler

Add mineral filler to the mixture using a storage silo equipped with a device to ensure a constant and uniform feed.

B.1.d Storage Tanks

Provide storage tanks equipped to heat and maintain the material at the temperatures recommended by the certified asphalt supplier. Place the discharge end of the circulating line below the surface of the asphalt material. Provide agitation for modified asphalt as recommended by the supplier.

Provide an outage table or chart and measuring stick for each storage or working tank. Equip tanks with provisions to take asphalt binder material samples. After delivery of asphalt binder material to the project, do not heat the material at temperatures greater than 350° F [175° C]. Do not store modified asphalt at temperatures greater than the manufacturer's recommendation.

B.1.e Asphalt Binder Control

If proportioning asphalt binder material by volume, equip the plant with either a working tank or a metering system to determine asphalt binder content of the mixture.

Provide a working tank with a capacity from 1,000 gal to 2,000 gal [3,800 L to 7,600 L]. Calibrate and supply the working tank with a calibrated measuring stick. The Contractor may connect the tank to a mixing unit and use it only during spot check operations as long as it is available at all times. Return feedback to the working tank during spot check operations.

Provide a metering system with at least one approved asphalt binder flow meter and an asphalt binder pump. Connect the flow meter to the asphalt binder supply to measure and display only the asphalt binder being fed to the mixer unit. Position the meter readout for convenient observation. Provide a means to compare the flow meter readout with the calculated output of the asphalt binder pump. Provide a system to display that shows the accumulated asphalt binder quantity being delivered to the mixer in gallons [liters] or to the nearest 0.001 ton [0.001 tonne]. Calibrate and adjust the system to maintain an accuracy of ±1 percent error for each plant set-up before producing the mixture.

Provide an outage table or chart and measuring stick for each storage or working tank. Equip tanks with provisions to take asphalt binder material samples. After delivery of asphalt binder material to the project, do not heat the material at temperatures greater than 350° F [175° C]. Do not store modified asphalt at temperatures greater than the manufacturer's recommendation.

B.1.e (1) Asphalt Binder Sampling Valve

Provide an asphalt binder sampling valve located between the pump and the drum. Sample asphalt binder from the weigh pod for batch plants.

B.1.f Dryer

The Department will not allow unburned fuel in the mix.

B.1.g Temperature Control
Equip the plant with enough temperature sensors to ensure temperature control of the aggregate and asphalt binder.

B.1.h Pollution 1717

B.2 Street Equipment

B.2.a Paver
Provide a paver capable of spreading and finishing to widths as shown on the plans and with an operational vibratory screed and automatic screed control to place mix without segregation.

Use an asphalt paver to place the mixture. When necessary, the Contractor may use a motor grader, when approved by the Engineer, to spread mixtures in areas that are inaccessible to a paver or when the quantity of mixture makes it impractical to place with a paver.

Use a shouldering machine to spread the mixture on shoulder surfacing and uniform width widening, when the placement width is too narrow for a paver.

Using a screed or strike-off assembly, produce a finished surface of the required evenness and texture without tearing, shoving, or gouging. For mainline paving, if the paving width is greater than the basic screed, auger and mainframe extensions, which meet manufacturer's recommendations for the paving width, are required unless otherwise directed by the Engineer. The Department will not allow strike-off only extension assemblies for mainline wearing course paving, unless the Engineer directs otherwise.

Equip all pavers with an approved automatic screed control. Sensor-operated devices need to include automatic controls that follow reference lines, or surfaces on one or both sides of the paver as required. Adjust the speed of the paver to produce the best results. A string line is only required if stated in the contract.

Spread all mixtures without segregation to the cross sections shown on the plans (excluding tight blade and scratch course applications) . The objective on the leveling layer is to secure a smooth base of uniform grade and cross section so that subsequent courses will be uniform in thickness. The Contractor may spread the leveling layer with a properly equipped paver or, when approved by the Engineer, a motor grader equipped with a leveling device or with other means for controlling the surface elevation of the leveling layer.

Place each course over the full width of the section under construction on each day's run, unless the Engineer directs otherwise.

B.2.b Trucks
Provide trucks with tight, clean, and smooth truck haul beds. Do not allow mixture to adhere to the truck beds. When directed by the Engineer, provide a cover that extends at least 1 ft [300 mm] over the truck bed sides and attach to tie-downs, if the truck is not equipped with a mechanical or automated covering system.

B.2.c Motor Graders
Use a motor grader with the following characteristics:

(1) Self-propelled,
(2) Equipped with pneumatic tires with a tread depth of ½ in [13 mm] or less,
(3) Equipped with a moldboard blade that is at least 10 feet [3 m], and
(4) With a wheelbase of at least 15 feet [4.5 m].

B.2.d Distributor
Provide a distributor capable of uniformly applying material up to 15 ft [4.6 m] wide and equipped with the following:

(1) An accurate volume measuring device with tachometer,
(2) Pressure gauges,
(3) Thermometer for measuring temperatures of tank contents,
(4) Power-operated pump, and
(5) Full circulation spray bars with lateral and vertical adjustments.

B.2.e Rollers
Compact each lift of asphalt to the density require in 2360.3.D, "Compaction."

B.2.e(1) Steel-Wheeled Rollers
Self-propelled steel wheeled compacting equipment must weigh at least 8 ton [7.3 tonne]. If using vibratory rollers, provide rollers that produce 3,085 lbf per ft [45 kN per m] of width and a vibratory frequency of at least 2,400 vpm using the low amplitude setting. Provide a roller capable of reversing without backlash and equipped with spray attachments for moistening rollers on both sets of wheels.

B.2.e(2) Pneumatic Tired Rollers

Self-propelled pneumatic tired compacting equipment must have a compaction width of at least 5 ft [1.5 m] and a gross wheel load force of at least 3,000 lb [13 kN] per wheel for traffic level 2 and level 3 mixtures, 5,000 lb [22 kN] per wheel for traffic level 4 and level 5 mixtures, and, if using vibratory, at least 8 ton [7.3 tonne] total mass. Provide a roller with a tire arrangement that obtains full compaction over the full width with each pass of the roller.

B.2.e(3) Trench Rollers

Self-propelled trench rollers must weigh at least 2,960 lb per foot [4,400 kg per meter] of width.

B.3 Tack Coat

Apply a uniform asphalt tack coat to the clean and dry existing asphalt or concrete surface and to the surface of each course or lift constructed, except for the final course or lift, in accordance with 2357. Coat the contact surfaces of all fixed structures and the edge of the inplace mixture in all courses at transverse joints and in the wearing course at longitudinal joints. Do not coat the longitudinal joint if a rubberized asphalt joint adhesive will be applied to the vertical face of the joint. A uniform application will not have streaks (corn rows), bare spots, puddles, or other irregular patterns. Allow emulsified asphalt tack coats to break, as indicated by a color change from brown to black, before placing subsequent lifts. Take tack samples from the asphalt distributor according to rates provided in the Material Control Schedule. The Inspector will monitor the sampling the Contractor performs.

C Joints

C.1 Construction Joints

Compact joints to produce a neat, tightly bonded joint that meets surface tolerances as described in 2360.3.E. Transverse and longitudinal joints are subject to the density requirement in accordance with 2360.3.D, "Compaction."

C.2 Transverse Joints

Construct a transverse joint, the full width of the paver, at right angles to the centerline when mixture placement operations are suspended. When work resumes, cut the end vertically for the full depth of the layer unless constructing a formed edge as approved by the Engineer.

C.3 Longitudinal Joint

Construct the longitudinal joint between strips and parallel to the pavement centerline. In multiple lift construction, construct the longitudinal joints between strips in each lift at least 6 in [150 mm] measured transversely from the longitudinal joints in the previously placed lift. If constructing a wearing course in an even number of strips, place one longitudinal joint on the centerline of the road. When constructing a wearing course in an odd number of strips, locate the centerline of one strip on the centerline of the road, provided that no joint is located in the wheel path area of a traffic lane. The Contractor will align longitudinal joints in multiple lift construction over portland cement concrete pavements directly over the concrete pavement longitudinal joints as approved by the Engineer.

At longitudinal joints formed by placing multiple strips, ensure the adjoining surface is higher but does not exceed ⅛ in [3 mm], after final compaction of the previously placed strip. When constructing a strip adjoining a previously placed strip or a concrete pavement, remove to the longitudinal joint line, any fresh mixture that overlaps a previously placed strip or pavement before rolling.

D Compaction

After spreading each course, compact in accordance with the maximum density method as described in 2360.3.D.1, unless the ordinary compaction method is called for in the special provisions or as described in 2360.3.D.2, "Ordinary Compaction." Do not allow rollers to stand on the uncompacted mixture or newly rolled pavement with a surface temperature greater than 140 °F [60 °C]. Do not roll with steel-wheeled rollers if rolling produces aggregate that is crushed, cracked, or pulverized or causes displacement of the mixture.

To maintain a true surface, correct the following by removing and replacing the material in the defective areas as directed by the Engineer at no additional cost to the Department:

(1) Variations such as depressions or high areas, which may develop during rolling operations; and
(2) Lean, fat, or segregated areas.

When spreading mixtures with a motor grader, compact the mixture with pneumatic tired rollers simultaneously with the spreading operation.

D.1 Maximum Density

Compact the pavement to at least the minimum required maximum density values in accordance with Table 2360-19, "Required Minimum Lot Density (Mat)," and Table 2360-20, "Longitudinal Joint Density Requirement." Density evaluation will include compacted mat density and compacted longitudinal joint density. Density evaluation will not include longitudinal joint density on lifts with a 1 percent reduced density requirement.

Table 2360-19 Required Minimum Lot Density (Mat)				
			SP Shoulders* ‖	
	SP Wear Mixtures* ‖	SP Non-Wear Mixtures* ‖	Designed at 3% Voids	Designed at 4% voids
% Gmm	92	93	93	92

* Reduce the minimum by 1 percent on the first lift constructed over PCC pavements.

‖ Reduce the minimum by 1 percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold in place recycled base courses and first lift of an overlay on roadway with a spring load restriction no greater than 7 ton [6.35 tonne], including shoulders.

Table 2360-20 Longitudinal Joint Density Requirement		
Location	Confined Edge of Mat*	Unconfined Edge of Mat ‖
Long joint wear and shoulder (4% air voids)	89.5	88.1
Long joint non-wear and shoulder (3% air voids)	90.5	89.1

* The Department defines "confined" as the edges of the placed mat abutting another mat, pavement surface, or curb and gutter.

‖ The Department defines "unconfined" or "unsupported" as no abutment on the side of the mat being placed with another mat or pavement surface.

D.1.a Shoulders Greater Than 6 ft [1.8 m]

Unless otherwise shown on the plans or required by the special provisions, compact shoulders wider than 6 ft [1.8 m] paved using the maximum density method. When shoulders are compacted by the maximum density method and are paved separately from the driving lane, or have a different required minimum density than the driving lane, delineate the lot tonnage placed on the shoulder in separate lots from the driving lanes for the day paving was conducted.

D.1.b Shoulders Equal to or Less Than 6 ft [1.8 m]

Unless otherwise shown on the plans or required by the special provisions, use the ordinary compaction method in accordance with 2360.3.D.2 to compact a narrow shoulder no wider than 6 ft [1.8 m] paved in the same pass as a driving lane or paved separately. The Department will exclude mixture compacted under ordinary compaction from lot density requirements and from incentive or disincentive payment.

When compacting a narrow shoulder using the maximum density method, compact to densities in accordance with Table 2360-19. If the minimum required density of the shoulder is different than the driving lane, delineate the tonnage placed on the shoulder in separate lots from the driving lane.

D.1.c Echelon Paving

The Department considers echelon paving, two pavers running next to each other in adjacent lanes, as separate operations.

D.1.d Density Determination (Core Bulk Density)

Calculate each individual lot's maximum density by averaging the results of the cores within the lot expressed as the percentage of the maximum specific gravity. Use Laboratory Test Method 1810 to determine core density unless the mixture is considered coarse graded. If 45 percent or less of the aggregate material passes the No. 4 [4.75 mm] sieve the Engineer may require bulk specific gravity be determined in accordance with Laboratory Manual Method 1816, Corelok.

Obtain the maximum specific gravity value for calculating the percentage density for the lot from the maximum gravity values taken from production tests during that day's paving. If the production tests during that day's paving result in only one or two maximum specific gravity values, use the moving average value at that test point. If production tests during that day's paving result in three or more maximum specific gravity values, use the average of those tests alone as indicated above.

D.1.e Timeline

Complete compaction within 8 h of mixture placement and before obtaining core samples. Only use pneumatic tired or static steel rollers for compaction performed between 6 h and 8 h after mixture placement. Do not reroll compacted mixtures with deficient densities.

D.1.f Stop Production

If all the lots in a day's production or greater than 50 percent of the lots on multiple days fail to meet the minimum density requirement stop production and determine the source of the problem. Discuss with the Engineer what corrective action will be taken to bring the work into compliance with specified minimum required density.

D.1.g Lot Determination

Table 2360-21 Lot Determination	
Daily Production, *ton [tonne]*	**Lots**
300* – 600 [270* – 545]	1
601 – 1,000 [546 – 910]	2
1,001 – 1,600 [911 – 1,455]	3
1,601 – 2,600 [1,456 – 2,360]	4
2,601 – 4,600 [2,361 – 4,175]	5
> 4,600 [4,175]	‖

* If producing no greater than 300 ton [270 tonne] of mix, establish the first lot when the total weight is greater than 300 ton [270 tonne].
‖ Add one lot for each additional 900 tons [820 tonne] or part thereof.

D.1.h Mat Density Cores

Obtain four cores in each lot. Take two cores from random locations as directed by the Engineer. Take the third and fourth cores, the companion cores, within 1 ft [0.3 m] longitudinally from the first two cores. Submit the companion cores to the Engineer immediately after coring and sawing. If the random core location falls on a longitudinal joint, cut the core with the outer edge of the core barrel 1 ft [0.3 m] away laterally from the edge of the top of the mat. Do not take cores for compacted mat density within 1 ft [300 mm] of any longitudinal joint. The Contractor is responsible for maintaining traffic, coring, patching the core holes, and sawing the cores to the paved lift thickness before density testing.

The Engineer may require additional density lots to isolate areas affected by equipment malfunction, heavy rain, or other factors affecting normal compaction operations.

D.1.i Contractor Core Testing

Take and test cores at least 4 in [100 mm] in diameter at locations determined and marked by the Engineer.

Mark samples with the lot number and core number or letter. Transport the cores to the laboratory daily taking care to prevent damage to them. Schedule the approximate time of testing during normal project work hours to allow the Engineer to observe the test and to record the saturated surface dry and immersed weight of the cores.

Determine the density by the end of the next working day after compaction. Measure each core three times for thickness before saw cutting. Report the average lift thickness on the core sheet. If placing multiple layers in a single day, saw and separate cores for each layer, test, and report by the end of the next working day. Place and compact mix into the coring hole to restore the surface within 24 h after coring or the Department will fine the Contractor $100 per working day per lot until restored.

D.1.j Companion Core Testing

The Department will select at least one of the two companion cores per lot to test for verification. For lots designated as longitudinal joint density lots, the Department will test at least one of the mat density companion cores and at least one of the longitudinal joint density companion cores.

D.1.k Tolerance Comparison

D.1.k(1) Tolerance Comparison – Individual

Compare the individual core bulk specific gravities obtained by the Contractor and by the Department. If the bulk specific gravity between the Contractor and the Department cores differ by more than 0.030, use the Department's bulk specific gravity.

D.1.k(2) Tolerance Comparison – Day's Shrinking Tolerance

For a second comparison of the cores that pass the individual tolerance criteria, compare the average of the Contractor's bulk specific gravities with the average of the Department's bulk specific gravities. Determine the tolerance by dividing 0.030 by the square root of the number of samples compared. Use all the Department's results for the day's paving if the cores do not fall within the determined tolerance.

D.1.l Recoring

The Engineer may allow the Contractor to re-core a sample if the sample was damaged in the coring process or damaged in transit to the laboratory through no fault of the Contractor.

D.1.m One Percent Reduced Density

The Department will exclude incentive payments for reduced minimum density in accordance with Table 2360-19, "Required Minimum Lot Density (Mat)." The Contractor may elect to waive the reduced density requirement and reevaluate the density in accordance with Table 2360-19, "Required Minimum Lot Density (Mat)," including incentives, for all cases except the first lift constructed over concrete pavement. The Contractor must notify the Engineer, in writing, after the first day's paving and by the end of the third day of paving of their intent to waive reduced density. Once reduced density has been waived the normal maximum density will remain in effect for the duration of mixture placement on that lift. For multi-year projects, the waiving of

reduced density will be for that year only and will be re-evaluated for subsequent years on an annual basis. The Contractor is required to comply with any construction requirements on subsequent lifts.

D.1.n Longitudinal Joint Density

Evaluate longitudinal joint density in one lot per day unless the total daily weight is greater than 5,000 ton [5,000 tonne]. If the total daily weight is greater than 5,000 ton [5,000 tonne], evaluate two lots per day. Randomly select the location to take cores for longitudinal joint density from the mat density core locations. Take six cores at this location. Take cores for longitudinal joint density with the outer edge of the core barrel within 6 in [150 mm] from the edge of the top of the mat for both sides of the mat. Take a companion core 1 ft [0.3 m] longitudinally from each core. Take two cores for mat density at either 2 ft [0.61 m] right or 2 ft [0.61 m] left of the center of the mat the Contractor is paving, regardless of random number generation.

D.1.o Imaginary Joint

An actual longitudinal joint will not exist if pulling the shoulder and driving lane in the same paving pass. Do not cut a core on the imaginary line where a joint would have existed had the shoulder and the drive lane been paved separately.

D.1.p Shoulders

D.1.p(1) Shoulder – Ordinary Compaction

If compacting the shoulder under the ordinary density specification, do not take longitudinal joint cores in shoulders. Core at the centerline longitudinal edge cores (6 in [150 mm] from the joint) and at the mat density cores (2 ft [0.61 m] right or left of the center of the paving pass).

D.1.p(2) Shoulder-Maximum Density Specification

Core at the following locations:

(1) Centerline longitudinal edge cores (6 in [150 mm] from the joint),
(2) Mat density cores (2 ft [0.61 m] right or left of the center of the paving pass), and
(3) Edge of the shoulder (6 in [150 mm] from the outside edge).

Do not cut cores on the imaginary line at the edge of the shoulder adjacent to the driving lane. Move coring locations on imaginary lines to 6 in [150 mm] inside the edge of the shoulder.

D.1.q Payment Schedule

Table 2360-22
Payment Schedule for Maximum Mat Density

SP Wear and SP Shoulders (4% Void) Density, %*	SP Non-Wear and SP Shoulders (3% Void), Density, %*	Mat Density Pay Factor A	
		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 93.6	≥ 94.6	1.03‖	1.05‖
93.1 – 93.5	94.1 – 94.5	1.02‖	1.04‖
92.0 – 93.0	93.0 – 94.0	1.00	1.00
91.0 – 91.9	92.0 – 92.9	0.98	0.98
90.5 – 90.9	91.5 – 91.9	0.95	0.95
90.0 – 90.4	91.0 – 91.4	0.91	0.91
89.5 – 89.9	90.5 – 90.9	0.85	0.85
89.0 – 89.4	90.0 – 90.4	0.70	0.70
< 89.0	< 90.0	†	†

* Calculate the percent of maximum specific gravity to the nearest tenth.

‖ Payment will only apply if the day's weighted average individual production air voids fall within - ½ percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2.G.7, "Production Tests" for the corresponding day and weight by the tons the corresponding test represents.

† The Department will pay for the HMA material represented by the lot at 70 percent of the relevant contract unit price; unless a single core density in the lot is less than 87.0 percent of the maximum specific gravity (G_{mm}). If a single core density is less than 87.0 percent of Gmm, the Engineer will decide if the mixture is subject to removal and replacement or if will be accepted at a reduced payment of 50 percent of the relevant contract unit price. If the Engineer decides the material is to be removed and replaced, the Contractor will do so at no additional cost to the Department. Take additional core samples to determine the limits of the removal and replacement area or 50% payment using the same offset from centerline as the original core. If the original low density core was taken within 1½ ft [0.45 m] of an edge of the paver pass, take the additional cores at 1½ ft [0.45 m] from the edge of the paver pass. Determine the densities at 50 ft [15 m] intervals both ahead and behind the point of unacceptable core density until finding a point of acceptable core density (>89.0% for 4% void and 1% reduced voids and >90.0% for 3% voids). If the 50 ft (15 m) incremental testing extends into a previously accepted lot, removal and replacement may be required, but, these results will not be used to recalculate the previously accepted lot density.

Perform the additional coring and testing at no cost to the Department. The Department will calculate the area of unacceptable pavement as the product of the longitudinal limits as determined by the 50 ft [15 m] cores and the full width of the paver pass, laying in the traffic lane or lanes. The Department will exempt shoulders from this calculation unless density failure occurred in the shoulder area.

Establish an additional density lot for the pavement that has been removed and replaced. Cut 2 cores randomly with companions for the Department (total 4 cores) and determine average density. Make payment in accordance with Table 2360-22 or Table 2360-23 excluding any incentive payment.

Determine the density for the remainder of the lot by averaging the original acceptable core density value with the first two acceptable core densities taken ahead and behind the unacceptable core density. Make payment in accordance with Table 2360-22 or Table 2360-23 excluding any incentive payment.

Table 2360-23* 1 Percent Reduced Table		
SP Wear and SP Shld (4% Void) Maximum Specific Gravity, %‖	**SP Non-Wear, and SP Shld (3% Void), Maximum Specific Gravity, %‖**	**Payment, %**
≥ 91.0	≥ 92.0	100
90.0 – 90.9	91.0 – 91.9	98
89.7 – 89.9	90.5 – 90.9	95
89.4 – 89.6	90.0 – 90.4	91
89.2 – 89.3	89.5 – 89.9	85
89.0 – 89.1	89.0 – 89.4	70
< 89.0†	< 89.0	†

* Reduce the minimum by 1 percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold inplace recycled base courses and first lift of an overlay on a roadway with a spring load restriction (including shoulders) no greater than 7 ton [6.35 tonne]. Reduce the minimum by 1 percent on the first lift constructed on PCC pavements (reduced density cannot be waived on PCC).

‖ Calculate the percent of maximum specific gravity to the nearest tenth.

† The Department will pay for the HMA material represented by the lot at 70 percent of the relevant contract unit price; unless a single core density in the lot is less than 87.0 percent of the maximum specific gravity (G_{mm}). If a single core density is less than 87.0 percent of Gmm, the Engineer will decide if the mixture is subject to removal and replacement or if will be accepted at a reduced payment of 50 percent of the relevant contract unit price. If the Engineer decides the material is to be removed and replaced, the Contractor will do so at no additional cost to the Department. Take additional core samples to determine the limits of the removal and replacement area or 50% payment using the same offset from centerline as the original core. If the original low density core was taken within 1½ ft [0.45 m] of an edge of the paver pass, take the additional cores at 1½ ft [0.45 m] from the edge of the paver pass. Determine the densities at 50 ft [15 m] intervals both ahead and behind the point of unacceptable core density until finding a point of acceptable core density (>89.0% for 4% void and 1% reduced voids and >90.0% for 3% voids). If the 50 ft (15 m) incremental testing extends into a previously accepted lot, removal and replacement may be required, but, these results will not be used to recalculate the previously accepted lot density. Perform the additional coring and testing at no cost to the Department. The Department will calculate the area of unacceptable pavement as the product of the longitudinal limits as determined by the 50 ft [15 m] cores and the full width of the paver pass, laying in the traffic lane or lanes. The Department will exempt shoulders from this calculation unless density failure occurred in the shoulder area.

Establish an additional density lot for the pavement that has been removed and replaced. Cut 2 cores randomly with companions for the Department (total 4 cores) and determine average density. Make payment in accordance with Table 2360-22 or Table 2360-23 excluding any incentive payment.

Determine the density for the remainder of the lot by averaging the original acceptable core density value with the first two acceptable core densities taken ahead and behind the unacceptable core density. Make payment in accordance with Table 2360-22 or Table 2360-23 excluding any incentive payment.

Table 2360-24* Payment Schedule for Longitudinal Joint Density (SP Non-wear and SP Shoulders, 4% Void)					
Longitudinal Joint (Confined Edge) Density, %‖	**Pay Factor B Longitudinal (Confined Edge)**		**Longitudinal Joint (Unsupported Edge) Density, %‖**	**Pay Factor C (Unsupported Edge)**	
	Traffic Level 2 & 3	Traffic Level 4 & 5		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 92.1	1.02†	1.03†	≥ 91.0	1.02†	1.03†
91.6 – 92.0	1.01†	1.02†	90.1 – 90.9	1.01†	1.02†
89.5 – 91.5	1.00	1.00	88.1 – 90.0	1.00	1.00
88.5 – 89.4	0.98	0.98	87.0 – 88.0	0.98	0.98
87.7 – 88.4	0.95	0.95	86.0 – 86.9	0.95	0.95
87.0 – 87.6	0.91	0.91	85.0 – 85.9	0.91	0.91
< 87.0	0.85	0.85	< 85.0	0.85	0.85

* The Department will limit incentive payment for longitudinal joint density to lots with evaluated longitudinal joint densities.

‖ Calculate the percent of maximum specific gravity to the nearest tenth.

† Payment will only apply if the day's weighted average individual production air voids fall within - ½ percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2.G.7, "Production Tests" for the corresponding day and weight by the tons the corresponding test represents.

Table 2360-25*
Payment Schedule for Longitudinal Joint Density
(SP Non-wear and SP Shoulders, 3% Void)

Longitudinal Joint (Confined Edge) Density, % ‖	Pay Factor B Longitudinal (Confined Edge)		Longitudinal Joint (Unsupported Edge) Density, % ‖	Pay Factor C (Unsupported Edge)	
	Traffic Level 2 & 3	Traffic Level 4 & 5		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 93.1	1.02†	1.03†	≥ 92.0	1.02†	1.03†
92.6 – 93.0	1.01†	1.02†	91.1 – 91.9	1.01†	1.02†
90.5 – 92.5	1.00	1.00	89.1 – 91.0	1.00	1.00
89.5 – 90.4	0.98	0.98	88.0 – 89.0	0.98	0.98
88.7 – 89.4	0.95	0.95	87.0 – 87.9	0.95	0.95
88.0 – 88.6	0.91	0.91	86.0 – 86.9	0.91	0.91
< 88.0	0.85	0.85	< 86.0	0.70	0.85

* The Department will limit incentive payment for longitudinal joint density to lots with evaluated longitudinal joint densities.
‖ Calculate the percent of maximum specific gravity to the nearest tenth.
† Payment will only apply if the day's weighted average individual production air voids fall within ½ percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2.G.7, "Production Test" for the corresponding day and weight by the tons the corresponding test represents.

D.1.r Pay Factor Determination

Determine the pay factor in accordance with the following:

(1) Case 1: Total Pay Factor = (Pay Factor A) × (Pay Factor B) × (Pay Factor C)
(2) Case 2: Total Pay Factor = (Pay Factor A) × (Pay Factor B) × (Pay Factor B)
(3) Case 3: Total Pay Factor = (Pay Factor A) × (Pay Factor C) × (Pay Factor C)

Where:
Pay Factor A = Mat density,
Pay Factor B = Confined edge density,
Pay Factor C = Unsupported edge density.

Use a pay factor of 1.00 for Pay Factor B, Pay Factor C, or both in lots where no cores are taken at the longitudinal joint.

D.2 Ordinary Compaction

Perform ordinary compaction for the following:

(1) Layers identified in the typical sections with a minimum planned thickness less than 1½ in [40 mm],
(2) Thin lift leveling,
(3) Wedging layers,
(4) Patching layers,
(5) Driveways, and
(6) Areas the Contractor cannot compact with standard highway construction equipment and practices.
(7) Bike paths, walking paths, and other similar non-traffic paving areas

If using the ordinary compaction method to evaluate density, use a control strip to establish a rolling pattern. Use the rolling pattern to compact the asphalt mixture for the layer on which the control strip is constructed or until constructing a new control strip. The Engineer may waive the control strip requirement in small localized areas or other areas not conducive to its establishment.

D.2.a Control Strip

Construct a control strip at least 395 sq. yd [330 sq. m] and of the same thickness as the lift the control strip represents at the beginning of the work on each lift of each course. Begin compacting immediately after spreading the mixture. Continue compacting until additional roller coverage does not produce appreciable increase in density. Determine densities by means of a portable nuclear testing device or approved alternate and create a growth curve to determine the optimum rolling pattern. Provide documentation of the growth curve to the Engineer. Roll the remainder of that course in accordance with the pattern developed in the test strip for that roller. Provide a new control strip in accordance with the following:

(1) If using a new JMF with a proportion change greater than 10 percent when compared to the currently produced mixture for a single stockpile aggregate,
(2) If changing the source of either aggregate or binder, or
(3) After 10 days of production.

D.2.b Equipment

Use rollers that meet the requirements in 2360.3.B.2.e. Use the same equipment type and weight on the remainder of the pavement course that was used to construct the control strip. Provide at least two rollers. Provide a tandem steel wheeled roller for final rolling. The Contractor may use trench rollers or mechanical tampers to compact areas inaccessible to the conventional type rolling equipment.

D.2.c Mixture Temperature

Refer to Table 2360-26, "Minimum Temperature Control" for the minimum laydown temperatures in all courses of the asphalt mixture as measured behind the paver or spreading machine. Do not pave when the air temperature is less than 32° F [0° C] unless otherwise directed by the Engineer in writing.

Table 2360-26*
Minimum Temperature Control

Air Temperature, *°F [°C]*	Compacted Mat Thickness, †			
	1 in [25 mm]	**1½ in [40 mm]**	**2 in [50 mm]**	**≥3 in [75 mm]**
32 – 40 [0-5]	—	265[129] ‖	255 [124]	250 [121]
41 – 50 [6-10]	270 [130] ‖	260 [127]	250 [121]	245 [118]
51 – 60 [11-15]	260 [127] ‖	255 [124]	245 [118]	240 [115]
61 – 70 [16-21]	250 [121] ‖	245 [118]	240 [115]	235 [113]
71 – 80 [22-27]	245 [118]	240 [115]	235 [113]	235 [113]
81 – 90 [28-32]	235 [113]	230 [110]	230 [110]	230 [110]
≥ 91 [33]	230 [110]	230 [110]	230 [110]	225 [107]

* Not applicable if using a Warm Mix Asphalt (WMA) additive or process
‖ Use at least one pneumatic-tire roller for intermediate rolling unless otherwise directed by the Engineer. The Engineer may specify or modify the minimum laydown temperature in writing.
† Based on the lift thicknesses shown on the plans.

D.3 Mat Density Cores (Optional Department Only Core Testing)

The Contractor can request all density cores be tested by the Department. The written request should be made at the pre-construction meeting and a written response, from the Department, either approving or denying the request will be made within 5 calendar days from the date of the request. Once approval is granted, Department Only Core Testing will remain in effect for the duration of the project. For multi-year projects, Department core testing will be for that year only. Cores will be tested in either the Department's Field Lab or in the Contractor's Field Lab. The Contractor is permitted to observe and record all weighing of the cores.

D.3.a Contractor Coring Responsibilities

Obtain two cores in each lot. Take cores of at least 4 in [100 mm] in diameter at locations determined and marked by the Engineer. If the random core location falls on a longitudinal joint, cut the core with the outer edge of the core barrel 1 ft [0.3 m] away laterally from the edge of the top of the mat. Do not take cores for compacted mat density within 1 ft [300 mm] of any longitudinal joint. Label samples with the lot number and core number or letter. The Contractor is responsible for maintaining traffic, coring, patching the core holes.

Measure each core three times for thickness before saw cutting. Report the average lift thickness to the Engineer. If placing multiple layers in a single day, measure and record lift thickness and then saw and separate cores for each layer. Place and compact mix into the coring hole to restore the surface within 24 h after coring or the Department will fine the Contractor $100 per working day per lot until restored.

The Engineer may require additional density lots to isolate areas affected by equipment malfunction, heavy rain, or other factors affecting normal compaction operations.

D.3.b Department Testing Responsibilities

The Department will take possession of the cores after they have been measured and cut. The Department will test all cores. Density results will be determined by the end day in which the cores were cut provided they are in the Department's possession by 10:00am, otherwise, results will be available the next working day. Test results will be reported on the Core Density Sheet.

D.3.c Longitudinal Joint Density

Evaluate longitudinal joint density in one lot per day unless the total daily weight is greater than 5,000 ton [5,000 tonne]. If the total daily weight is greater than 5,000 ton [5,000 tonne], evaluate two lots per day. Randomly select the location to take cores for longitudinal joint density from the mat density core locations. Take three cores at this location. Take cores for longitudinal joint density with the outer edge of the core barrel within 6 in [150 mm] from the edge of the top of the mat for both sides of the mat. Take one core for mat density at either 2 ft [0.61 m] right or 2 ft [0.61 m] left of the center of the mat the Contractor is paving, regardless of random number generation.

E Surface Requirements

After compaction, the finished surface of each lift shall be reasonably free of segregated, open and torn sections, and shall be smooth and true to the grade and cross section shown on the plans with the following tolerances:

Table 2360-27
Surface Requirements

Course/Location	Description	Tolerance
Leveling/1st lift using automatics	Tolerance also applies to 1st lift placed other than leveling when automatics are used.	½ in [15 mm]
Wear	Tolerance of final 2 lifts from the edge of a 10 foot [3 m] straightedge laid parallel to or at right angles to the centerline.	¼ in [6 mm]
Shoulder Wear, Temporary Wear & bypasses	Tolerance from the edge of a 10 foot [3 m] straightedge laid parallel to or at right angles to the centerline.	¼ in [6 mm]
Transverse joints/construction joints	Tolerance from the edge of a 10 foot [3 m] straightedge centered longitudinally across the transverse joint. Correction by diamond grinding required when directed by the Engineer.	¼ in [6 mm]
Transverse Slope	Tolerance for surface of each lift exclusive of final shoulder wear.	Not to vary by more than 0.4 % from plans.
Distance from edge of each lift and established centerline.	No less than the plan distance or more than 3 inches [75 mm] greater than the plan distance. The edge alignment of the wearing lift on tangent sections and on curve sections of 3 degrees or less can't deviate from the established alignment by more than 1 inch [25 mm] in any 25 foot [7.5 m] section.	See Description
Final wear adjacent to concrete pavements.	After compaction the final lift wear adjacent to concrete pavements must be slightly higher but not to exceed 1/4" [6mm] than the concrete surface.	See Description
Final wear adjacent to fixed structures.	After compaction the final lift wear adjacent to gutters, manholes, pavement headers, or other fixed structures must be slightly higher but not to exceed 1/4" [6mm] than the surface of the structure.	See Description
Finished surface of each lift.*	Must be free of segregated and open and torn sections and deleterious material. *Excluding tight blade and scratch courses.	See Description

Cut or saw and then remove and replace material placed outside the described limitations at no additional cost to the Department. If the Engineer determines the material can remain in place outside the limits, the Department will pay for the material at a reduced cost of $10 per sq. yd [$12 per sq. m]. The Department will consider any single occurrence of material outside the limitations to have a minimum dimension of at least 1 sq. yd [1 sq. m] in any dimension.

In addition to the list the above the pavement surface must meet requirements of 2399 (Pavement Surface Smoothness) requirements.

E.1 Lift Thickness

After compaction, the thickness of each lift shall be within a tolerance of ¼ in [6 mm] of the thickness shown on the plans, except that, if automatic grade controls are used, this thickness requirement will not apply to the first lift placed. This thickness requirement will not apply to a leveling lift whether or not automatic grade controls are required. The Engineer may require removal and replacement of any part of any lift that is constructed to less than the minimum required thickness, at no additional cost to the Department.

Measure cores taken for density determination for thickness also. Measure each core three times for thickness before sawing. Report the average of these three measurements. Document each lot's average core thickness and submit to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The Engineer will use the average of all core thickness measurements per day per lift to determine daily compliance with thickness specifications.

On that portion of any lift constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the lift to the plan thickness plus ¼ in [6 mm] may be excluded from the pay quantities or at the discretion of the Engineer and at the Contractor's expense may be required to be removed and replaced.

F Asphalt Mixture Production (FOB Department Trucks)

Produce asphalt mixture for the Department. Load the mixture being produced onto Department furnished trucks at the mixing plant at a time agreed on by the Engineer and Contractor. The Engineer will notify the Contractor of the total quantity of mixture required not less than 2 weeks prior to completion of the final wearing course. The Engineer will not accept the asphalt mixture if it is unsuitable for the intended use.

G Small Quantity Paving

A MDR is not required for planned project quantities less than 9,000 sq. yd inches (4,500 sq. yd per 2-inch thickness, etc) [191,200 m^2 mm] or 500 ton [450 tonne]. Verify in writing that the asphalt mixture delivered to the project meets the requirements of Table 3139-3 and Table 2360-7, "Mixture Requirements." The Department will obtain samples, as determined by the Engineer, to verify mixture requirements and to perform material acceptance in accordance with 2360.2.G.14.b, "Isolated Failures at Mixture Start-Up — Production Air Voids," 2360.2 G.14.c, "Individual Failure — Gradation, Percent Asphalt Binder, Production Air Voids, and Adj. AFT," and 2360.2.G.14.h, "Coarse and Fine Aggregate Crushing Failure."

2360.4 METHOD OF MEASUREMENT

When paying for material by weight, the Engineer will measure separately asphalt mixture of each type by weight based on the total quantity of material hauled from the mixing plant. The Engineer will not make deductions for the asphalt materials.

When paying for material by area, the Engineer will separately measure asphalt mixture of each type and for each specific lift by area and by thickness on the basis of actual final dimensions placed.

2360.5 BASIS OF PAYMENT

The contract unit price for asphalt mixture used in each course includes the cost of constructing the asphalt surfacing and providing and incorporating asphalt binder, mineral filler, hydrated lime. Anti-stripping additives may be permitted or required as indicated in 2360.2.C.

The Department will pay for additives required by the contract at the relevant contract unit price for the mixture. The Department will pay for additives incorporated as directed by the Engineer as extra work in accordance with 1402.5, "Extra Work."

The Department will apply reduced payment if the mixture includes steel slag as one of the aggregate proportions and the production lab density at the design gyrations at the recommended or established asphalt content is greater than 160 lb per cu. ft [2,565 kg per cu. m]. The Department will pay for the mixture at the contract unit price, calculated as follows:

$$\%Payment = \frac{100 - (100 \times (production_density_at_design_gyrations - 160)}{160}$$

$$\left[\%Payment = \frac{100 - (100 \times (production_density_at_design_gyrations - 2{,}565)}{2{,}565}\right]$$

If the plans do not show a contract pay item for shoulder surfacing and other special construction, the Department will include payment for the quantities of material used for these purposes in the payment for the wearing course materials.

Complete yield checks and monitor thickness determinations to construct the work as shown on the plans. Use the tolerances for lift thickness in accordance with 2360.3.E, "Surface Requirements" and surface smoothness requirements in accordance with 2399 for occasional variations and not for continuous over-running or under-running, unless otherwise required by the Engineer.

The contract unit price for asphalt mixture production includes the cost of the material and loading onto Department-provided trucks at the mixing plant.

The Department will pay for plant mixed asphalt pavement on the basis of the following schedule:

Item No.:	Item:	Unit:
2360.501	Type SP* Wearing Course Mixture †‡	ton [metric ton]
2360.502	Type SP* Non-Wearing Course Mixture †‡	ton [metric ton]
2360.503	Type SP*‖ Course Mixture †‡# in [mm] thick,	square yard [square meter]
2360.504	Type SP*‖ Course Mixture †‡	square yard [square meter]
2360.505	Type SP * Bituminous Mixture for Specified Purpose	ton [metric ton]
2360.506	Type SP * Bituminous Mixture Production	ton [metric ton]

* Aggregate size Designation, 9.5, 12.5 or 19 as appropriate, see 2360.1.A.3.
‖ "Wearing" or "Non Wearing" as appropriate.
† Traffic level in accordance with Table 2360-1, "Traffic Levels."
‡ AC binder grade designation (Table 2360-2).
\# Lift thickness shown on the plans.

2363 PERMEABLE ASPHALT STABILIZED STRESS RELIEF COURSE (PASSRC) AND PERMEABLE ASPHALT STABILIZED BASE (PASB)

2363.1 DESCRIPTION

PASSRC is typically constructed on the in place concrete or bituminous surface to act as a separation layer and move water rapidly from beneath the unbonded concrete overlay.

PASB is typically constructed on a prepared base under a new concrete or bituminous surface to quickly drain surface infiltrated water accumulating under the pavement.

2363.2 MATERIALS

A Aggregate.

Use MnDOT 3139.3.

B Asphalt Binder

Use MnDOT 3151.A (PG 64-22)

C. Mixture Design

C.1 Sample Submittal

At least 15 days prior to the beginning of mixture production, submit representative samples of aggregate and the asphalt binder to perform the PASSRC or PASB mix design in District Materials Lab where the project is located. Submit aggregates that require magnesium sulfate soundness at least 30 days prior to the start of asphalt production.

C.2 Aggregate

1. Submittal. Submit to the District Materials Engineer an 80 lb [35 kg] sample of aggregate retained on the #4 [4.75 mm] sieve and 35 lb [15 kg] of aggregate passing the #4 [4.75 mm] sieve. The Contractor will obtain and store an equal size sample until the Mixture Design Report (MDR) is issued.
2. Intent to Sample. Provide the agency with 24 hour advance notification.
3. Testing. Test for the quality of each source, class, type and size of virgin and non-asphaltic salvage aggregate source will be done for the mix design.

C.3 Asphalt Binder

1. Submittal. Submit 4- 1 quart [1.0 L] samples of the same PG grade as required and also from the same supplier as production will come from.

C.4 Mixture

Provide the proposed Job Mix Blend for each combination of aggregates to be used in the mixture. Include the following information:

1. Composite gradation. Based on the proportions of each material, determine the composite gradation in percent of total aggregates.
2. Individual gradation. Determine the gradation for each individual component.
3. Source. Document the aggregate source, pit number, and a description of all materials.

C.5 Mixture Design Report (MDR)

The Engineer will issue an MDR when the mixture design is successfully completed. The MDR will include the Job Mix Formula (JMF) requirements for gradation and asphalt cement content. Paving without an MDR is not allowed.

D. Mixture Quality Management.

D.1 Sampling and Testing

Production sampling and testing rates for start-up and production are shown in the Schedule of Materials Control (MCS). Take aggregate quality samples as directed by the Engineer. Sample the following items in accordance with the MCS:

1. Gradation.
2. Coarse Aggregate Angularity
3. Asphalt Content

D.2 Documentation

Include the following production test rests, and mixture on the Department approved Test Summary sheet.

1. Gradation. Sieves listed in 3139.3.B
2. Coarse aggregate angularity
3. Percent asphalt binder content (spot check).

4. Aggregate proportions in use at the time of sampling
5. Tons where sampled
6. Cumulative tons.
7. Tons represented by test
8. Signature Line for Agency and Contractor Representative.
9. MnDOT verification sample test result.

D.3 JMF Limits

The mixture production targets and JMF limits, as shown in Table 2363-1, are listed on the MDR. Field results may deviate from the JMF target; however, JMF limits as show below are used as the specification limits for acceptance.

Table 2363-1
JMF Limits

Item	JMF Limits
Gradation	Gradation Broadband
Asphalt Binder Content	-0.4%

2363.3 CONSTRUCTION REQUIREMENTS

A. Handling and Placement.

1. Mixing and Compaction Temperature. Use binder supplier recommended temperatures. Unless authorized by the Engineer, do not produce the mixture no more than 30°F above the recommended maximum mixing temperature. The Department will not pay for or allow placement of any mixture produced at more than 30°F above the recommended maximum mixing temperature.
2. Rutting of Existing Surface. Equipment used to deliver or place the mixture cannot rut the inplace aggregate base (filter) layer or subgrade, or tear or displace the geotextile if used. Any ruts formed must be repaired and leveled to satisfaction of the engineer, at no cost to the agency, prior to placing the mixture so that water draining through the mixture will not pond and create soft spots in the base/subgrade.

B. Surface Preparation.

Remove loose or deteriorated surfacing and clean the surface by power sweeping and air blasting. Removal of deteriorated areas from joints, cracks, bituminous patched areas, etc. may require air blasting, the use of a small milling machine, or handwork as directed by the Engineer. Air blasting must performed with at least 100 psi [690 kPa] equipment.

C. Maintenance.

The contractor is responsible to maintain the integrity of the PASSRC or PASB until the concrete or bituminous pavement is placed on it. Any deficiencies in thickness, smoothness, or density need to be corrected.

1. Contamination. Keep the PASSRC and PASB and associated drains free of soils or other contaminates. Contaminated material shall be removed and replaced by the Contractor to the satisfaction of the Engineer at no cost to the Department.
2. Drainage. Maintain drainage so water is not allowed to pond in the PASSRC or PASB.
3. Construction Equipment. Concrete hauling units, either loaded or empty are permitted on the PASSRC. Only the paver, rollers, and bituminous haul trucks are only allowed to drive on the PASB. The bituminous haul trucks can only drive on the PASB immediately in front of the paver to unload, and then leave the PASB as soon as the bituminous is unloaded.
4. Density. PASSRC and PASB need to be dense and stable after construction so it will not rut when the overlying pavement is placed.
5. Damage. The contractor will repair the PASB or PASSRC promptly by the Contractor, as directed by the engineer, at no expense to the Agency.

D. BLANK

E. BLANK

F. BLANK

G. Pavement Density.

1. Method. Use MnDOT 2360.3.D.2, Ordinary Compaction Method
2. Temperature. The contractor is advised that it may be necessary to permit the permeable asphalt layer to cool sufficiently before compaction rolling to prevent rutting and shoving. In no case will compaction be allowed at less than 110°F [43°C].
3. Water. Water may not be used to accelerate the cooling process.
4. Rollers. Self-propelled steel wheeled compacting equipment must weigh at least 8 ton [7.3 tonne]. Rollers must be steel wheeled both front and back and capable of reversing without backlash and equipped with spray

attachments for moistening both rollers. Vibratory compaction will **NOT** be allowed. When the mixture placed exceeds 100 tons per hour, at least two rollers must be used. Adequacy of compaction to provide stability will be judged by the Engineer. Over rolling, to the extent that aggregate particles degrade, is not permitted.

H. Verification Testing.

Verification testing will be performed on the Quality Assurance samples for gradation and coarse aggregate angularity. The department will monitor 1 asphalt binder content spotcheck per day. Allowable differences (tolerances) between contractor and MnDOT test results are specified below in Table 2363-2. Substitute the Agency results for acceptance when the tolerance is exceeded.

Table 2363-2
Allowable Differences between Contractor and Department Test Results

Item	Allowable Difference
Coarse Aggregate Angularity, % fractured faces (%P)	15
Asphalt binder content:	
Gradation sieve, % passing:	
No. 4 [4.75 mm] and larger	5
No. 30 [0.600 mm]	3
No. 200 [0.075 mm]	2.0

I Failing Materials

(Gradation, Coarse Aggregate Angularity, and Extracted Asphalt Binder Content)

The determination of price adjustments for failing materials will be based on the specification limits outlined in Table 2363-3 as shown below for that specific test. Reduced payment as shown in the table below will be applied to all tonnage represented by the individual test results that do not meet the limits. The Contractor cannot continue to produce failing mixture. A continual basis is defined as all lots in a day's production failing to meet specification requirements for gradation, crushing, or binder content, or more than 50% of the lots on two or more consecutive days which fail to meet specification requirements for gradation, crushing, or binder content.

Table 2363-3
Reduced Payment Schedule

Item	Pay Factor, % *
Gradation	95
Coarse aggregate crushing	90
Asphalt binder content‖	90

* Apply the lowest pay factor when using multiple reductions on a single test.
‖ No price reduction for asphalt content in excess of allowable tolerance provided there is no visual observation of asphalt drain down.

J. Thickness and Smoothness Requirements.

1. Elevation. The finished surface of permeable asphalt layer at any point of measurement must not vary be more than ±5/8 inch [16 mm] from the prescribed elevation for that point as determined from the grades staked by the Engineer and the cross section in the Plan.
2. Thickness. Within ±1/4 inch [6 mm] of the compacted depth shown on the typical section in the plan.
3. Deficient. The contractor will correct any areas which are deficient by more than 1/4 inch [13 mm] by scarifying, adding mixture, compacting, shaping, and finishing in accordance with these specifications, or directed by the Engineer.
4. Tolerances. Normal specification tolerances apply for bituminous and concrete.

2363.4 METHOD OF MEASUREMENT

Measurement for PASB and PASSRC will be in accordance with the following. Bituminous mixture and bituminous material for mixture will be paid for separately.

Measurement will be made by the weight of bituminous mixture for the permeable asphalt layer. Payment will be made at the Contract bid price per ton [metric ton]. Payment for the accepted bituminous mixture will be payment in full for all costs of constructing the permeable asphalt layer, including the costs of mixture production, aggregate incorporation, placement, and compaction. Cost for Bituminous material is specifically excluded. Measurement will be made by the weight of bituminous material incorporated into the permeable asphalt layer. Payment will be made at the Contract bid price per ton [metric ton]. Payment for Bituminous material, based on the acceptance of the permeable asphalt layer, will be payment in full for bituminous material, any additives, and the incorporation of the bituminous material into the mixture.

2363.5 BASIS OF PAYMENT

Payment for the accepted quantity of permeable asphalt layer at the Contract unit price of measure will be compensation in full for all costs of furnishing and applying all materials required in this specification. The unit price includes all labor materials, and equipment necessary to complete the work.

Payment for geotextile, when required for widening designs, will be considered incidental.

Item No.	Item	Unit
2363.509	Bituminous Mixture for Permeable Asphalt Stabilized Stress Relief Course	ton [metric ton]
2363.509	Bituminous Mixture for Permeable Asphalt Stabilized Base	ton [metric ton]
2363.509	Bituminous Material for Mixture	ton [metric ton]

2365 STONE MATRIX ASPHALT -- SMA

2365.1 DESCRIPTION

This work consists of constructing a Stone Matrix Asphalt Wearing Course Mixture (SMA) placed on a prepared surface in accordance with these specifications.

Construct the SMA to the lines, grades, thicknesses, and typical cross-sections shown on the plans or established by the Engineer.

Stone Matrix Asphalt Mixture Designation Code: **SMWEE640E**

2365.2 MATERIALS

A Aggregates

Use only virgin aggregates.

A.1 Aggregate Requirements

Provide mineral aggregate meeting the requirements of Table 2365-1, "Stone Matrix Asphalt Aggregate Gradation Broad Bands" and Table 2365-2, "Stone Matrix Asphalt Mixture Aggregate Requirements":

Table 2365-1
Stone Matrix Asphalt Aggregate Gradation Broad Bands
(% passing of total washed gradation)

Sieve Size, inch (mm)	% Passing
¾" (19.0)	100
½" (12.5)	86-96
3/8" (9.5)	60-85
#4 (4.75)	25-35
#8 (2.36)	15-25
#200 (0.075)	8.0-12.0

Table 2365-2 Stone Matrix Asphalt Mixture Aggregate Requirements	
Aggregate Blend Property	**Requirements**
Coarse Aggregate Angularity (MnDOT 1214) (one face/two face), %wear	100/90
Fine Aggregate Angularity	Use manufactured sand
Coarse Aggregate Absorption, % (MnDOT 1204)	$\leq$ 2
Voids in Coarse Aggregate (VCA_{DRC}) (MnDot 1211 & AASHTO T19)	$VCA_{mix} < VCA_{DRC}$
Flat and Elongated Particles, max % by weight, (MnDOT 1208)	10 (3:1 ratio)
Clay Content (MnDOT 1215)	45
Total Spall in fraction retained on the #4 [4.75mm] sieve (MnDOT 1209)	1.0
Maximum Spall Content in Total Sample (MnDOT 1209)	1.0
Maximum Percent Lumps in fraction retained on the #4 [4.75mm] sieve	0.5
Class B Carbonate Restrictions	
Maximum% -#4 [-4.75mm]	50
Maximum% +#4 [-4.75mm]	0

A.2 Los Angeles Ratter

The Los Angeles Rattler loss on the coarse aggregate fraction (material retained on the **#**4 sieve **[**4.75-mm] cannot exceed 35 percent for any individual source used within the mix (MnDOT 1210).

A.3 Magnesium Sulfate loss on coarse aggregate fraction for each source. .....3139 C

A.4 Mineral Filler AASHTO M17

B Additives

An additive is any material added to an asphalt mixture or material, such as mineral filler, asphalt additives, anti-strip, stabilizers, and similar products that do not have a specific pay item. When the Contract requires additives, compensation is included with the pay items for the appropriate mixture. If directed to incorporate additives, the compensation will be as Extra Work, at the unit price specified in the proposal. No compensation will be made for additives incorporated at the Contractor's option.

Do not incorporate additives into the mixture without approval of the Engineer. Add anti-foaming agents to asphalt cement at the manufacturer's recommended dosage rate.

C SMA Asphalt Stabilizer AASHTO 305

Use a cellulose fiber asphalt stabilizer additive to control drain-down in the SMA mixture. Feed the stabilizing additive through a separate system that proportions the required amount of stabilizer in uniform distribution at a dosage rate within 0.2-0.4 percent by weight of the total mix. The system must have low-level and no-flow indicators and a printout of the feed rate in lbs/min. Additionally, the stabilizer supply line must include a section of transparent pipe for observing consistency of flow or feed.

D Asphalt Binder Material 3151

Use PG 70-28, meeting the requirements of AASHTO MP 19-10.

E Mixture Design

E.1 General Design

Design the mixture in conformance with AASHTO R 46-08, Standard Practice for Designing Stone Matrix Asphalt. Additional information on SMA mix design is found in Appendix B of the National Asphalt Pavement Association information Series 122, Designing and Constructing SMA Mixtures State-of-the-Practice.

Use MnDOT Laboratory Manual Method 1816 (Corelok) to determine mixture bulk specific gravity.

E.2 Aggregate

At least 15 calendar days before beginning production, submit to the District Materials Laboratory a minimum of 80 lbs (35kg) for aggregate quality testing.

At least 30 calendar days prior to production, submit to the District Materials Laboratory 80 lbs (35kg) of each aggregate that require magnesium sulfate soundness testing.

At least 7 working days prior to the start of asphalt production, submit a minimum of 150 lbs. [60kg] of the coarse aggregate fraction from the selected design blend (JMF). This fraction will be tested for the voids in coarse aggregate (VCA_{drc}) (MnDOT 1211 & AASHTO T19).

E.3 Mixture Sample

At least 7 working days before the start of asphalt production, submit the proposed Job Mix Formula (JMF) in writing and signed by a Level II Quality Management mix designer for each combination of aggregates to be used in the mixture. Include test data to demonstrate conformance to mixture properties as specified in Table 2365-1, "Stone Matrix Asphalt Mixture Aggregate Gradation Broadband", Table 2365-2, "Stone Matrix Asphalt Mixture Aggregate Requirements" and Table 2365-5, "Stone Matrix Asphalt Mixture Requirements". Use forms approved by the Department for the submission. Submit the design as a Laboratory Mix Design (Option 1).

Submit an uncompacted mixture sample plus briquettes, in conformance with the JMF, compacted at the optimum asphalt content and required compactive effort for laboratory examination and evaluation. Provide a mixture sample size and the number of compacted briquettes and in accordance with the following:

Table 2365-3
Stone Mastic Asphalt Mixture Sample Requirements

Item	Gyratory Design
Uncompacted mixture sample size	75 lb [30 kg]
Number of compacted briquettes	2
Coarse Aggregate Fraction	150 lb (60kg)

F.1 Tensile Strength Ratio

At least 7 days before actual production, submit sample to the District Materials Laboratory for verification of moisture sensitivity retained tensile strength ratio (TSR). The Engineer may test material submitted for TSR verification for maximum specific gravity G_{mm} compliance in addition to TSR results. The Engineer will reject the submitted mix design if the tested material fails to meet the G_{mm} tolerance. If the Engineer rejects a mix design, re-submit a new mix design as described above. The Contractor may use one of the following options to verify that the TSR meets the requirements in Table 2365-5, "Stone Matrix Asphalt Mixture Requirements".

F.1.a Option A

Batch material at the design proportions including optimum asphalt. Split the sample before curing and allow samples to cool to room temperature, approximately 77 °F [25 °C]. Submit 80 lb [35 kg] of mixture to the District Materials Laboratory for curing and test verification. Use a cure time of 2 h ±15 minutes at 290 °F [144 °C] cure time for both groups and follow procedures Laboratory Manual Method 1813.

F.1.b Option B

Batch and cure in accordance with Option A. Compact, and submit briquettes and uncompacted mixture in accordance with Table 2365-4, "Option B Mixture Requirements".

Table 2365-4
Option B Mixture Requirements

Item	Gyratory Design
Un-compacted mixture sample size	8,200 g
Number of compacted briquettes*	6
Compacted briquette air void content	5.5 % – 6.5 %

* 6 in [150 mm] specimens.

For both options, cure for 2 h ±15 min at 290° F [144° C] meeting the requirements in the MnDOT Laboratory Manual Method 1813.

G Mixture Requirements

The Department will base initial mixture evaluation on the trial mix tests in accordance with Table 2365-5, "Stone Matrix Asphalt Mixture Requirements" and Table 2365-6, "Stone Matrix Asphalt Minimum Asphalt Content".

Table 2365-5 Stone Matrix Asphalt Mixture Requirements	
Gyrations for $\mathbf{N_{design}}$	75
Air Voids, % -- Wear	4.0%
Fines/Effective Asphalt	1.2-2.0
Tensile Strength Ratio, min%	70
VMA, %	17.0
VFA, % -- Wear	70-80
Draindown - based on a 1 hour reading at the anticipated production temperature	$\leq$ 0.3 %
Stabilizer by weight of total mix, %	0.2 – 0.4
VCA Ratio	$VCA_{MIX}<VCA_{DRC}$
Minimum Asphalt Requirement, % by weight of mix	See Table 2365-6

G.1 Minimum Asphalt Content

Asphalt content is established based on the combined aggregate bulk specific gravity, Gsb. Use Table 2365-6, "Stone Matrix Asphalt Minimum Asphalt Content" to determine the minimum asphalt content.

Table 2365-6 Stone Matrix Asphalt Minimum Asphalt Content	
Combined Aggregate Bulk Specific Gravity	Minimum Asphalt Content, Percent
<2.400	6.8
2.401-2.450	6.7
2.451-2.500	6.6
2.501-2.550	6.5
2.551-2.600	6.3
2.601-2.650	6.2
2.651-2.700	6.1
2.701-2.750	6.0
2.751-2.800	5.9
2.801-2.850	5.8
2.851-2.900	5.7
2.901-2.950	5.6
2.951-3.000	5.5

G.2 Documentation

Include the following documentation and test results for each JMF submitted for review.

(1) Names of the individuals responsible for the QC of the mixture during production,
(2) Low project number of the contract on which the mixture will be used,
(3) The following temperature ranges as supplied by the asphalt binder supplier:
  (3.1) Laboratory mixing and compaction,
  (3.2) Plant discharge, and
  (3.3) Field compaction.
(4) The percentage in units of 1 percent (except the No. 200 sieve [0.075 mm] in units of 0.1 percent) of aggregate passing each of the specified sieves for each aggregate to be incorporated into the mixture.
(5) Source descriptions of the following:
  (5.1) Location of material,
  (5.2) Description of materials,
  (5.3) Aggregate pit or quarry number, and
  (5.4) Proportion amount of each material in the mixture in percent of total aggregate.
(6) Composite gradation based on (4) and (5) above.
(7) Bulk and apparent specific gravities and water absorption (by % weight of dry aggregate). Both coarse and fine aggregate, for each product used in the mixture. Use MnDOT Laboratory Manual Method 1204 and 1205. The tolerance allowed between the Contractor's and the Department's specific gravities are G_{sb} (individual) = 0.040 [+4 and -4] and G_{sb} (combined) = 0.020.
(8) Test results from the composite aggregate blend at the proposed JMF proportions showing compliance with Table 2365-2, "Stone Matrix Asphalt Mixture Aggregate Requirements":
  (8.1) Coarse Aggregate Angularity,
  (8.2) For the trial blend(s), determine the unit weight of aggregates (lb/ft3), voids in the Coarse Aggregate-Dry Rodded Condition (VCADRC) according to AASHTO T19. The VCA ratio (VCAmix/VCADRC) shall be less than 1.0, i.e. VCAmix< VCADRC.
  (8.3) Flat and Elongated determined at 3:1 ratio
(9) Asphalt binder percentage in units of 0.1 percent based on the total mass of the mixture and the PG grade.

(10) Each trial mixture design includes the following:

(10.1) Using the selected design gradation, prepare mixes at the three binder contents in increments of 0.5 percent with at least one point above and one point below the optimum asphalt binder percentage.

(10.2) Conduct draindown test (AASHTO T305) on loose mix at a temperature 27°F (15°C) (15°C) higher than anticipated production temperature.

(10.3) Maximum specific gravity for each asphalt binder content calculated based on the average of the effective specific gravities measured by using at least two maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt binder content.

(10.4) Test results on at least two specimens at each asphalt binder content for the individual and average bulk specific gravities, density, and heights.

(10.5) Percent air voids of the mixture at each asphalt binder content.

(10.6) VMA for each asphalt binder content.

(10.7) Fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent.

(10.8) Evidence that the completed mixture will conform to the specified VCA ratio of less than 1.0.

(11) Percent and manufacturer's data for type of stabilizer used.

G.3 Mixture Design Report

The Department will issue an initial Mixture Design Report (MDR) consisting of the JMF after review of the submitted design. The review will include the Department's test results submitted aggregate and mixture. A preliminary MDR will provide the JMF limits to begin production of a test strip.

G.4 Initial SMA Test Strip Verification

Do not begin full-scale production of the SMA mixture until it is shown, in a test strip, that the mixture can be produced, placed, and compacted to the requirements of this specification. Limit the test strip to 500 tons with a minimum requirement of 200 tons placed at the specified thickness and width indicated in the contract. During construction of the test strip take a minimum of 2 mixture samples to determine mixture properties as shown in the Production Start-Up Testing Rate table shown above. Take one sample within the first 100 tons of mixture produced and the other randomly within the remaining mixture produced. After both samples are obtained cease production of the SMA until mixture properties are tested and evaluated by both the Contractor and the Department. Resume production when:

1) The Contractor's and the Department's test results are within the allowable testing tolerances shown in Table 2365-7, and
2) Each of the Contractor's test results are within the JMF limits as indicated on the Mixture Design Report, and
3) The average of the two Contractor test results meets the requirements shown in the table for SMA mixture requirements, and
4) The average of two cores from the roadway meets the minimum density requirement as specified in this provision. One core shall be taken at random in the area representative of where the first mixture sample was obtained. The other core shall be taken at random in the area representative of the second mixture sample.

If the material in the test strip does not meet the requirements listed above another test strip will be required. With the approval of the Engineer, the test strip may be placed within the project limits. A final MDR will be issued once the test strip meets specification requirements.

H Mixture Quality Management

H.1 Quality Control

Perform Quality Control (QC) as part of the production process. QC is the process control of the operations related to mixture production and determining the quality of the mixture being produced. The QC sample is the Contractor's sample taken and tested during production and used to control the production process. Provide and maintain a QC program for stone matrix asphalt pavement production, including mix design, process control inspection, sampling and testing, and adjustments in the process related to the production of the stone matrix asphalt pavement.

H.2 Plant Certification

Provide the following to obtain certification:

(1) Completed and submitted request form application for plant inspection.

(2) Site map showing stockpile locations.

(3) Signed asphalt plant inspection report showing the plant and testing facility passed as documented by Asphalt Plant Inspection Report (TP 02142-02, TP 02143-02). The inspection report must also include documentation showing plant and laboratory equipment has been calibrated and is being maintained to the tolerance shown in the Bituminous Manual and sections 1200, 1800, and 2000 of the Mn/DOT Laboratory Manual.

(4) A Department-signed Mixture Design Report (MDR) before mixture production.

H.3 Quality Assurance

The Engineer will perform Quality Assurance (QA) as part of the acceptance process. QA is the process of monitoring and evaluating various aspects of the Contractor's testing as described below. The QA sample is the Department's companion sample to the Contractor's QC sample. QA testing is performed to accept the work. The Engineer will perform the following:

(1) Conduct QA and verification sampling and testing,
(2) Observe the QC sampling and tests,
(3) Monitor the required QC summary sheets and control charts,
(4) Verify calibration of QC laboratory testing equipment,
(5) Communicate Department test results to the Contractor's personnel on a daily basis, and
(6) Ensure Independent Assurance (IA) sampling and testing requirements are met.

H.4 Verification Sample

The Department will test a verification sample to assure compliance of the Contractor's QC program. The Department will provide the Contractor a verification companion, which is defined as a companion sample to the verification sample MnDOT uses. Take all verification samples from the truck box at the plant site. Test and use this verification companion sample as part of the QC program. Use the verification companion sample to replace the next scheduled QC sample. The Department recommends sampling enough material to accommodate retesting in case the samples fail.

Perform verification testing on at least one set of production tests daily to verify the requirements of Table 2365-1, "Stone Matrix Aggregate Gradation Broad Bands", Table 2365-2, "Stone Matrix Asphalt Pavement Mixture Aggregate Requirements", and Table 2365-5, "Stone Matrix Asphalt Mixture Requirements". Compare the verification companion sample to the verification sample for compliance with allowable tolerances in Table 2365-7. The Department will consider the verification process complete if the Contractor's verification companion meets the tolerances in Table 2365-7.

If the tolerances between the Contractor's verification companion and the Department's verification sample do not meet the requirements of Table 2365-7, the Department will retest the material. If the retests fail to meet tolerances, the Department will substitute the Department's verification test results for the Contractor's results in the QC program and use those results for acceptance.

Table 2365-7
Allowable Differences between Contractor and Department Test Results

Item	Allowable Difference
Mixture bulk specific gravity (G_{mb})	0.030
Mixture maximum specific gravity (G_{mm})	0.019
VMA	1.2
Coarse Aggregate Angularity, % fractured faces (%P)	15
Asphalt binder content:	
Ignition Oven %	0.3
Gradation sieve, % passing:	
¾ in [19.0 mm] , ½ in [12.5 mm], ⅜ in [9.5 mm]	6
No. 4 [4.75 mm]	5
No. 8 [2.36 mm]	4
No. 200 [0.075 mm]	2.0

I Contractor Quality Control

Provide QC technicians certified as a Level I Bituminous Quality Management (QM) Tester meeting the requirements of the MnDOT Technical Certification Program for QC testing and Level II Bituminous QM Mix Designer to make process adjustments. Provide at least one person per paving operation certified as a Level II Bituminous Street Inspector.

Provide a laboratory with equipment and supplies for Contractor quality control testing and maintain with the following:

(1) Up-to-date equipment calibrations and a copy of the calibration records with each piece of equipment,
(2) Telephone,
(3) Fax and copy machine; however, the Engineer may waive the requirement to have a fax machine if internet and email are available,
(4) Internet and Email,
(5) Computer,
(6) Printer, and
(7) Microsoft Excel, version 2007 or newer.

Laboratory equipment need to meet the requirements listed in Section 400 of the Bituminous Manual, Laboratory Manual, and these specifications, including having extraction capabilities. Before beginning production, the laboratory equipment needs to be calibrated and operational.

J Sampling and Testing

Take QC/QA samples from the truck box at the plant site. Sample randomly and in accordance with the Schedule of Materials Control and this provision. QC/QA samples are to be quartered from a larger sample of mixture. The procedure for truck box sampling is on the Bituminous Office website. Store compacted QC mixture specimens and loose QC and Department's QA mixture companion samples for 10 calendar days. Label these split companion samples with companion numbers. Determine random numbers and locations using the Bituminous Manual, Section 5-693.7 Table A or ASTM D 3665, Section 5.

K Start-Up and Production Test Rates

K.1 Start –Up Testing Rates

At the start of production, for the first 2,000 ton [1,800 tonne] of mix, perform testing at the following frequencies:

Table 2365-8
Stone Matrix Asphalt Production Start-Up Testing Rates

Production Test	Testing Rates	Lab Manual Method
Bulk Specific Gravity	1 test per 500 tons (450 metric tons)	MnDOT 1816 (Corelok)
Maximum Specific Gravity	1 test per 500 tons (450 metric tons)	MnDOT 1807
Air Voids (calculated)	1 test per 500 tons (450 metric tons)	MnDOT 1808
Asphalt Content	1 test per 500 tons (450 metric tons)	MnDOT 1852 & 1853
VMA (Calculated)	1 test per 500 tons (450 metric tons)	AASHTO R46 & SP 2
Gradation	1 test per 500 tons (450 metric tons)	MnDOT 1203
Fines to Effective AC (calculation)	1 test per 500 tons (450 metric tons)	
Fine Aggregate Angularity*		MnDOT 1206
Coarse Aggregate Angularity	1 test per 1000 tons (900 metric tons)	MnDOT 1214
VCA Ratio (calculation)	1 test per 500 tons (450 metric tons)	AASHTO R46 & T19
Draindown	1 test per 500 tons (450 metric tons)	AASHTO T305

* No FAA requirement, however, fine aggregate shall be 100% crushed.

K.2 Production Test Rates

After producing the first 2,000 ton [1,800 tonne] of each mix type test at the following frequencies:

Table 2365-9
Stone Matrix Asphalt Production Testing Rates

Production Test	Sampling/Testing Rates	Lab Manual Method
Bulk Specific Gravity	1 test per 1000 tons (900 metric tons)	MnDOT 1816 (Corelok)
Maximum Specific Gravity	1 test per 1000 tons (900 metric tons)	MnDOT 1807
Air Voids (calculated)	1 test per 1000 tons (900 metric tons)	MnDOT 1808
Asphalt Content	1 test per 1000 tons (900 metric tons)	MnDOT 1852 & 1853
VMA (calculated)	1 test per 1000 tons (900 metric tons)	AASHTO R46 & SP 2
Gradation	1 test per 1000 tons (900 metric tons)	MnDOT 1203
Fines to Effective AC (calculated)	1 test per 1000 tons (900 metric tons)	AASHTO R46 & SP 2
Coarse Aggregate Angularity	2 tests/day for a minimum of 2 days, then 1 per day if CAA is met. If CAA >8% of requirement, 1 sample/day but test 1/week.	MnDOT 1214
Fine Aggregate Angularity (FAA)*		MnDOT 1206
TSR	As directed by the Engineer	MnDOT 1813
Aggregate SpG & Absorption	As directed by the Engineer	MnDOT 1204, 1205
Mixture Moisture Content	As directed by Engineer	MnDOT 1855
Asphalt Binder	Sample 1st load then 1 per 250,000 gal (1,000,000 liter) -sample size 1 qt.	MnDOT 5-693.920
Draindown	1 test per day	AASHTO T305
VCA Ratio (calculated)	1 test per 1000 tons (900 metric tons)	AASHTO R46

* No FAA requirement, however, fine aggregate shall be 100% crushed.

L Documentation:

Maintain documentation, including test summary sheets and control charts, on an ongoing basis. File reports, records, and diaries developed during the work as directed by the Engineer. These documents become the property of the Department.

Number test results in accordance with the MDR and record on forms approved and provided by the Department.

Include the following production test results and mixture information on the Department approved test summary sheet:

(1) Percent passing on all sieves in accordance with Table 2365-1, "Stone Matrix Asphalt Pavement Aggregate Gradation Broad Bands".
(2) Coarse aggregate crushing (1 & 2 face),
(3) Maximum specific gravity ($G_{mm.}$),
(4) Bulk specific gravity (G_{mb}),
(5) Percent total asphalt binder content.
(6) Calculated production air voids (V_a),
(7) Aggregate proportions in use at the time of sampling,
(8) Individual aggregate Gsb (both minus #4 and combined),
(9) Tons where sampled,
(10) Tons represented by a test and cumulative tons produced,
(11) Signature Line for MnDOT and Contractor Representative,
(12) Mixture Moisture Content, and
(13) MnDOT verification sample test result.
(14) VCA ratio.
(15) Drain-down value in percent
(16) VMA
(17) Fines to effective asphalt ratio (F/E)
(18) Amount of stabilizer

Submit copies of failing test results to the Engineer on a daily basis.

Provide the Engineer with asphalt manifests or bill of lading's (BOL) on a daily basis.

Provide a daily plant diary, including a description of QC actions taken. Include changes or adjustments on the test summary sheets.

Provide an automated weigh scale and computer generated weigh ticket. Ensure the ticket indicates the following information:

(1) Project number,
(2) Mix designation, including binder grade,
(3) Mixture Design Report number,
(4) Truck identification and tare,
(5) Net mass, and
(6) Date and time of loading.

Furnish an electronic printout (long form recordation) from an automated plant blending control system at 20 minute intervals when the plant is producing mixture. The Engineer may waive this requirement if the plant does not have the capability to produce the automated blending control information; however, the Contractor must then perform daily spotchecks to determine percent new asphalt added.

Include the following information on the plant control printout for Drum Plants:
(1) Both the virgin and recycle belt feed rates (tons/hr),
(2) Feeder bin proportions (%),
(3) Total % asphalt cement in the mixture,
(4) Virgin asphalt cement added (%)
(5) Mixture Temperature °F [°C],
(6) Mixture code,
(7) Date and time stamp, and
(8) Current tons of mixture produced and daily cumulative tons of mixture produced at time of printout.

Provide a daily electronic printout of the plant calibration (SPAN) numbers for each bin and meter.

M JMF Limits

Table 2365-10
Stone Matrix Asphalt JMF Limits (N=4)

Item	JMF Limits
Production air voids, %	±1.0
Asphalt Binder Content, Percent	±0.4
VMA	-0.3
Sieve - % Passing	
3/4"[19mm], 1/2" [12.5mm], 3/8" [9.5 mm]	± 4
No. 4 [4.75], No. 8 [2.36 mm]	± 3
No. 200 [0.075 mm]	± 2.0

The mixture production targets and JMF limits are listed on the Mixture Design Report. JMF limits are used as the criteria for acceptance of materials based on individual (single) test results. Gradation JMF limits are not allowed outside the broadband requirements in Table 2365-1, "Stone Matrix Asphalt Aggregate Gradation Broad Bands".

M.1 Moving Average Calculation

Calculate a moving average as the average of the last four test results. Continue the calculation without interruption, except begin new summary sheets and charts annually for winter carry-over projects and if an asphalt plant is re-setup in the same site after it has been moved out.

M.2 JMF Bands

JMF Bands are the area between the target, as identified on the Mixture Design Report, and the JMF limits.

N JMF Adjustment

Begin mixture production with materials within 5 percent of the design proportions and other mixture parameters within the JMF limits in accordance with Table 2365-10, "Stone Matrix Asphalt JMF Limits" for gradation, asphalt content, and aggregate proportions meeting the requirements of the reviewed Mixture Design Report. Use all aggregate proportions meeting the requirements of the Mixture Design Report unless the aggregate proportion is 0 percent.

O JMF Request for Adjustment

Make a request to the Bituminous Engineer or District Materials Engineer for a JMF adjustment to the mix design if the QC test results indicate a necessary change to achieve the specified properties. Do not use aggregates or materials not part of the original mix design to make adjustments unless otherwise approved by the Engineer, in conjunction with the District Materials Engineer or the Department Bituminous Engineer.

A Certified Level II Bituminous QM Mix Designer will review the requested change for the Department. If the request meets the design requirements in Table 2365-1," Stone Matrix Asphalt Pavement Aggregate Gradation Broad Bands", Table 2365-2," Stone Matrix Asphalt Pavement Mixture Aggregate Requirements", and Table 2365-5, "Stone Matrix Asphalt Pavement Mixture Requirements," the Department will issue a revised Mixture Design Report.

Use an interactive communication process with the Engineer before making JMF adjustments. Make JMF adjustments only within the mixture specification gradation design broadbands in accordance with Table 2365-1, "Stone Matrix Asphalt Pavement Aggregate Gradation Broad Bands". Submit a new JMF if redesigning the mixture.

The department will not allow consecutive requests for a JMF adjustment without production data.

P Failing Materials – Gradation, Coarse Aggregate Angularity, Air Voids, VMA, and Percent Asphalt Binder

Material acceptance is based on individual and moving average test results. Use isolated test results for acceptance of air voids and VMA at the start of mixture production. The Department will consider individual test results greater than two times the JMF bands as failing. The Department will fail moving average test results exceeding the JMF limits.

Stop production and make adjustments if the moving average values exceed the JMF limits. Restart production after performing the adjustments and notifying the Engineer. Resume testing at the accelerated rates and for the tests listed in Table 2365-8, "Production Start-Up Testing Rates," for the next 2,000 ton [1,800 tonne] of mixture produced. Continue calculating the moving average after the stop in production.

The Department will consider mixture produced where the moving average of four exceeds the JMF limits as unsatisfactory in accordance with 2365.2.G.14.d, "Moving Average Failure at Mixture Start-Up – Production Air Voids," 2365.2.G.14.e, "Moving Average Failure at Mixture Start-Up — Adjusted AFT," 2365.2.G.14.f, "Moving Average Failure - Production Air Voids," and 2365.2.G.14.g, "Moving Average Failure — Percent Asphalt Binder Content, Gradation, and Adj. AFT."

P.1 Isolated Failures at Mixture Start-Up – Production Air Voids

At the start-up of mixture production, use the first three isolated test results for production air voids before establishing a moving average of four. Calculate isolated production air voids using the maximum mixture specific gravity and the corresponding bulk specific gravity from that single test. After testing four samples and establishing a moving average of four, the Department will base acceptance on individual and moving average production air voids.

The Department will not accept the material if any of the first three isolated test results for production air voids exceeds twice the JMF bands from the target listed on the Mixture Design Report at the start of production. The Department will reduce payment for unacceptable material in accordance with Table 2365-16, "Reduced Payment Schedule for Individual Test Results." The Department will calculate the quantity of unacceptable material on the tonnage placed from the sample point of the failing test to the sample point when the isolated test result is back within twice the JMF bands. If the failure occurs at the first test after the start of production, the Department will calculate the tonnage subject to reduced payment as described above, including the tonnage from the start of production.

If isolated air voids are less than 1.0 percent or greater than 7.0 percent, the Engineer will either reduce the payment or order the material removed and replaced at no additional cost to the Department. The Engineer may require the Contractor to test in-place mixture to better define the removal and replacement limits. The Engineer may require the Contractor to test in-place mixture placed before the failing test result. If the Engineer reduces the payment, the Department will pay for the material at 50 percent of the contract unit price.

P.2 Individual Failure – Gradation, Percent Asphalt Binder, Production Air Voids, and VMA

Table 2365-11
Reduced Payment Schedule for Individual Test Results

Item	Pay Factor, % *
Gradation	95
VMA	85
Coarse aggregate crushing	90
Asphalt binder content	90
Production air voids, individual‖ and isolated†	80

* Apply the lowest pay factor when using multiple reductions on a single test.
‖ Calculate individual air voids using the moving average maximum specific gravity and the bulk specific gravity from that single test.
† Calculate the isolated air voids from the maximum specific gravity and the bulk specific gravity from that single test. The Engineer will only use isolated void test results for acceptance for the first three tests after mixture production start-up.

P.3 Individual Failure at Mixture Start-Up– VMA

At the start-up of mixture production, before a moving average of four can be established, the first three (3) individual test results for VMA will be used for acceptance. After 4 samples have been tested and a moving average of four can be established, acceptance will be based on individual and moving average VMA.

If, at the start of production, any of the first three (3) individual VMA test results exceeds twice the JMF bands from the target listed on the Mixture Design Report, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2365-11 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the test results are back within twice the JMF limits. When the failure occurs at the first test, after the start of production, the tonnage subjected to reduce payment shall be calculated as described above and shall include the tonnage from the start of production.

P.4 Moving Average Failure at Mixture Start-Up – Production Air Voids

If a moving average failure occurs within any of the first three moving average results after mixture start-up (tests 4, 5, 6), the Department will accept the mixture if the individual air void, corresponding to the moving average failure meets the JMF limits. The Department will not accept material if the individual air void fails to meet the JMF limit. The Department will reduce payment for unacceptable material unless the Engineer determines that the isolated air void corresponding to the individual air void meets the JMF limit. The Department will pay for unacceptable material at 70 percent of the relevant contract unit price. The Department will calculate the quantity of material subject to reduce payment as the tons placed from the sample point of the failing moving average result and corresponding individual air void beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit. If the failure occurs at the first test after the start of daily production, the Department will include tonnage from the start of production that day with the tonnage subjected to reduced payment.

P.5 Moving Average Failure at Mixture Start-Up – VMA

When a moving average failure occurs within any of the first 3 moving average results after mixture start-up (tests 4, 5, 6), the mixture will be considered acceptable if the individual VMA, corresponding to the moving average failure is within the JMF limits. If the individual VMA is not within the JMF limit, the mixture will be considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 75 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of the failing moving average result and corresponding individual VMA beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit.

P.6 Moving Average Failure – Production Air Voids

A moving average production air void failure occurs when the individual production air void moving average of four exceeds the JMF limit. The Department will consider the mixture unacceptable and subject to reduced payment. The Department will pay for unacceptable mixture at 70 percent of the contract unit price. The Department will calculate the quantity of mixture subject to reduced payment as the tons placed from the sample point of all individual test results beyond the JMF limits, which contributed to the moving average value that exceeded the JMF limit, to the sampling point where the individual test result meets the JMF limits. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subject to reduced payment.

Table 2365-12 Reduced Payment Schedule for Moving Average Test Results	
Item	**Pay Factor, %***
Gradation	90
Coarse and fine aggregate crushing	NA (individual failures only)
VMA	80
Asphalt binder content	80
Production air voids	70
* Lowest Pay Factor applies when there are multiple reductions on a single test.	

Test result is back within the JMF limit.

P.7 Moving Average Failure – Percent Asphalt Binder Content, VMA, and Gradation

For mixture properties including asphalt binder content, VMA, and gradation, where the moving average of four exceeds the JMF limits, the mixture is considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment, percent of the Contract bid price, is shown in Table 2365-12. Tonnage subjected to replacement or reduced payment is calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving average value that exceeded the JMF limit, to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

P.8 Coarse Aggregate Crushing Failure

If any CAA test results do not meet the requirements specified in Table 2365-1, the Department may reduce payment for the placed material in accordance with Table 2365-11, "Reduced Payment Schedule for Individual Test Results." The Department will calculate the quantity of material subject to reduced payment as the tons placed from the sample point of the failing test until the sampling point where the test result meets the specifications. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subjected to reduced payment.

2365.3 CONSTRUCTION REQUIREMENTS

A Restrictions

A.1 Asphalt Release Agents

Do not use petroleum distillates to prevent adhesion of asphalt mixtures to equipment. An asphalt release agent must meet the criteria for "Effect on Asphalt" as described in the most recent Asphalt Release Agent on file in MnDOT's Office of Environmental Services. Drain excess release agents from tuck boxes prior to loading.

A.2 Edge Drop Off

When construction is under traffic, the requirements of 2221.3.D will apply.

A.3 Surge and Storage Bins

Store the asphalt mixture for no more than 1 h at storage facilities that prevent segregation of the mix and drainage of asphalt from the mix. Maintain the mixture at within 9 °F [5 °C] of the temperature when discharged from the silo or mixer and prevent excessive cooling or overheating.

A.4 Weather Limitations and Paving Date

Do not perform work within the roadway in the spring until removal of seasonal load restrictions on roads in the vicinity unless otherwise approved by the Engineer.

Do not place SMA when weather or roadbed conditions or moisture conditions of the roadway surface are judged unfavorable by the Engineer.

Place SMA mixtures only when the ambient air temperatures are at least 10C (50F).

A.5 Mixing and Discharge of Materials

Notify the Engineer of the recommended mixing temperatures as provided from the asphalt supplier. Unless authorized by the Engineer, do not produce the mixture no more than 30°F above the recommended maximum mixing temperature. Use the automated plant control printout to monitor discharge temperature. The Department will not pay for or allow placement of any mixture produced at more than 30°F above the recommended maximum mixing temperature.

A.6 Asphalt Binder Sampling Valve

Obtain asphalt binder samples from a sampling valve located between the pump and the drum. Sample each type of asphalt binder used in mixture production after 50 tons of mixture has been produced, then sample at a rate of one per 250,000 gal [1,000,000 L. A minimum of 1 gallon of binder must be drawn and wasted from the sampling valve before the actual sample is drawn. Provide a 1 qt [1.0 L] sized sample. Take samples meeting the requirements of the Bituminous Manual, 5-693.920. The Inspector will monitor the sampling the Contractor performs. Record sample information on an Asphalt Sample Identification Card.

Submit the sample to the Central Materials Laboratory. Contact the Department Chemical Laboratory Director for disposition of failing asphalt binder samples.

B Distributor

Provide a distributor capable of uniformly applying material up to 15 ft [4.6 m] wide and equipped with the following:

(1) An accurate volume measuring device with tachometer,
(2) Pressure gauges,
(3) Thermometer for measuring temperatures of tank contents,
(4) Power-operated pump, and
(5) Full circulation spray bars with lateral and vertical adjustments.

C Tack Coat

Apply a uniform asphalt tack coat to the clean and dry existing asphalt or concrete surface and to the surface of each course or lift constructed, except for the final course or lift, in accordance with 2357. Coat the contact surfaces of all fixed structures and the edge of the inplace mixture in all courses at transverse joints and in the wearing course at longitudinal joints. Do not coat the longitudinal joint if a rubberized asphalt joint adhesive will be applied to the vertical face of the joint. A uniform application will not have streaks (corn rows), bare spots, puddles, or other irregular patterns. Allow emulsified asphalt tack coats to break, as indicated by a color change from brown to black, before placing subsequent lifts. Take tack samples from the asphalt distributor according to rates provided in the Material Control Schedule. The Inspector will monitor the sampling the Contractor performs.

D Rollers

D1 Steel-Wheeled Rollers

Use self-propelled steel wheeled compacting equipment must weigh at least 8 ton [7.3 tonne]. Steel-wheel rollers in the vibratory mode are only allowed when approved by the Engineer.

D2 Pneumatic Tired Rollers

Self-propelled pneumatic tired compacting equipment is only allowed when approved by the Engineer.

E Compaction

After spreading each course, compact in accordance with the maximum density method as described below, unless the ordinary compaction method is otherwise specified in the special provisions. Do not allow rollers to stand on the uncompacted mixture or newly rolled pavement with a surface temperature greater than 140 °F [60 °C].

To maintain a true surface, correct the following by removing and replacing the material in the defective areas as directed by the Engineer at no additional cost to the Department:

(1) Variations such as depressions or high areas, which may develop during rolling operations; and
(2) Lean, fat, or segregated areas.

E.1 Maximum Density

Compact the pavement to at least the minimum required maximum density values in accordance with Table 2365-13, "Required Minimum SMA Lot Density.

Table 2365-13
Required Minimum SMA Lot Density

	All SMA Mixtures
% Gmm	93.0

E.1.a Density Determination (Core Bulk Density)

Calculate each individual lot's maximum density by averaging the results of the cores within the lot expressed as the percentage of the maximum specific gravity. Use Laboratory Test Method 1816, Corelok, to determine core density.

E.1.b Timeline

Complete compaction within 8 h of mixture placement and before obtaining core samples. Only use pneumatic tired or static steel rollers for compaction performed between 6 h and 8 h after mixture placement. Do not reroll compacted mixtures with deficient densities.

E.1.c Stop Production

If all the lots in a day's production or greater than 50 percent of the lots on multiple days fail to meet the minimum density requirement stop production and determine the source of the problem. Discuss with the Engineer what corrective action will be taken to bring the work into compliance with specified minimum required density.

E.1.d Lot Determination

Table 2365-14 Lot Determination	
Daily Production, *ton [tonne]*	**Lots**
300* – 600 [270* – 545]	1
601 – 1,000 [546 – 910]	2
1,001 – 1,600 [911 – 1,455]	3
1,601 – 2,600 [1,456 – 2,360]	4
2,601 – 4,600 [2,361 – 4,175]	5
> 4,600 [4,175]	‖
* If producing no greater than 300 ton [270 tonne] of mix, establish the first lot when the total weight is greater than 300 ton [270 tonne]. ‖Add one lot for each additional 900 tons [820 tonne] or part thereof.	

E.1.e Mat Density Cores

Obtain four cores in each lot. Take two cores from random locations as directed by the Engineer. Take the third and fourth cores, the companion cores, within 1 ft [0.3 m] longitudinally from the first two cores. Submit the companion cores to the Engineer immediately after coring and sawing. If the random core location falls on a longitudinal joint, cut the core with the outer edge of the core barrel 1 ft [0.3 m] away laterally from the edge of the top of the mat. Do not take cores for compacted mat density within 1 ft [300 mm] of any longitudinal joint. The Contractor is responsible for maintaining traffic, coring, patching the core holes, and sawing the cores to the paved lift thickness before density testing.

The Engineer may require additional density lots to isolate areas affected by equipment malfunction, heavy rain, or other factors affecting normal compaction operations.

E.1.f Contractor Core Testing

Take and test cores at least 4 in [100 mm] in diameter at locations determined and marked by the Engineer.

Mark samples with the lot number and core number or letter. Transport the cores to the laboratory daily taking care to prevent damage to them. Schedule the approximate time of testing during normal project work hours to allow the Engineer to observe the test and to record the corelok testing of the cores.

Determine the density by the end of the next working day after compaction. Measure each core three times for thickness before saw cutting. Report the average lift thickness on the core sheet. If placing multiple layers in a single day, saw and separate cores for each layer, test, and report by the end of the next working day. Place and compact mix into the coring hole to restore the surface within 24 h after coring or the Department will fine the Contractor $100 per working day per lot until restored.

E.1.g Companion Core Testing

The Department will select at least one of the two companion cores per lot to test for verification.

E.1.h Tolerance Comparison

E.1.h(1) Tolerance Comparison – Individual

Compare the individual core bulk specific gravities obtained by the Contractor and by the Department. If the bulk specific gravity between the Contractor and the Department cores differ by more than 0.030, use the Department's bulk specific gravity.

E.1.h(2) Tolerance Comparison – Day's Shrinking Tolerance

For a second comparison of the cores that pass the individual tolerance criteria, compare the average of the Contractor's bulk specific gravities with the average of the Department's bulk specific gravities. Determine the tolerance by dividing 0.030 by the square root of the number of samples compared. Use all the Department's results for the day's paving if the cores do not fall within the determined tolerance.

E.1.i Recoring

The Engineer may allow the Contractor to re-core a sample if the sample was damaged in the coring process or damaged in transit to the laboratory through no fault of the Contractor.

E.1.j Payment Schedule

Determine payment for density in accordance with Table 2365-15.

Table 2365-15 Payment Schedule for Maximum Density	
Percent of Maximum Specific Gravity	Percent Payment
Above 97.0	98
93.0 –97.0	100
91.0 – 92.9	98
89.0-90.9	95
Less than 89.0	remove and replace

F Surface Requirements

After compaction, the finished surface of each lift shall be reasonably free of segregated, open and torn sections, and shall be smooth and true to the grade and cross section shown on the plans with the following tolerances:

Table 2365-16 Surface Requirements		
Course/Location	**Description**	**Tolerance**
Wear	Tolerance of final 2 lifts from the edge of a 10 foot [3 m] straightedge laid parallel to or at right angles to the centerline.	¼ in [6 mm]
Transverse joints/construction joints	Tolerance from the edge of a 10 foot [3 m] straightedge centered longitudinally across the transverse joint. Correction by diamond grinding required when directed by the Engineer.	¼ in [6 mm]
Transverse Slope	Tolerance for surface of each lift exclusive of final shoulder wear.	Not to vary by more than 0.4 % from plans.
Distance from edge of each lift and established centerline.	No less than the plan distance or more than 3 inches [75 mm] greater than the plan distance. The edge alignment of the wearing lift on tangent sections and on curve sections of 3 degrees or less can't deviate from the established alignment by more than 1 inch [25 mm] in any 25 foot [7.5 m] section.	See Description
Final wear adjacent to concrete pavements.	After compaction the final lift wear adjacent to concrete pavements must be slightly higher but not to exceed 1/4" [6mm] than the concrete surface.	See Description
Final wear adjacent to fixed structures.	After compaction the final lift wear adjacent to gutters, manholes, pavement headers, or other fixed structures must be slightly higher but not to exceed 1/4" [6mm] than the surface of the structure.	See Description
Finished surface of each lift.	Must be free of segregated and open and torn sections and deleterious material.	See Description
Finished Surface	No flushing or "fat" spots	See Description

Cut or saw and then remove and replace material placed outside the described limitations at no additional cost to the Department. If the Engineer determines the material can remain in place outside the limits, the Department will pay for the material at a reduced cost of $10 per sq. yd [$12 per sq. m]. The Department will consider any single occurrence of material outside the limitations to have a minimum dimension of at least 1 sq. yd [1 sq. m] in any dimension.

In addition to the list the above the pavement surface must meet requirements of 2399 (Pavement Surface Smoothness) requirements.

F.1 Lift Thickness

After compaction, the thickness of the SMA will be within a tolerance of ¼ in [6 mm] of the thickness shown on the plans. The Engineer may require removal and replacement of any part of any lift that is constructed to less than the minimum required thickness, at no additional cost to the Department.

Measure cores taken for density determination for thickness also. Measure each core three times for thickness before sawing. Report the average of these three measurements. Document each lot's average core thickness and submit to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The Engineer will use the average of all core thickness measurements per day per lift to determine daily compliance with thickness specifications.

On that portion of any lift constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the lift to the plan thickness plus ¼ in [6 mm] may be excluded from the pay quantities or at the discretion of the Engineer and at the Contractor's expense may be required to be removed and replaced.

2365.4 METHOD OF MEASUREMENT

When paying for material by weight, the Engineer will measure separately asphalt mixture of each type by weight based on the total quantity of material hauled from the mixing plant. The Engineer will not make deductions for the asphalt materials.

2365.5 BASIS OF PAYMENT

The contract unit price for asphalt mixture used in each course includes the cost of constructing the asphalt surfacing and providing and incorporating asphalt binder, mineral filler, and asphalt stabilizer.

The Department will pay for additives required by the contract at the relevant contract unit price for the mixture. The Department will pay for additives incorporated as directed by the Engineer as extra work in accordance with 1402.5, "Extra Work."

If the plans do not show a contract pay item for shoulder surfacing and other special construction, the Department will include payment for the quantities of material used for these purposes in the payment for the wearing course materials.

Complete yield checks and monitor thickness determinations to construct the work as shown on the plans. Use the tolerances for lift thickness in accordance with Table 2365-16, "Surface Requirements" and surface smoothness requirements in accordance with 2399 for occasional variations and not for continuous over-running or under-running, unless otherwise required by the Engineer.

The Department will pay for plant mixed SMA on the basis of the following schedule:

Item No.:	Item:	Unit:
2365.501	Type SM* Wearing Course Mixture †‡	ton [metric ton]

* Aggregate size Designation 12.5
† Traffic level 6
‡ AC binder grade designation "H"

2399 PAVEMENT SURFACE SMOOTHNESS

2399.1 DESCRIPTION

This work consists of measuring the smoothness of the final concrete or bituminous surface.

A Definitions

The Department defines "Smoothness" as the Mean Roughness Index (MRI) value per 0.1 mi [0.16 km] segment. The Department defines "Areas of Localized Roughness" (ALR) as areas greater than or equal to the limiting criteria for a continuous MRI calculation with a 25 ft [7.62 m] interval, as calculated using the FHWA's Profile Viewing and Analysis (ProVAL) software.

2399.2 MATERIAL REQUIREMENTS

A Inertial Profiler (IP)

Provide a Department certified, calibrated, and documented IP meeting the requirements of ASTM E 950, Class 1 and procedures maintained by the MnDOT Pavement Engineering Section. Refer to the procedures maintained by the MnDOT Pavement Engineering Section or to the MnDOT Smoothness website for the required settings for individual certified IPs.

Provide an IP capable of producing a profilogram and exporting raw profile data in an unfiltered electronic Engineering Research Division (ERD) file format. Produce ERD filenames in the YYMMDD-T-N-D-L-B-E.ERD standardized format in accordance with Table 2399-1:

Table 2399-1
Standardized Naming Convention for ERD Files

Abbreviation	Definition
YY	Two-digit year
MM	Month (include leading zeros)
DD	Day of month (include leading zeros)
T	Route type (I, MN, US, CSAH, etc.)
N	Route number (no leading zeros) and auxiliary ID (if applicable, for example E, W, etc.)
D	Primary route direction (I or D)
L	Lane number (1 for driving lane, increasing by one for each lane to the left)
B	Beginning station
E	End station

B Profile Analysis Software

Use ProVAL software to conduct a profile analysis to determine Smoothness and ALR. Report MRI values in units of in per mi to one digit right of the decimal [m per km to two digits right of the decimal] in accordance with conventional rounding procedures.

C Operator Certification

Provide an operator, trained in the operation of the particular IP in accordance with 2399.2.A, "Inertial Profiler," and knowledgeable in the use of the required profile analysis software in accordance with 2399.2.B, "Profile Analysis Software." Ensure profiler operators pass a proficiency test and possess a current certification issued by the Department. The Contractor may access a list of certified operators on the MnDOT Smoothness website. Provide documentation of operator certification to the Engineer.

D Submittals

D.1 Before Profiling

Provide the Engineer with current, valid documentation, issued by the Department, indicating both the IP and the operator certification.

D.2 Day of Profiling

Submit a printout containing the IP's settings, each segment's left and right wheel path International Roughness Index (IRI) values, and the signature of the operator to the Engineer on the same day of the profiling.

Submit electronic files in ERD format representing the raw data from each pass on the same day of the profiling.

If the Contractor fails to submit actual data to the Engineer on the day of profiling, the Department will require the Contractor to reprofile the measured segments.

D.3 Upon Completion of Pavement Placement

Within 5 calendar days of the placement of all mainline pavement and before beginning corrective work, submit a paper ProVAL summary report for each lane, indicating the results of the "Smoothness Assurance" analyses. Use the ERD filenames in accordance with 2399.2.A, "Inertial Profiler" to create ProVAL summary reports.

If the summary reports indicate no ALR, submit a final spreadsheet summary in accordance with 2399.2.D.5, "After Corrective Work."

D.4 Before Corrective Work

If the summary reports indicate any ALR, submit a written corrective work plan to the Engineer in accordance with 2399.3.E, "Corrective Work." Include the beginning and ending points of locations planned for correction in the corrective work plan. Do not begin corrective work before the Engineer approves the plan.

If the Engineer elects to assess a monetary deduction for ALR in accordance with Table 2399-7 instead of requiring corrective work, submit a final spreadsheet summary in accordance with 2399.2.D.5, "After Corrective Work."

D.5 After Corrective Work

After reprofiling, submit a paper summary ProVAL report for each lane, indicating the results of updated "Smoothness Assurance" analyses to the Engineer. Submit a spreadsheet summary in tabular form, with each 0.1 mi [0.16 km] segment occupying a row to the Engineer. The Contractor may access an acceptable spreadsheet summary template in electronic form on the MnDOT Smoothness website.

2399.3 CONSTRUCTION REQUIREMENTS

Using an IP, measure the final pavement surface for MRI unless otherwise excluded in Table 2399-3.

Unless otherwise approved by the Engineer, perform all profiling in the presence of the Engineer. Schedule profiling with the Engineer. Reprofile any pavement profiled in the absence of the Engineer as directed by the Engineer at no additional cost to the Department.

The Engineer will use a 10 ft [3.05 m] straightedge to evaluate areas excluded from surface testing with the IP in accordance with Table 2399-3.

A Pavement Surface Testing

Remove objects and foreign material from the pavement surface before performing the pavement surface evaluation. Provide traffic control required for testing and performing corrective work on the final pavement surface.

Run the IP in the direction of traffic. Measure profiles in the left and right wheel paths of each lane.

Test and evaluate each lane separately. The Engineer will determine the length in miles [kilometers] of each mainline traffic lane. Operate the IP at the optimum speed as recommended by the manufacturer.

Separate each lane into segments 0.1 mi [0.16 km] in length. Evaluate the remainder segment less than 0.1 mi [0.16 km] in each lane as an independent segment. The Engineer will prorate pay adjustments for length.

Make each pass continuously, regardless of length, and end passes before exclusions in accordance with Table 2399-3, "Areas Excluded from Smoothness and ALR Evaluation." Begin each subsequent pass 50 ft [15.24 m] before, and including, construction headers and end-of-day work joints. In concrete pavements, evaluate terminal headers tying into existing portland cement concrete pavement.

For percent improvement projects, measure Smoothness before the beginning of construction and after the completion of construction. Use the same stationing for the final profiling as the stationing used for the initial profiling to allow for a direct comparison of Smoothness when calculating the percent improvement. Measure the Smoothness Before Paving and the Smoothness After Paving values with the same IP.

The Engineer will use a 10 ft [3.05 m] straightedge to measure for surface deviations greater than ¼ in [6.35 mm] in 10 ft [3.05 m]. The Engineer will evaluate transverse joints by centering the straightedge longitudinally across the transverse joint.

B Exclusions

Table 2399-2 indicates areas that are excluded from Smoothness evaluation, but still require measurement with an IP, and are subject to evaluation for ALR and the 10 ft [3.05 m] straightedge. Table 2399-3 indicates areas that are excluded from surface testing with the IP, but are subject to evaluation with the 10 ft [3.05 m] straightedge

Table 2399-2 Areas Excluded from Smoothness Evaluation
For All Pavements
Paving in areas with a posted vehicle speed less than or equal to 45 mph [73 km/hr]
Ramps and loops
Acceleration and deceleration lanes less than or equal to 1,000 ft [304.80 m] in length
Projects less than 1,000 ft [304.80 m] in length
Bridge decks and approach panels – the occurrence of bridges shall not interrupt the continuity determination
For Bituminous Pavements
Single lift overlays placed directly on concrete
For Concrete Pavements
Intersections constructed under traffic – begin and end exclusion 100 ft [30.48 m] from the intersection radius
Doweled shoulders greater than or equal to 10 ft [3.05 m] in width

Table 2399-3 Areas Excluded from Smoothness and ALR Evaluation
For All Pavements
Paving in areas with a posted vehicle speed less than or equal to 35 mph [56 km/hr]
Turn lanes, crossovers
Paving in areas with a cautionary vehicle speed less than or equal to 35 mph [56 km/hr]
10 ft [3.05 m] on either side of obstructions in lane that obstruction is located
Side streets, side connections
150 ft [45.72 m] before stop signs at an intersection
150 ft [45.72 m] before yield signs at a roundabout
For Bituminous Pavements
Paved shoulders
Intersections where mainline profiles are merged or blended into the cross street profile – begin and end exclusion 100 ft [30.48 m] from the intersection radius
For Concrete Pavements
Doweled shoulders less than 10 ft [3.05 m] in width
Headers adjacent to colored concrete

C Calculations

C.1 Smoothness

Obtain Smoothness values in an individual lane using the ProVAL "Smoothness Assurance" analysis with the 250 mm filter.

For percent improvement projects, use the Smoothness Before Paving and Smoothness After Paving values to calculate the percent ride improvement.

C.2 Areas of Localized Roughness

Identify ALR using the ProVAL "Smoothness Assurance" analysis, calculating MRI with a continuous short interval of 25 ft [7.62 m] with the 250 mm filter.

D Pay Adjustments

D.1 Smoothness

Evaluate Smoothness requirements using the equations and criteria in accordance with the following tables:

(1) Table 2399-4 for bituminous pavements,
(2) Table 2399-5 for concrete pavements, and
(3) Table 2399-6 for percent improvement projects.

The Engineer will base pay adjustments on the segment Smoothness value (or percent improvement value, for percent improvement projects) measured at the completion of surface pavement, unless corrective work is required by the summary report results. If a segment is less than 100 ft [30.48 m] in length and Table 2399-4, Table 2399-5, or Table 2399-6 requires corrective work, the Engineer will waive the corrective work requirement for the segment and instead assess a prorated disincentive. The Department will still subject the segment to ALR analysis in accordance with Table 2399-7

For segments requiring corrective work, reprofile the entire 0.1 mi [0.16 km] segment after performing corrective work as directed by the Engineer and enter the reprofiled Smoothness values into the final spreadsheet summary.

D.1.a Bituminous Pavements

Table 2399-4 contains pay adjustments for bituminous pavements. See Section 2360, "Plant Mixed Asphalt Pavement" of the Special Provisions for the ride equation requirements.

Table 2399-4
Smoothness Pay Adjustments and Corrective Work for Bituminous Pavements

Equation	Smoothness in/mi [m/km]	Pay Adjustment $/0.1 mi [0.16 km]
HMA-A	< 25.0 [0.397]	400.00
	25.0 – 75.0 [0.39 – 1.18]	800.00 – 16.000 × Smoothness [800.00 – 1013.763 × Smoothness]
	> 75.0 [1.18]	Corrective Work to ≤ 50.0 in/mi [0.79 m/km]
HMA-B	< 30.0 [0.52]	270.00
	30.0 – 80.0 [0.47 – 1.26]	594.00 – 10.800 × Smoothness [594.00 – 684.290 × Smoothness]
	> 80.0 [1.26]	Corrective Work to ≤ 60.0 in/mi [0.94 m/km]
HMA-C	< 35.0 [0.55]	180.00
	35.0 – 95.0 [0.55 – 1.50]	390.00 – 6.000 x Smoothness [390.00 – 380.161 x Smoothness]
	> 95.0 [1.50]	Corrective Work to ≤ 65.0 in/mi [1.03 m/km]

For bituminous projects, the Engineer will not pay any positive Total Pay Adjustments if greater than 25 percent of all mainline density lots for the project fail to meet the minimum density requirements in accordance with 2360, "Plant Mixed Asphalt Pavement."

D.1.b Concrete Pavements

For concrete pavements, the Engineer will use equation PCC-A.

Table 2399-5
Smoothness Pay Adjustments and Corrective Work for Concrete Pavements

Equation	Smoothness in/mi [m/km]	Pay Adjustment $/0.1 mi [0.16 km]
PCC-A	< 45.0 [0.71]	890.00
	45.0 – 85.0 [0.71 – 1.34]	2892.50 – 44.500 × Smoothness [2892.50 – 2819.527 × Smoothness]
	> 85.0 [1.34]	Corrective Work to ≤ 65.0 in/mi [1.103 m/km]

D.1.c Percent Improvement Projects

The Engineer will base pay adjustments on the segment percent improvement values. The Engineer will calculate the percent improvement in accordance with the following equation:

$$\%I = \frac{Smoothness\ Before\ Paving - Smoothness\ After\ Paving}{Smoothness\ Before\ Paving} \times 100$$

Determine the Smoothness Before Paving value before patching or other repair. Determine the Smoothness After Paving value after the completion of paving and any corrective work.

Table 2399-6 Smoothness Pay Adjustments and Corrective Work for Percent Improvement Projects		
Equation	**Percent Improvement (%I)**	**Pay Adjustment, per $/0.1 mi [$/0.1609 km] segment**
PI	> 670.0	180.00
	30.0 to 70.0	−180.00 + 5.143 × (%I)
	< 30.0	Corrective Work to %I of at least 80.0

For bituminous percent improvement projects, the Engineer will not pay any positive Total Pay Adjustments if greater than 25 percent of all mainline density lots for the project fail to meet minimum density requirements in accordance with 2360, "Plant Mixed Asphalt Pavement."

Correct segments with a percentage improvement of less than 33.0 percent at no additional cost to the Department as required by the Engineer.

D.2 Areas of Localized Roughness

The Engineer will evaluate ALR in accordance with Table 2399-7, "ALR Monetary Deductions and Corrective Work Requirements."

Table 2399-7 ALR Monetary Deductions and Corrective Work Requirements		
Equation	**25 ft [7.62 m] Continuous MRI, in/mi [m/km]**	**Corrective Work or Monetary Deduction, per linear 1.0 ft [0.30 m]**
HMA-A or HMA-B, and a posted vehicle speed > 45 mph [73 km/hr]	< 175.0 [2.76]	Acceptable
	≥ 175.0 [2.76] to < 225.0 [3.55]	Corrective Work unless both the Engineer and the Contractor agree to a monetary deduct of $25.00
	≥ 225.0 [3.55]	Corrective Work unless both the Engineer and the Contractor agree to a monetary deduct of $125.00
PCC-A and a posted vehicle speed > 45 mph [73 km/hr]	< 125.0 [1.97]	Acceptable
	≥ 175.0 [2.76] to < 225.0 [3.55]	Corrective Work unless both the Engineer and the Contractor agree to a monetary deduct of $25.00
	≥ 225.0 [3.55]	Corrective Work
HMA-C, PI, ramps. loops, concrete intersections constructed under traffic, or any paving with a posted vehicle speed ≤ 45 mph [73 km/hr]	< 225.0 [3.55]	Acceptable
	≥ 225.0 [3.55]	$25.00

The Engineer will consider areas of ALR acceptable if the retested segment contains no ALR. The Department will reduce payment for ALR remaining after retesting as determined by the Engineer and in accordance with Table 2399-7, "ALR Monetary Deductions and Corrective Work Requirements."

D.3 Straightedge Evaluation

The Engineer will allow variations less than or equal to ¼ in [6.35 mm] within the span of the straightedge in the longitudinal or transverse direction to remain in place without correction or penalty.

The Engineer will require corrective work on surface deviations greater than ¼ in [6.35 mm] within the span of the straightedge in any direction. For corrected variations, the Engineer will accept deviations less than or equal to ¼ in [6.35 mm] within the span of a 10 ft [3.05 m] straightedge in any direction.

E Corrective Work

Notify the Engineer at least 24 hr before beginning corrective work. Do not begin corrective work before the Engineer approves the methods and procedures in writing.

Perform corrective work using a surface diamond grinding device consisting of multiple diamond blades, unless otherwise approved by the Engineer. Fog-seal diamond ground bituminous surfaces as required by the Engineer and at no additional cost to the Department. Repair and replace joint sealant damaged by diamond grinding on concrete pavement as directed by the Engineer and at no additional cost to the Department.

The Contractor may correct bituminous pavements by overlaying the area or replacing the area by milling and inlaying as approved by the Engineer. If milling and inlaying or overlaying, perform work in accordance with 2399, "Pavement Surface Smoothness," over the entire length of the correction. If milling and inlaying or overlaying, use a transverse saw cut to begin and end the surface correction.

Perform corrective work across the entire lane width. Maintain the pavement cross slope through corrective areas.

Perform coring to determine if diamond grinding corrective work results in thin pavements, as directed by the Engineer. Provide additional coring for thickness verification at no additional cost to the Department. The Department may reduce the payment for thin pavement sections after diamond grinding. Handle residue and excess water resulting from diamond grinding in accordance with 1717, "Air, Land, and Water Pollution."

Perform surface corrections before placing permanent pavement markings. Replace permanent pavement marking damaged or destroyed by corrective work at no additional cost to the Department.

Reprofile segments containing corrected areas with the same certified IP in accordance with 2399.2.A, "Inertial Profiler" within 5 calendar days after the completion of corrective work required by the Engineer.

F Retesting

Perform retesting as directed by the Engineer and within 30 days of the original profiling.

If the retested Smoothness values differ from the original Smoothness values by greater than 10 percent, the Engineer will use the retested values as the basis for acceptance and pay adjustments. If the retested values differ from the original values by greater than 10 percent, the Department will not pay for the cost of retesting.

If the retested Smoothness values differ by less than or equal to 10 percent of the original Smoothness values, the Engineer will use the original values. If the Engineer verifies the accuracy of the original results, the Department will pay for retesting as directed by the Engineer, except for retesting required after corrective work, at $100.00 per lane mi [$62.14 per lane km] retested or $500.00, whichever provides the greater amount.

2399.4 METHOD OF MEASUREMENT — (BLANK)

2399.5 BASIS OF PAYMENT

The Department will include the cost of the IP, testing, and traffic control in the relevant contract unit price for wearing course mixture for bituminous pavements, concrete pavement for concrete pavements, or for concrete grinding.

Bridges and Structures

2401 CONCRETE BRIDGE CONSTRUCTION

2401.1 DESCRIPTION

This work consists of constructing portions of a bridge made of concrete, except for concrete piling (2452), special wearing courses (2404), and precast concrete members (2405 and 2412).

The Department defines "bridge deck slab" as the complete structural slab and wearing course constructed monolithically. The Department defines "bridge structural slab" as only the structural unit upon which will be constructed a separately cast wearing course. The Department defines "bridge slab" as either "bridge deck slab" or "bridge structural slab."

2401.2 MATERIALS

A Concrete 2461

Provide concrete mix designations as shown on the plans for the specific item of work.

B Reinforcement Bars 3301

C Steel Fabric 3303

D Spiral Reinforcement 3305

E Preformed Joint Filler 3702

F Concrete Joint Sealer, Hot Poured Type 3723

G Concrete Joint Sealer, Preformed Type 3721

2401.3 CONSTRUCTION REQUIREMENTS

A General

Refer to 2402, "Steel Bridge Construction," 2404, "Concrete Wearing Course for Bridges," 2451, "Structure Excavations and Backfills," 2452, "Piling," 2471, "Structural Metals," and 2472, "Metal Reinforcement," for constructing bridges.

B Falsework and Forms

Use forms for concrete except portions of footings that extend into solid rock. Do not cast concrete against the side of an earth excavation instead of forming. If the special provisions allow driving the sheets along the neat line of a footing, the Contractor may use cofferdam sheets as forms for footings.

B.1 Material Requirements, with Allowable Stresses or Loads

B.1.a Falsework Piling

Calculate safe pile-bearing capacities in accordance with 2452, "Piling."

B.1.b Structural Shapes and Fabricated Assemblies

Reduce the safe load capacity for material or fabricated assembly that has a loss of section due to corrosion, damage, or previous fabrication. Do not splice shapes used as beams at points of maximum bending stress. All splices shall develop yield on the gross section and fracture on the net section.

Design trusses, other fabricated sections, and steel beams meeting the requirements of the AASHTO *Guide Design Specifications for Bridge Temporary Works* and the AASHTO *Standard Specifications for Highway Bridges*. The Contractor may increase the allowable stresses in the AASHTO *Standard Specifications for Highway Bridges* by no greater than one-third.

Design and use form ties and other steel devices planned for casting into concrete so that the major part, or the entire device, remains permanently in the concrete. If using a device that passes through a concrete surface exposed to view in the completed structure, use a device removable to a depth of at least 1 in [25 mm] from the concrete face without spalling or damaging the concrete.

B.1.c Lumber

Provide lumber free of defects that may adversely affect its strength or the appearance of exposed concrete lines and surfaces, such as crooks, twists, warps, and variations in dimensions. Surface the side of lumber pieces that will contact concrete. If not using form lining, surface or dress and match abutting edges to prevent mortar leakage.

Working stresses for lumber shall not exceed the maximum stresses specified in the Bridge Construction Manual, Falsework and Forms section. Provide sheathing lumber, either with or without form lining, at least 1 in [25 mm] nominal thick and no greater than 8 in [200 mm] wide for exposed concrete surfaces. If a single piece of lumber will completely cover a concrete surface and the lumber is not cupped or warped, the Contractor may use wider lumber. For curved surfaces with a radius of less than 5 ft [1,500 mm], the Contractor may use sheathing thinner than 1 in [25 mm] nominal as approved by the Engineer.

B.1.d Plywood Sheathing

Provide plywood for form sheathing meeting the following requirements and characteristics:

(1) Consisting of at least five plies,
(2) Nominal thickness of at least ¾ in [20 mm],
(3) Plyform exterior grade with sanded or overlaid surfaces specially manufactured for use as form sheathing, and
(4) Strength requirements as specified in the Bridge Construction Manual, Falsework and Forms section.

The Contractor may use the plywood without backing if it meets the above requirements.

For curved surfaces with a radius of less than 5 ft [1,500 mm] and for slab sections between girders or beams, the Contractor may provide plywood sheathing thinner than ¾ in [20 mm] nominal, as approved by the Engineer.

B.1.e Form Lining

If the contract requires form lining, use plywood sheathing with a smooth surfaced material that will produce a concrete surface substantially as smooth and uniform as that obtained using sanded or overlaid plywood sheathing in good condition with no warps or damaged areas. Use the same kind of form lining material throughout an exposed concrete face. Place the form lining to produce a smooth contact surface that is free of defects. Provide smooth form lining free of defects that cause irregularities that the specified concrete finishing operations in 2401.3.F, "Finish of Concrete," cannot remove.

Provide form lining material with a uniform thickness and edges that form mortar tight joints.

Ensure that bolt, nail, or rivet heads and weld deposits are flush with the form lining face in contact with concrete.

If using form lining sheets or sections, use material that minimizes the number of joints.

B.1.f Forms for Circular Columns

Use forms that can withstand design concrete pressures without distortion. Use forms to produce a concrete surface free of visible ridges and depressions. If form lining is shown on the plans, the Contractor may use fiber molds. When using form brands not previously used, provide the Engineer with the manufacturer's data.

B.1.g Chamfer Strips

Provide chamfer strips, smooth on all sides and uniform in cross section dimensions without rounded corners. If using wood strips, provide wood strips made of straight grain soft wood. Size chamfer strips as shown on the plans and in accordance with 2401.3.B.6, "Form Construction."

B.2 Design of Falsework and Forms

Submit detailed plans for falsework and forms to the Engineer.

Provide falsework members designed to safely carry the following forces:

(1) Deadload of the falsework members only,
(2) Deadload of the green concrete, computed at 150 lb per cu. ft [23.6 kN per cu. m],
(3) A vertical live load of 20 lb per sq. ft [0.96 kN per cu. m] applied on the upper concrete surface,
(4) Deadload of the forms and other falsework members supported by the members, and
(5) Equipment loads and material stockpile loads anticipated for use during construction.

Provide forms designed to safely carry the following forces:

(1) Deadload of the forms only,
(2) The deadload of green concrete, computed at 150 lb per cu. ft [23.6 kN per cu. m],
(3) A vertical live load of 50 lb per sq. ft [2.4 kN per cu. m] applied on the upper concrete surface.
(4) All equipment loads and material stockpile loads anticipated for use during construction.

Consider the specified live load as the minimum. Adjust for concentrated loads that may produce higher live loads on a member than the minimums specified.

Provide falsework and forms designed in accordance with the following as specified in the Bridge Construction Manual, Falsework and Forms section:

(1) Concrete pressures,

(2) Standard formulas,
(3) Allowable stresses,
(4) Deflections, and
(5) Deviations of alignment.

Provide credible information regarding the performance of the proposed falsework and forms under concrete load construction for any type of construction not included in the Bridge Construction Manual, Falsework and Forms section, as requested by the Engineer.

Before using devices or fabrications that the Engineer determines the Department does not have sufficient performance information on, conduct full scale field or laboratory testing of falsework and forms at no additional cost to the Department, as directed by the Engineer.

B.3 Form Lining Requirements

Nail form lining backed by sheathing to prevent bulging. Fasten plywood at least ¾ in [20 mm] thick to its supports to ensure stiffness and close contact between the plywood and supports.

Tightly butt edges of plywood sheets and form panels without offset to form a mortar tight joint. The Engineer will allow the Contractor to patch or seal joints that will not seal with cold water putty, expandable foam, or an equivalent approved by the Engineer.

Place joints in form lining sections or between adjacent form panels following the same horizontal line. Place horizontal joints on all columns of a unit to the same level. Align joints in form lining vertically and horizontally.

On forms for concrete faces exposed to view, drill holes for form bolts through sheathing or form lining without splintering the face of the form in contact with the concrete. If using both sides of sheathing, avoid splintering on both faces.

Use form lining in accordance with 2401.3.B.1.e, "Form Lining," for formed surfaces. The Department will not require use of form lining for buried surfaces or surfaces hidden from view in the completed structure, except as shown on the plans.

If using recessed rustication strips to divide a concrete surface into panels as shown on the plans, set rustications to cover the joints in the form lining. Concrete panels with a rubbed surface finish or a special surface finish do not require form lining joints to be covered by rustication strips.

B.4 Falsework Requirements

Support falsework on piling, on ledge rock, on parts of the structure, or on temporary footings.

Do not weld on the primary stress-carrying steel members of the bridge superstructure except as specified in 2402, "Steel Bridge Construction."

Drive falsework piling to a bearing capacity and penetration that will adequately support the superimposed loads without settlement as shown in the falsework plans.

Use temporary footings to support falsework in accordance with the following:

(1) Submit geotechnical borings, testing, analysis, and calculations, including soil bearing capacity, anticipated settlement, and sliding resistance, for proposed footings showing that detrimental settlement will not occur under maximum construction loads and conditions anticipated at the site.
(2) Protect footings from undermining, freezing, or being overspread with water.
(3) Use when approved by the Engineer, otherwise support with pilings.

Cut off falsework piling in a bent to provide uniform bearing for the pile cap. Securely fasten caps to the pile heads or posts. Securely brace each falsework bent with timber of adequate size as shown on the falsework plans. Securely brace the bents to adjacent bents.

Provide falsework for superstructures in widths greater than the overall width of the superstructure to brace side forms to the falsework.

On bridges with separate roadways, support the form and falsework supports for each roadway slab with beams or girders under that roadway.

Locate primary supports for concrete slab spans and the bottom slab for concrete box girders no greater than 2 ft [600 mm] from the construction joints in the slabs.

Provide falsework for slab overhangs for steel beam spans capable of resisting torsional stresses. Use knee bracing, cross bracing, struts, ties, or other methods approved by the Engineer to prevent pronounced deflections caused by stresses. Bracing is particularly critical when slab overhangs are greater than the beam depth.

B.5 Removal of Falsework

Do not release falsework supporting concrete structures and concrete members until the completion of the curing period in accordance with 2401.3.G, "Concrete Curing and Protection," plus 1 calendar day of drying out time. Release falsework supporting post tensioned structures after stressing the post tensioning tendons as described in the specifications and shown on the plans.

Do not place loads on concrete members until completion of curing and after the release of falsework, unless otherwise approved by the Engineer.

Determine adequate strength for the complete structure using the last concrete cast affected by the release of falsework.

Loosen supporting falsework to allow the concrete to uniformly and gradually take the stresses due to its own weight.

Begin releasing the falsework at or near the center of a span for the full width of the span. Simultaneously release falsework toward both ends of the span unless otherwise approved by the Engineer. On continuous span concrete superstructures, with or without cantilevers and hinges, release falsework simultaneously and uniformly in all spans unless otherwise approved by the Engineer.

Remove falsework piles located within the roadbed to an elevation of at least 4 ft [1,200 mm] below the subgrade adjacent to the pile. Remove falsework piles located in a stream or lake bed and within the limits of low water to the elevation matching the surface of the stream or lake bed. In established navigation channels, remove falsework to an elevation of at least 2 ft [600 mm] below the surface of the channel bottom. Remove all other piles to an elevation of at least 2 ft [600 mm] below ground elevation.

Remove falsework supports used for the top slab of concrete box girder spans and steel box girder spans.

Unless otherwise approved by the Engineer, remove temporary footings unless the top surfaces of the footings are at least 4 ft [1,200 mm] below the grading grade or at least 2 ft [600 mm] under other ground surfaces.

Backfill and compact open excavations resulting from the removal of falsework in accordance with 2451, "Structure Excavations and Backfills," at no additional cost to the Department.

B.6 Form Construction

Provide forms meeting the following requirements and characteristics:

(1) Designed and constructed to safely resist the pressure of fluid concrete under vibration and of other loads incidental to the construction operations,
(2) Constructed and erected mortar tight so that the finished concrete conforms to the dimensions and contours shown on the plans, and so that undulations and waves on exposed finished concrete surfaces do not exceed the maximum shown in the Bridge Construction Manual, Falsework and Form section,
(3) Set true to the designated lines shown on the plans, and
(4) Rigidly maintained until the concrete has sufficiently hardened to allow removal of forms per 2401.3.B.8, "Removal of Forms."

For vertical construction joints in a concrete unit with a rubbed surface finish, locate joints in form sections to allow the removal of the major part of the forms to allow the initial rubbed surface finish on the cast portion.

Construct vertical forms that will permit removal independent from overhead falsework.

Construct forms in a way that rustication strips or smaller form elements will remain attached to the form upon removal from the concrete.

Place sheathing lumber horizontally unless otherwise approved by the Engineer.

Construct splices in wales so the wale remains effective continuously for its entire length. Stagger splices in each member of a double wale at least one stud space.

The Contractor may leave openings in the forms to clean out extraneous matter or to facilitate the placement of concrete if the Engineer approves the number and location of openings. Construct closures for openings to ensure a tight fit flush with the adjoining surfaces.

Unless the plans show otherwise, use chamfer strips with ¾ in [20 mm] sides to form chamfered corners where exposed intersecting concrete surfaces meet at angles no greater than 90 degrees. The Department will not require chamfered corners at the corners of beam stools under decks with mortar tight joints. If the contract does not require joint edging, use similar moldings with ½ in [15 mm] sides at all joints exposed to view. Fasten moldings at intervals no greater than 6 in [150 mm].

Set chamfer strips at the tops of pier caps supported on falsework in a manner that will allow adjustment to true bridge seat elevation after the placement of the bulk of the cap concrete.

The Contractor may provide forms for keyways at construction joints in concrete constructed with nominal lumber dimensions and with side bevels no greater than 1:10.

Provide forms for open joints capable of removal without damaging the joint after the removal of the form.

If the contract requires a construction joint between the bridge slab and railings, curbs, or medians, set the forms for subsequent placement after placement of the bridge slab in all spans that could cause a deflection in the span the superimposed concrete is cast on.

Before setting grade elevations for curbs, sidewalks, medians, and railings, free the concrete box girder spans and concrete slab spans from temporary supports.

Do not drive nails into the hardened concrete to fasten forms for roadway faces of curbs, sidewalks, and medians. Use braces and struts to maintain proper line and batter for roadway curb face, sidewalk, and median forms, if these are cast separately from the slab. Do not use internal spreaders. Remove bolts and pins set or drilled into the slab for the form work to a depth of at least 1½ in [40 mm] below the slab surface without spalling or damaging the concrete. Fill the holes flush with non-shrink grout listed on the Approved/Qualified Products List.

If constructing a bridge with a horizontal curve as shown on the plans, construct the forms for edges of slab, curbs, copings, medians, and railings to that degree of curvature within a tolerance of ⅛ in [3 mm] in 10 ft [3,000 mm].

B.7 Treatment of Forms

Before placing reinforcement, treat the contact faces of forms with a form coating material in accordance with 3902, "Form Coating Material." Apply the form coating at the rate recommended by the manufacturer.

Protect form lining treated before erection from accumulations of dust and dirt.

Use water to flush faces of forms that contact concrete immediately before placement of concrete.

B.8 Removal of Forms

Remove forms and form ties carefully to prevent spalling or marring of the concrete surface and to avoid breaking off concrete corners.

The Contractor may remove forms for the roadway face of curbs, sidewalks, and medians when the concrete can retain its shape and if weather conditions allow the start of the specified concrete finish per 2401.3.F.2.d, "Curb, Sidewalk, and Median Finish," immediately after removing the forms. Allow other forms to remain in place for at least 12 h after casting the concrete or longer if stripping the forms will damage the concrete or prevent disengaging the form ties.

Remove column and wall forms before releasing the falsework supports from concrete supported by the column or wall.

When the contract requires a surface finishing operation to be completed within a definite period of time after casting, remove the forms in time to allow enough time for the finishing operation. Do not remove the forms sooner than the minimum time required for curing. Do not remove forms for rustication, fluting strips, and drain recesses at the same time as the face forms. Leave rustication, fluting strips, and drain recesses forms in place until it is possible to remove these items without spalling, chipping, or marring of concrete corners or edges.

Remove forms for the webs of concrete box girder spans and provide the web concrete with an ordinary surface finish before setting the forms for the top slab in place at that location.

Remove interior forms in concrete box girder spans. Remove deck forms on the interior of steel box girder spans. Clear loose material from the inside of the concrete box girders and steel box girders, and sweep the box clean.

B.9 Re-Use of Forms

The Contractor may reuse forms and form liners if they remain in good condition and strength. If the form lining between supports show conspicuous permanent set, remove the form lining and correct before reuse.

Plug or cover open holes in sheathing. Plug open holes in form lining flush with the lining. Repair blemishes on the form lining surface to a smooth and even surface. Clean adhering concrete and extraneous matter from form surfaces in contact with concrete before reuse.

C Placement of Concrete

C.1 General Requirements

Complete the placement of forms, falsework, bracing, and reinforcement bars for the entire concrete cast and have concrete placement and finishing equipment and curing material on site before placing the concrete.

Notify the Engineer at least 24 h in advance of the casting of concrete to allow the Engineer to inspect forms, reinforcement bars, materials, and equipment. Do not place concrete until the Engineer inspects and approves the work.

Perform mixing, placing, and finishing of concrete under adequate lighting conditions.

Transport and place concrete without segregating the batch materials. Place concrete in or near its final position without displacing the reinforcement while completely enveloping the reinforcement in the concrete.

Keep equipment for transporting, placing, and finishing concrete free of foreign matter and coatings of hardened concrete. Waste the water used for cleaning equipment outside of the forms as approved by the Engineer.

Clean forms and reinforcement bars and remove debris inside the forms before placing concrete.

Place concrete under water only when used for a cofferdam seal and as shown on the special provisions or as approved by the Engineer.

When placing concrete on or against earth and porous rock foundations, moisten the surfaces before placing concrete.

Footings cast in solid rock will not require side forms.

Place concrete between required or permissible joints as shown on the plans in a continuous operation. If a breakdown in the concrete placement operation occurs and the concrete placed to that point sets so that re-vibration is not possible, cover the surface of the concrete with an approved bonding agent or mortar as directed by the Engineer before placing fresh concrete against it.

Place concrete at a rate that does not exceed fluid pressure for which forms were designed. Stop casting operations at signs of overstress or excessive deflection.

Except for seals, deposit and compact concrete in continuous horizontal layers no greater than 1 ft [300 mm] thick. In columns and thin walls, the Contractor may increase the thickness by no greater than 3 ft [1,000 mm]. Place and compact concrete before the concrete in the preceding layer takes its initial set. Place layers of concrete within 1 h of placing the next layer of concrete at the same point, unless otherwise directed by the Engineer.

Do not drop concrete from a height greater than 4 ft [1,200 mm] unless confined in a vertical down spout or other approved type of pipe or unless the Engineer approves another placement method. Use as many down spouts as needed to place concrete at a horizontal level. The Contractor may use inclined pipes, belts, or chutes to discharge concrete into the hopper of the downspout if the Contractor provides approved means of preventing segregation.

Place concrete buckets as close as practical to the point of deposit before discharging concrete at a regulated rate. Do not discharge excess concrete in a pile for rehandling.

Remove laitance and foreign matter if it accumulates on the inside of the forms.

Do not mix dried or hardened concrete accumulations with fresh concrete. As the concrete rises in the forms, keep the form surfaces and reinforcement bars free of concrete spatters that may harden and become part of the mix. Remove dried concrete and dust accumulations on the form surfaces and reinforcement bars above construction joints before placing the next concrete lift. Do not damage the form surfaces, reinforcement bar coating, or the steel-to-concrete bond when removing excess concrete.

Work the coarse aggregate away from the forms. Force the concrete under and around the reinforcement bars without displacing the bars.

If casting a wall or column greater than 5 ft [1,500 mm] tall integrally with a beam, strut, or slab, allow from 30 min to 90 min, as determined by the Engineer, to elapse between placement of the concrete to the level of the bottom of the beam, strut, or slab and placement of the concrete above this level.

For caps supported by more than one column, cast columns uniformly and allow from 30 min to 90 min to elapse, as determined by the Engineer, before placing the cap.

Clean set concrete of loose material, laitance, and dirt before placing fresh concrete against it. Sand or water blast superstructure concrete to clean the set concrete. Avoid damage to coating on reinforcement bars. Before placing the fresh

concrete, draw the forms for the fresh concrete tight against the set concrete. Keep the contact surfaces of the set concrete wet until depositing the fresh concrete.

If the Engineer determines that shock waves from pile driving, blasting, or other operations will damage the concrete, complete these operations before placing concrete or suspend these operations until the concrete gains adequate strength per 2401.3.G, "Concrete Curing and Protection."

Do not support runways for concrete transportation by the forms unless approved by the Engineer.

Remove the span falsework and obtain an acceptable bridge slab cure before placing concrete railings unless otherwise approved by the Engineer.

C.2 Cold Weather Protection of Concrete

Protect concrete from cold weather from October 1 to April 15 when working north of the 46th parallel and from October 15 to April 15 when working south of the 46th parallel.

C.2.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete, to the Engineer for acceptance, including maintenance of temperatures during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plan.

C.2.b General

Preheat the forms, in-place concrete, reinforcement bars, and items including the top flanges of beams to a minimum of 40 °F [5 °C] when the temperatures of these surface areas are below freezing before placing concrete. Do not apply flames directly to concrete or steel.

Provide insulated forms, insulation, or heating and housing facilities to maintain a concrete temperature of at least 60 °F [15 °C] during the curing period. Vent the heated enclosures to prevent the buildup of carbon dioxide.

Provide imbedded temperature sensors and monitoring devices for all bridge slabs. Provide a minimum of two sensors and at least one additional sensor per 5,000 sq. ft [465 sq. m] of bridge slab.

Keep the forms, insulation, and housing enclosure in place until the completion of cold weather protection as defined in 2401.3.G, "Concrete Curing and Protection."

Gradually discontinue the use of cold weather protection so the rate of temperature reduction adjacent to the concrete surfaces does not exceed 20 °F [11 °C] during any 12 h period until the surface temperature reaches the ambient air temperature.

The Engineer will base anticipated concrete placement and curing temperatures on weather forecasts or on typical temperature data for the time of year at the location of the structure.

C.2.c Bridge Slabs, Box Girder Bottom Slabs, and Box Girder Webs

Place and cure concrete in bridge slabs, box girder bottom slabs, and box girder webs in accordance with the following:

C.2.c(1) Ambient Air Temperatures below 36 °F [2 °C]

If the Engineer anticipates air temperatures below 36 °F [2 °C], place concrete only after placing housing needed to heat the pour area and maintain required pour temperatures of at least 60 °F [15 °C].

C.2.c(2) Ambient Air Temperatures above 36 °F [2 °C] during Placement but below 34 °F [1 °C] during Curing

When the air temperature is greater than 36 °F [2 °C] during placement but is anticipated to fall below 34 °F [1 °C] during curing, do not place concrete until as much insulation or housing and heating are in as needed to protect the concrete from freezing. The Contractor may install insulation and housing after completion of concrete finishing, as approved in the cold weather protection plan if the insulation and housing hinders concrete placement.

C.2.d Bridge Deck Slab

Remove the conventional wet curing material from the slab surface at the end of the curing period, if opening a bridge deck slab to traffic before April 15. For 25 calendar days after removing the curing material or until April 15, whichever comes first, heat and provide housing to ensure free air circulation above the concrete surface to dry the concrete and prevent the temperature of the concrete from falling below 40 °F [5 °C].

D Compaction of Concrete

Compact concrete, except for cofferdam seals, using mechanical vibration applied internally. Operate vibrators at a frequency of at least 4,500 impulses per min [75 Hz]. Compact each batch of concrete immediately after placement.

Apply vibrators at points no farther apart than twice the radius of the vibrator's visibly effective range. Manipulate the vibrators to work the concrete around reinforcement and imbedded fixtures and into the corners and angles of the forms. Use

spading to supplement vibration to produce smooth surfaces and dense concrete along form surfaces and in corners and locations unreachable by vibrators.

Apply vibration at the point of deposit of freshly deposited concrete. Vibrate long enough to compact the concrete but not so long as to cause segregation and localized areas of grout. Insert and withdraw vibrators in a vertical orientation.

Do not apply vibration to, or apply vibration directly on reinforcement bars to sections of concrete that has hardened to the degree that the concrete ceases to be plastic under vibration. Do not use vibrators to make concrete flow in the forms; this action will cause segregation.

Use non-metallic vibrator head for compaction of concrete around epoxy-coated components per 2472.3.C.3, "Special Requirements for Coated Bars."

E Joint Construction

Perform joint construction as shown on the plans and in accordance with the following:

E.1 Transverse Construction Joints

Make grooves or saw cuts ⅜ in [10 mm] wide by 1 in [25 mm] deep in accordance with the following unless otherwise shown in the plans or directed by the Engineer:

(1) At transverse construction joints in the bridge slab unless otherwise directed by the Engineer,
(2) To the full width of the roadway between gutter lines, and
(3) Directly over the construction joint before placement of curb forms.

E.2 Weakened Plane Joints

Use a grooving tool or a removable insert when casting the slab to extend and form a weakened plane under sidewalks and at other slab locations where a saw cut is not possible. Place the insert or groove to cut the fresh concrete on a straight line to a depth of 1 in [25 mm]. When using an insert, coat with oil or grease before placement. Withdraw the insert when the concrete has set enough to retain the groove shape with the insert removed.

Locate the weakened plane to fall vertically below the sidewalk, curb, or median joint at that location. On skewed bridges with exterior girders or beams under curbs, sidewalks, or medians that are normal to the longitudinal axis of the bridge, extend the weakened plane using a removable insert. Place the insert as a continuation of the line to be cut, extending to the centerline of the exterior girders or beams.

Outward from the centerline of the exterior girders or beams, place the weakened plane common to the joint placed in the curb, sidewalk, or median. Form a vertical ½ in [13 mm] v-shape in the edge of the slab at the end of the weakened plane at that location.

E.3 Open or Filled Joints

Form the distance between faces of open joints with removable inserts, headers, or templates to provide the opening shown on the plans for the temperature range prevailing at the time of concrete placement. Refer to the tabulation shown on the plans or shop drawings for the required openings at various temperatures. The temperatures listed represent the temperature anticipated when the slab is cast. Joints may widen due to concrete shrinkage.

After placing the bridge slab adjacent to an elastomeric seal expansion joint, and after curing and drying the concrete, the Engineer will measure the constructed joint openings. The Engineer may reject openings that deviate from the size shown on the plans by greater than $^{3}/_{16}$ in [5 mm] as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work." The Department will also consider offsets at joints between segments as unacceptable work.

The Contractor may use preformed joint filler to form vertical joints. When using cork joint filler to form a vertical joint, anchor with copper nails 2½ in [65 mm] long at 20 in [500 mm] centers. Where the contract requires chamfered corners at joints created by using preformed material, trim the preformed filler back to the inside of the vee formed by the chamfer strip.

E.4 Expansion Joint Devices

Provide, assemble, and install bridge slab expansion joint devices as shown on the plans and in accordance with 2402.3.K, "Expansion Joint Devices."

F Finish of Concrete

F.1 General

Surface finish concrete that is properly set, and only during weather conditions, or with weather protection, approved by the Engineer.

F.2 Formed Surfaces

F.2.a Ordinary Surface Finish

Provide ordinary surface finish on formed surfaces of concrete structures. If applying special surface finishes to conventionally formed concrete surfaces, sand or water blast the surface before ordinary surface finishing to break the surface film and to remove laitance, form release agent, dirt, and other foreign matter that might adversely affect adhesion of special surface finishes.

Immediately after removing the forms, examine the concrete surfaces for defects. Remove and repair concrete with porosity, honey comb, or segregated materials, as approved by the Engineer. The Engineer will approve the time, method, and materials used to make concrete repairs. Repair small areas with mortar as specified for surface cavities. The Engineer may require formed surfaces to repair large areas. The repairs may require a bonding agent, mechanical bonds, or both. Cure repair work as approved by the Engineer. The Engineer may reject concrete sections with extensive, irreparable defects as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

Remove fins and projections from exposed surfaces and from surfaces that will be waterproofed.

Clean, saturate with water, and fill with mortar all surface cavities produced by form ties. Clean, saturate with water, and fill with mortar all surface cavities on exposed surfaces with a diameter of at least ⅜ in [10 mm]. The Department defines "exposed surfaces," as surfaces exposed to view in the completed structure, above low water, and above the final ground line. At unexposed surface locations or areas where the Engineer determines repairs will not affect the appearance of the completed structure, clean and fill cavities caused by removing falsework, brackets, form ties, or hanger rods with a silicone caulk listed on the Approved/Qualified Products List for "Moisture Cured Polymeric Joint Sealer."

Use mortar consisting of three parts standard portland cement, six parts mortar sand, and water to fill surface cavities. Use enough water to produce a mortar consistency as dry as possible to use effectively. Mix the mortar 1 h before use.

Provide a latex or acrylic-based bonding agent listed on the Approved/Qualified Products List for special surface finish. Mix the bonding agent into the mortar used for ordinary surface finishing on areas that will receive a special surface finish. Add the bonding agent to the mixing water at a ratio of one part bonding agent to three parts water.

Fill the cavities with mortar. Compact the cavities in place, point, and trim flush with the concrete surface. On exposed surfaces, remove mortar stains or streaks outside the area of the filled cavity.

After completing the concrete work, remove visible streaks, stains, and blemishes from the surface if the special provisions do not show additional surface finishing on an exposed surface. Perform additional surface finishing on an exposed surface for which the contract that requires only ordinary surface finish when adjoining form lining sheets present sharply contrasting colors or textures. Provide sack rubbed surface finish as a corrective measure if the surface appearance remains sharply contrasting after the completion of the ordinary surface finish.

If applying the ordinary surface finish before the completion of the curing period, minimize interruption to the curing when performing the finishing.

F.2.b Sack Rubbed Surface Finish

In areas with numerous surface voids on an exposed surface, the Contractor may use sack rubbed finish to fill the smaller voids in lieu of the method described under ordinary surface finish. Fill form tie holes and other cavities of at least ⅜ in [10 mm] in accordance with 2401.3.F.2.a, "Ordinary Surface Finish."

Grind or sandblast the concrete surface to remove blemishes, discolorations, and thin mortar films covering surface voids.

After the completion of the structure, and when further construction will not produce blemishes and discolorations on the surface, perform the following operations:

(1) Saturate the surface with water and, beginning at the top, use a rubber float to apply a mortar mixture to fill the voids. Mix the mortar using the following requirements:
  (1.1) One part standard portland cement,
  (1.2) One part mortar sand, and
  (1.3) Contains sufficient water to produce a moderately thick paste that will remain in place when applied.
  Rewet the concrete surface if it dries before applying the mortar paste.

(2) After the mortar sets in the voids, but before it completely dries, rub the floated surface using a burlap sack filled with a dry mix of mortar to remove mortar in excess of what was needed to fill the voids. The Engineer will approve equally effective means of removing the excess mortar.

(3) Produce a completed surface meeting the following requirements and characteristics:
  (3.1) Free of blemishes, discolorations, and surface voids,
  (3.2) Uniform in texture and appearance, except for the difference in texture between filled voids and the remainder of the surface.

Correct surfaces not meeting the requirements of this section as approved by the Engineer.

F.2.c Special Surface Finish

Provide a special surface finish for bridges and surfaces required by the contract to produce a smooth surface uniform in texture and appearance.

Use a Department-approved system listed on the Approved/Qualified Products List for "Special Surface Finish System," to apply a special surface finishing consisting of commercially packaged mortar, bonding agent, and 100 percent acrylic paint. Blend the mortar, bonding agent, and water in the proportions recommended by the manufacturer. Provide 100 percent acrylic paint in accordance with 3584, "Exterior Masonry Acrylic Emulsion Paint," and blend at a rate of 1 gal per 50 lb [3.8 L per 22.7 kg] of dry mortar mix. Produce a mixture suitable for spray application to vertical concrete surfaces at the specified coverage rate, below.

Mix and remix materials as recommended by the manufacturer.

Apply two coats of the mixture by spraying, as recommended by the manufacturer, using a total coverage rate of 16 sq. ft per gal [0.4 sq. m per L] of material. Use the first coat to cover the entire surface, taking care not to cause runs, sags, or excessive build-up.

The Contractor may begin special surface finishing operations, including any topcoat applications, at an ambient air temperature of at least 39 °F [4 °C] and rising. Suspend special surface finishing operations if the ambient air temperature falls to 45 °F [7 °C] and is dropping.

Begin surface finishing operations only when it is possible to perform the work continuously from beginning to completion on any one bridge.

Perform surface finishing so that after drying the final surface is uniform in color and texture, without evidence of laps or breaks in continuity. Perform corrective work on unsatisfactorily finished areas coated with special surface finishing or topcoat as directed by the Engineer and at no additional cost to the Department.

F.2.d Curb, Sidewalk, and Median Finish

Provide a surface finish of formed surfaces of medians, delineator curbs, and the roadway face of curbs and sidewalks in accordance with the following:

(1) Begin ordinary surface finish operations immediately after removing the forms and work continuously to completion. As the ordinary surface finish progresses, rub the surface with a cork float or fine carborundum stone to produce a paste on the surface and to expose and fill depressions and surface cavities. Float the paste to a smooth surface free of coarse texture, swirls, and ridges. Before the surface sets, brush the surface lightly with a fine bristled brush to remove cement films and produce a uniform surface with a fine grained and sanded texture, and

(2) Complete the surface finishing of the formed surface within 48 h after concrete placement.

F.2.e Railing Finish

Do not allow horizontal or vertical irregularities greater than ¼ in [6 mm] in any 10 ft [3,000 mm] length of finished concrete railing. The Engineer may reject surfaces and edges not meeting this tolerance as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work." Remove and replace unacceptable work as directed by the Engineer. Remove and replace extensive areas (greater than 10 percent of railing length) with deviations greater than ½ in [13 mm]. If the Engineer does not direct the Contractor to remove and replace unacceptable work, the Contractor may leave the work in place with the following price adjustments:

(1) For deviations from $^{5}/_{16}$ in to ½ in [7 mm to 13 mm], the Department will pay for concrete railing at 75 percent of the contract unit price, and

(2) For minor areas (less than or equal to 10 percent of railing length) with deviations greater than ½ in [13 mm], the Department will pay for concrete railing at 50 percent of the contract unit price.

F.3 Unformed Surfaces

F.3.a Miscellaneous Unformed Surfaces

Finish unformed upper horizontal and inclined surfaces, except for the surface of bridge slabs and the surface at horizontal construction joints, in accordance with the following:

Do not use steel trowels and steel shod floats. Use wood or wood shod templates and strike-offs. Use hand floats and darbies with wood, canvas, rubber, or cork contact surfaces. Use metal edgers that do not form offsets greater than $^{1}/_{16}$ in in the concrete surface. Do not create waves in the concrete surface when edging. In lieu of using an edger, the Contractor may form rounded corners using a cove strip that does not create an offset greater than $^{1}/_{16}$ in with adjacent concrete surfaces.

Place excess concrete in the forms and compact by internal vibration. After a 30 min delay, strike off and screed the surface with a template forcing the coarse aggregate below the finished surface leaving the surface slightly above finished elevation to allow for settlement during curing. Repeat the screeding and strike-off operation to obtain the elevation shown on the plans and contour, except for edging. Waste laitance and excess mortar outside of the forms. After the final strike off and screeding, hand

float the surface to correct irregularities and seal surface tears. Immediately after the water sheen leaves the surface, rework the surface to a uniform texture using a float. Tool rounded corners and edges to final radius forcing the coarse aggregate beneath the finished radius. Float to remove trails left by the edging tools.

Apply final texture and finish to the surface in accordance with the following:

(1) Brush or broom bridge curbs and sidewalks and the floor slabs, ramps, landings, and stair treads for pedestrian bridges and tunnels in a transverse direction using a fairly stiff bristled brush or broom to produce a surface finish meeting the following requirements and characteristics:
  (1.1) Visibly serrated,
  (1.2) Not slippery when wet, and
  (1.3) Uniform throughout in texture and appearance.
(2) Brush the cement film from the surface to provide a uniform, fine grained, sanded texture using a fine bristled brush.

Ensure the finished surface does not vary by greater than ⅛ in [3 mm] from a 10 ft [3,000 mm] straightedge laid longitudinally on the surface, with transverse surfaces substantially as shown on the plans.

F.3.b Bridge Slabs

F.3.b(1) General

Before placing concrete for a section of bridge slab, and after setting the strike-off rails or guides to correct elevation, check the top reinforcement for vertical position by operating the strike-off on the rails or guides in the presence of the Engineer. Attach a filler strip ¼ in [6 mm] thinner than the minimum concrete cover requirements to the bottom of the strike-off during this check to detect reinforcement bars that may encroach on the required clearance.

Place the following in a continuous operation proceeding uniformly from edge to edge of the slab or from end to end of the section:

(1) Each bridge slab section between joints,
(2) Each bridge slab section between an end bulk-head and a joint, or
(3) With no joints specified, the entire slab.

If the contract does not require a specific sequence or direction for casting slab sections, submit plans for the proposed casting procedures for approval. Before starting construction, obtain the Engineer's approval for any change to the casting plans.

Perform bridge slab placement and finishing during daylight hours. If working at night, provide a "well-lighted" area to accomplish QC/QA inspections. "Well-lighted" is defined as a minimum of 50 foot candles of artificial light or natural daylight. Use a light meter with readings in foot candles to verify the adequacy of the lighting.

If at least two spans of continuous beams or girders support a bridge slab section, place concrete at a rate that concrete will remain plastic for at least one-half a span length back of an intermediate support until placement has proceeded to a point one-half of the span length ahead of that support. Provide approved admixtures to retard concrete setting time as required to maintain plasticity.

If simple span girders support a bridge slab section or if the Contract requires sequence casting for wide continuous beam bridge decks, place concrete at a forward rate of at least 20 ft per h [6,000 mm per h] without producing cold joints between partially hardened concrete and the adjacent newly placed concrete.

F.3.b(2) Strike-Off of Bridge Slab

On bridge slabs, strike off and screed the roadway surface after concrete placement and compaction. Rescreed to the cross-slope and longitudinal profile as required by the contract.

Remove and displace bleed water or laitance that rises to the surface outside the forms. Do not work, smooth, or disturb the concrete surface while bleed water and laitance remain on the surface.

Place the concrete at a rate that ensures the initial strike-off operation is never greater than 10 ft [3,000 mm] behind the placement operation. Maintain the head of concrete parallel with the initially screeded surface. Leave excess concrete carried in front of the screed on the surface when reaching the head of the concrete. Mix with freshly deposited concrete before compacting. When the initial strike-off operation reveals low areas, fill these areas with additional concrete before continuing. Avoid walking in the concrete after the initial pass of the screed.

Use a combined longitudinal and transverse motion of a template supported or suspended from rigid guides to strike-off and screed the surface. The Contractor may use approved mechanically rotated templates instead of one of the screeding motions. Use rails, bulk-heads, or the side forms as screed guides for manual strike-off. Use rails as guides for power-operated strike-offs, with provisions for vertical adjustment. Support the screed rails for power-operated screeds on the exterior beams, girders, or webs of the structure unless otherwise approved by the Engineer. Obtain the Engineer's approval if planning to support screed rails on the side forms or on any falsework independent of the superstructure.

Construct screed rails in a manner that will allow vertical adjustment after concrete is placed on concrete deck girders and concrete slab span bridges. During concrete placement, check elevations and vertically adjust if necessary.

If an outside webwall of a box girder is under a sidewalk or curb, the Contractor may modify the sidewalk or curb reinforcement to accommodate the running rail system for the power strike-off machine as approved by the Engineer and at no additional cost to the Department.

Use a self propelled power-operated strike-off machine or other machine approved by the Engineer to screed the roadway surface of bridge slabs.

The Department will not require screed rails for templates used for strike-off and screeding of a bridge structural slab. If using screed rails, use screed rails in accordance with this section.

Use templates supported on slab reinforcement bars in accordance with the following requirements:

F.3.b(2)(a) Templates

Provide templates fabricated by a manufacturer with at least 10 years' experience. If using templates greater than 24 ft [7,315 mm] long, demonstrate adjustments for crown breaks as approved by the Engineer. Evenly attach vibrators across template length and provide templates that will automatically shut-off vibration when forward motion stops.

F.3.b(2)(b) Template Supports

Space supports to prevent sag in the template.

For portions of template supports in contact with reinforcement, provide template supports consisting of round tubes or rods with a smooth, low friction surface. Provide skis at least 5 ft [1,520 mm] long with a gradual "turn-up" nose sufficient to prevent entrapment in reinforcement.

Support transverse reinforcement bars within 6 in [150 mm] of the location where template support skis will ride.

F.3.b(2)(c) Operations

Provide a manual or powered winch to advance the template. Do not anchor winch cables to reinforcement bars. The Contractor may attach the winch cable to beam shear studs or stirrups.

Spread and level concrete in front of template without causing "float" or overriding.

F.3.b(2)(d) Reinforcement

Securely tie and rigidly support top reinforcement in accordance with 2472.3.C, "Placing, Supporting, and Tying Bar Reinforcement." Before placing the concrete, demonstrate that the equipment and methods proposed for use will not damage or displace reinforcement bars. Provide additional bar support, additional supports for template, or both upon visible deflections of reinforcement.

If the use of a power-operated strike-off screed is specified, provide mechanical screeding motion with equipment moving on flanged or grooved wheels resting on the screed rails. If exterior beams or girders that lie under the roadway slab support the running rails, the Contractor may finish the area between the rail and the gutter without the use of the power-operated screed. In this area, use suitable guides to determine the required gutter profile and, after plastic shrinkage, straighten and true the area to the required profile and cross-slope. Ensure the screed carries a surplus of concrete in the front during screeding operations. Perform the final screeding to cover as long a section as practicable without stopping.

F.3.b(3) Final Finish Texture

After consolidating, screeding, and floating the concrete draw a carpet drag longitudinally along the bridge slab before the concrete attains its initial set to obtain a final finish texture. Adjust the carpet drag to produce a texture approved by the Engineer. Use a carpet drag meeting the following characteristics and requirements:

(1) Mounted on a work bridge,
(2) A longitudinal length of 3 ft [1,000 mm],
(3) Width equal to the concrete placed,
(4) Artificial grass type,
(5) Molded polyethylene pile face,
(6) Blade length of from ⅝ in to 1 in [15 mm to 25 mm], and
(7) Total weight of at least 70 oz per sq. yd [2.37 kg per sq. m].

In lieu of the carpet drag texturing, the Contractor may use coarse broom texturing as approved by the Engineer.

Immediately following the carpet drag, texture the bridge deck slab surface with a transverse metal-tine pattern produced by using a device meeting the following characteristics and requirements:

(1) Equipped with steel tines from 4 in to 6 in [100 mm to 150 mm] long and from $^{1}/_{12}$ in to ⅛ in [2 mm to 3 mm] thick,

(2) Steel tines arranged to obtain randomized grooves from ⅛ in to $^{5}/_{16}$ in [3 mm to 8 mm] deep, and
(3) Variable spacing between tines from ⅝ in to 1 in [16 mm to 25 mm],

The Contractor may use other texturing equipment that will produce an equivalent texture as approved by the Engineer. Do not texture within 1 ft [300 mm] of curbs.

Hand-float the roadway surface of bridge structural slabs only to close up areas of exposed aggregate. Texture the roadway surface as approved by the Engineer to produce a final surface serrated, grooved, or roughened greater than that normally produced by conventional brooming. Do not tear out or loosen particles of coarse aggregate during texturing.

Produce a final surface meeting the following requirements:

(1) Free of porous spots and irregularities,
(2) Have the required crown,
(3) Does not vary by greater than ⅜ in [10 mm] on a bridge structural slab when checked with a 10 ft [3,000 mm] straightedge placed longitudinally, and
(4) Does not vary by greater than ⅛ in [3 mm] on a bridge deck slab when checked with a 10 ft [3,000 mm] straightedge placed longitudinally.

F.3.b(4) Bridge Slab Finish Under Curbs, Concrete Railings, Sidewalks, and Medians

Float the top surface of the bridge slab under curbs, concrete railings, sidewalks, and narrow medians producing a rough surface with the coarse aggregate embedded in mortar. Provide a smooth finished strip 2 in [50 mm] wide at the edge of the slab and under the roadway face of curbs, concrete railings, sidewalks, and narrow medians.

Choose one of the following alternates to prepare the top surface of the roadway slab directly under wide island type medians:

(1) Sandblast or shotblast the slab surface to remove laitance. Apply a cement bonding grout to the concrete consisting of portland cement mixed with water forming a slurry having the consistency of paint before placing median concrete. Place median concrete on wet bonding grout.
(2) Drill and anchor ½ in [13 mm] diameter dowels into the slab parallel to each median gutterline. Place the dowels 1 ft [300 mm] in from the gutterlines at 2 ft [610 mm] centers. Drill the dowels at least 4 in [100 mm] into the roadway slab and projecting 4 in [100 mm] into the median concrete. Grout the dowels with an approved epoxy or set with approved mechanical anchorages.

F.3.b(5) Bridge Slab Finish for Bottom Slab Concrete Box Girders

Strike off the top surface of the concrete in the bottom slab of concrete box girders and finish to within a ¼ in [5 mm] tolerance when checked with a 10 ft [3,000 mm] straightedge. The Department will not require additional finishing of this surface.

F.3.b(6) Surface Smoothness Check

After completion of the curing period, the Engineer will check the bridge slab surface for trueness, using a 10 ft [3,000 mm] straightedge for transverse and longitudinal checks. The Engineer will perform at least two longitudinal checks in each traffic lane and one check at each gutter. Sweep the surface clean of debris before the Engineer performs the checks.

Correct surfaces outside of the specified tolerance of a 10 ft [3,000 mm] straightedge in accordance with 2401.3.F.3.b(3), "Final Finish Texture," as required by the Engineer. Mill high spots. Remove concrete in low spots designated for removal to at least 2 in [50 mm] below required grade and then recast to the proper grade with an approved product. Restore removed tine texture. The nonconforming areas not satisfactorily corrected are subject to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

Remove high spots before filling adjacent depressions. If not placing a wearing course, coat areas corrected by surface grinding with a surface sealer listed on the Approved/Qualified Products List.

F.3.b(7) Preparation of Bridge Seats

Power grind the bearing areas of bridge seats to produce a surface that does not vary by greater than $^{1}/_{16}$ in [1.6 mm] from the required plane for steel base plates or by greater than ⅛ in [3.2 mm] for elastomeric bearing pads.

G Concrete Curing and Protection

Cure newly placed concrete by providing protection against the following:

(1) Rapid loss of moisture,
(2) Freezing temperatures,
(3) High temperatures,
(4) Abrupt temperature changes,

(5) Vibration exceeding a normal or reasonable limit as specified in the Bridge Construction Manual, Chapter 5-393.362, "Vibration Protection,"
(6) Shock waves, and
(7) Prematurely applied loads.

The Department defines the curing time as the period that begins with completion of concrete placement until completion of the curing as determined by the Engineer. For cast-in-place concrete, continue curing until the concrete attains a strength based on a percentage of anticipated compressive strength in accordance with 2461.2.F.3.b, "Grade Designation," and the following:

Table 2401-1
Curing Requirements for Concrete Bridge Elements

Bridge Element	Percent of Compressive Strength
Bridge superstructures, unless otherwise specified	65
Diaphragms and end webs not a part of box girders and cast before the bridge slab	45
Railing	45
Sections not included in superstructures	45

When the plans show a permissible construction joint, the Contractor may begin subsequent concrete placement before completion of the curing period, unless otherwise shown on the plans.

Do not subject railing concrete to loading until the concrete has attained at least 60 percent of the anticipated compressive strength.

Do not allow heavy equipment, such as ready-mix trucks, on the bridge slab until after completion of the curing period. After the curing period, operate equipment at speeds less than 10 mph [16 km/h] to minimize shock waves. Restrict mixer revolution to agitation speed while on the bridge slab. Do not allow equipment with gross weight greater than 15 ton [14 metric ton] on the bridge slab for box girder and slab span bridges until one week after completion of the curing period.

The Engineer may allow some modification of the requirement for continuous curing without interruption for the purpose of setting wall or column forms on footings, but only when the Contractor protects the concrete from freezing or excessive drying during the interruption period. Resume curing at the earliest opportunity, and cure until completion. If using heated enclosures during the curing period, vent heaters and other equipment operated within the enclosure to prevent the buildup of carbon dioxide.

If the curing period ends after October 15, extend the curing time for bridge concrete to reach 70 percent of its anticipated compressive strength.

Compute strength gain percentages in accordance with Table 2401-2. During freezing or anticipated freezing temperatures, verify the computed strength by casting and breaking control cylinders in accordance with 2461.3.G.5, "Test Methods and Specimens." The Engineer will determine if the concrete has cured adequately if the two methods produce different results.

Table 2401-2
Determination of Strength Gain of Structural Concrete*, % per 24 h

Concrete Surface Temp. ‖ *°F [°C]*	Previously Accumulated Strength Gain † % of 28 Day Value													
	5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
75 [24]	15	15	15	15	14	13	12	11	10	9	8	7	6	6
70 [21]	15	15	15	15	14	13	12	11	10	9	8	7	6	6
65 [18]	14	14	14	14	13	12	11	10	9	8	7	6	6	5
60 [16]	12	12	12	12	11	10	9	9	9	8	7	6	6	4
55 [13]	10	11	11	10	9	8	8	8	8	7	6	5	5	3
50 [10]	8	9	9	8	7	7	7	7	7	6	5	4	4	3
45 [7]	6	8	7	6	6	6	6	5	5	4	4	3	3	2
40 [4]	5	6	6	6	5	5	5	4	4	3	3	3	2	2

* Table values indicate incremental strength gain for 24 h periods at temperatures from 40 °F to 75 °F [4 °C to 24 °C] when the concrete has previously accumulated a specific strength gain percentage.
‖ Represents temperature at the surface of the concrete for the section (or part section) being cured.
† Represents accumulative strength gain of structural grade concrete made with type I cement as a percentage of its compressive strength if cured for 28 days at 75 °F [24 °C].

The Contractor may also use Table 2401-1 for concrete mixtures containing no greater than 15 percent Class C fly ash as a cement substitution. Use control cylinders to determine strength gain for concrete containing ground granulated blast furnace slag in any amount or cement substitutions greater than 15 percent.

If using control cylinders to determine if concrete attained minimum strength, cure in accordance with the following:

(1) Cure sections or units requiring anticipated compressive strength of at least 65 percent for at least 96 h., and
(2) Cure sections or units requiring anticipated compressive strength of at least 45 percent of for at least 72 h.

Do not credit strength gain for any period of time when the concrete does not indicate the presence of a surface-moist condition or when the temperature at the concrete surface is less than 40 °F [5 °C]. The Engineer will consider concrete sections defective if exposed to freezing temperatures or excessive drying during the curing period. Perform the following for defective sections as directed by the Engineer:

(1) Remove and replace,
(2) Remove to a depth as directed by the Engineer and replace,
(3) Sandblast and overlay with epoxy mortar or epoxy with sand broadcast, or
(4) Cover with an epoxy seal coat.

The Department may reduce payment for defective concrete sections as directed by the Engineer.

During freezing temperatures, seal or temporarily fill anchor bolt holes and other depressions that may collect water with closed cell polystyrene or other satisfactory material.

Provide a slab placement and curing plan for each bridge to the Engineer for approval at least two weeks before placement. Include the following information in the placement and curing plan:

(1) Anticipated concrete delivery rates;
(2) Estimated start and finish time;
(3) Material, labor and equipment proposed for placing, finishing, and curing including placement of wet burlap, soaker hose, or other system to maintain the deck in a moist condition during the curing period;
(4) Number of work bridges proposed for use;
(5) Number of people responsible for the various tasks; and
(6) Bulkheading methods and materials proposed for use if the Contractor cannot maintain the proposed concrete placement rates.

Attend a pre-placement meeting 2 days to 4 days before the slab placement to review the information and details provided in the placement and curing plan.

After completing the tine texturing for bridge deck slab and after free water has disappeared from the surface, apply a membrane curing compound in accordance with 3754.2, "Requirements, Poly-Alpha Methylsytrene (AMS) Membrane Curing Compound." Apply curing compound using approved power-operated spray equipment. Provide a uniform, solid white, opaque coverage of membrane cure material on exposed concrete surfaces (equal to a white sheet of paper). Place the membrane cure within 30 min of concrete placement unless otherwise directed by the Engineer. If the Contractor fails to meet these requirements, the Department may reduce the contract unit price for the concrete item in accordance with 1503, "Conformity with Contract Documents."

Provide curing compound for moisture retention until the placement of a conventional wet curing. Apply conventional wet curing when walking on the concrete will not produce imprints deeper than $^{1}/_{16}$ in [1.6 mm]. Keep the deck slab surface continuously wet for an initial curing period of at least 7 calendar days including weekends, holidays, or both if these fall within the 7-calendar-day curing period.

Apply conventional wet curing to bridge slabs immediately following the finishing machine or air screed. Use conventional wet curing consisting of pre-wetted burlap covered with white plastic sheeting. Place the burlap to cover 100 percent of the deck area without visible openings. Place the wet curing within 30 min after the finishing machine completes the final strike-off of the concrete surface. If the Contractor fails to place the wet curing within 30 min, the Department will monetarily deduct $500 for every 5 min period, or any portion thereof, after the initial time period until the Contractor places the wet curing as approved by the Engineer. The Department may assess the deduction more than once. Keep the slab surface continuously wet for an initial curing period of at least 7 calendar days. Use a work bridge to follow the finish machine. Provide an additional center rail on wide bridges, if necessary.

Protect concrete exposed to wind, sunlight, or temperatures that cause surface drying during the curing period by placing a wet covering as soon as the set of the concrete will allow placing of the materials without marring the surface. Do not use membrane curing compound as an alternative for wet curing, except for slope paving, footings, and other sections later covered

with backfill material. Do not use membrane curing compound on an area planned for covering by and bonding to subsequent concrete construction.

Maintain a moist surface condition during the curing period.

The Engineer will accept the curing period as complete when the Contractor meets the requirements of this section.

H Slipforming of Bridge Railing

Instead of using conventional forming methods, the Contractor may slipform concrete bridge railing in accordance with the following requirements:

H.1 Reinforcement Bars

Do not tack weld reinforcement bars. Use additional reinforcement ties at rebar intersections to maintain the rigidity of the reinforcement bar cage.

Place reinforcement in accordance with 2472, "Metal Reinforcement."

H.2 Concrete Mix

Use 3S12 concrete mix design for slipformed railing. The Engineer will reject concrete with a slump greater than 1¼ in [30 mm].

H.3 Construction Requirements

Perform the following construction requirements:

(1) Check the clear distance from the slipform template to the reinforcement bars in the presence of the Engineer. During this check, attach fill strips to the slipformer to detect areas of reinforcement bars that may encroach on the required concrete cover. Perform this check for the full distance of the anticipated subsequent pour area, less any areas of hand-formed rail.
(2) Edge the joints with a small radius edger before placing the curing materials.
(3) If shown on the plans, saw-cut the top portion of the joint to the full depth within 24 h of the concrete placement to a width of ⅜ in [10 mm].
(4) Seal the joint with a silicone sealer listed on the Approved/Qualified Products List. Seal saw-cut joints to a depth of at least 1 in [25 mm].
(5) Conventionally form the ends of the railing with the guardrail plate in place.
(6) Conventionally form the railing sections for a distance of at least 4 ft [1,200 mm] on each side of areas that the slipform machine cannot access.
(7) Maintain the gutter line or railing face location as shown on the plans. The Contractor may increase the slab overhang by no greater than 1 in [25 mm] and batter the outside of the barrier or railing by no greater than 1 in [25 mm].
(8) Use either chamfer or radii strips at horizontal and vertical edges.
(9) Restrict the time interval for delivery of ready-mix concrete to no greater than 1 h when adding the air-entraining agent to the mix at the central plant.
(l0) Wet cure the railing by applying conventional wet curing to the railing immediately following the machine. Use conventional wet curing consisting of pre-wetted burlap covered with separate white plastic sheeting or poly-coated burlap. Place the burlap to cover 100 percent of the railing area without visible openings. Place the wet curing within 30 min after the machine completes the final strike-off of the concrete surface. If the Contractor fails to place the wet curing within 30 min, the Department will monetarily deduct $500 for every 5 min period, or any portion thereof, after the initial time period until the Contractor places the wet curing as approved by the Engineer. The Department may assess the deduction more than once. Keep the railing surface continuously wet for an initial curing period of at least 7 calendar days.

I Joint and Crack Sealing

I.1 Joint Sealing

Place joint sealer material of the type as shown on the plans or special provisions in accordance with 2301.3.L, "Joint Sealing."

Complete concrete curing prior to installation of sealing materials. A minimum of 14 days drying is required prior to application of sealers. Sawcut joints, sandblast, blow clean, and ensure the concrete surfaces are dry at the time the sealer is installed. Perform work as per manufacturer's recommendations.

Construct preformed joint(s) as detailed in the plans and in conformance with the following requirements.

1. Use bituminous felt that complies with AASHTO M33, modified to the extent that the load required to compress the test specimen to 50 percent of its thickness before test be not more than 1200 psi (8274 kPa).

2. Supply cork complying with 3702, "Preformed Joint Fillers".

3. Supply polystyrene complying with the following:

Compressive Strength for Polystyrene Elements		
Type	**Compressive Strength (min.) [5% deflection]**	**Characteristics**
A (High Density)	30 psi [207 kPa]	Closed Cell Expanded Polystyrene
B (Low Density)	10 psi [69 kPa]	Molded Polystyrene
Test for compressive strength of polystyrene in accordance with ASTM D 1621. Furnish evidence that the material meets these requirements, if requested by the Engineer.		

Seal construction joints and saw cuts in the deck, curb face, sidewalk, and median with a concrete joint sealer listed on the Approved/ Qualified List for "Silicone Joint Sealants," or in accordance with 3723, "Hot-Poured, Elastic Type Joint And Crack Sealer," or 3725, "Hot-Poured, Extra-Low Modulus, Elastic-Type Joint and Crack Sealer."

I.2 Crack Sealing

The Engineer will visually inspect the bridge deck slab, including decks of pedestrian bridges, and will mark cracks that require sealing appearing on the top surface of the slabs. Seal cracks with a bridge surface and crack sealer listed on the Approved/Qualified Products List. Apply the sealer as recommended by the manufacturer.

2401.4 METHOD OF MEASUREMENT

A Structural Concrete

The Engineer will separately measure each grade or mix of structural concrete based on the dimensions shown on the plans.

If measuring bridge slab concrete by area, the Engineer will base the measurement on end-of-slab stationing and out-to-out transverse dimensions of the slab.

If measuring sidewalk concrete by area, the Engineer will base the measurement on the end-to-end bridge dimension along the centerline of the sidewalk and the overall width of the sidewalk block.

If measuring raised median concrete by area, the Engineer will base the measurement on the end-to-end slab dimension and overall width of the median.

The Engineer will base the measurement of median barrier concrete on the end-to-end slab dimensions.

The Engineer will measure concrete railings or concrete bases for metal railing based on the horizontal lengths between the outside end faces of railings or end posts.

The Engineer will not deduct for the volumes of concrete displaced by metal reinforcement, structural steel sections, floor drains, conduits, pile headers, chamfer strips with side dimensions no greater than 2 in [50 mm], or for variations in camber and deflections as shown on the plans.

The Engineer will not increase concrete quantity measurements for extra concrete used to secure true conformity of the elevation profile and cross section in the finished roadway slab as shown on the plans. The Engineer will consider floor thickness as the thickness shown on the plans as the minimum thickness, unless the plans show other dimensions. The Engineer will not include concrete for keyways in quantity computations.

B Metal Reinforcement 2472.4

C Structure Excavation

If the plans show separate items for one or more classes of structure excavation, the Department will classify the excavation in accordance with 2451.3.B.2, "Types," and the Engineer will measure the excavation in accordance with 2451.4.A, "Structure Excavation," for cast-in-place structures.

D Granular Material 2451.4.B

2401.5 BASIS OF PAYMENT

The contract unit price for structural concrete of each grade mix includes the cost of constructing the bridge structure complete in place, except for costs with a separate contract unit price as shown on the plans.

If the Contractor elects to pour the concrete end diaphragms with the bridge slab, using the same concrete mix for the diaphragms as used for the slab, the Department will pay the Contract bid price for end diaphragm concrete and will not pay for the end diaphragm concrete using the relevant contract unit price for the bridge slab concrete.

The contract pound [kilogram] prices for *Reinforcement Bars, Steel Fabric,* and *Spiral Reinforcement* includes the costs of providing, fabricating, delivering, and placing the metal reinforcement. The contract pound [kilogram] price for *Reinforcement Bars Delivered* includes the cost of providing, fabricating, and delivering the material. The contract pound [kilogram] price for *Reinforcement Bars Placed* includes the costs of placing the material in the structure as specified.

The Department will pay for structure excavation, soil bearing tests, and backfill materials in accordance with 2451.5, "Basis of Payment, Structure Excavations and Backfills."

The Department contract unit price for the relevant concrete bridge construction contract item includes the cost of providing and placing joint sealer and crack sealer.

The Department will pay for concrete bridge construction on the basis of the following schedule:

Item No.:	Item:	Unit:
2401.501	Structural Concrete (Mix No.)	cubic yard [cubic meter]
2401.511	Structural Concrete (Mix No.)	square foot [square meter]
2401.512	Bridge Slab Concrete (Mix No.)	square foot [square meter]
2401.513	Type ___ Barrier Concrete (Mix No.)	linear foot [meter]
2401.514	___ Median Barrier Concrete (Mix No.)	linear foot [meter]
2401.515	Sidewalk Concrete (Mix No.)	square foot [square meter]
2401.516	Raised Median Concrete (Mix No.)	square foot [square meter]
2401.521	Structure Excavation, Class ___	cubic yard [cubic meter]
2401.539	Reinforcement Bars Delivered	pound [kilogram]
2401.540	Reinforcement Bars Placed	pound [kilogram]
2401.541	Reinforcement Bars ___	pound [kilogram]
2401.542	Steel Fabric ___	pound [kilogram]
2401.543	Spiral Reinforcement	pound [kilogram]

2402 STEEL BRIDGE CONSTRUCTION

2402.1 DESCRIPTION

This work consists of the erection of those portions of bridges and structures that are made of structural steel and miscellaneous metals.

2402.2 MATERIALS

A Structural Metals 2471

B High Strength Bolts, Direct Tension Indicators, and Pin Bolts 3391

C Elastomeric Bearing Pads 3741

2402.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Structural Steel Components of Concrete Bridges 2401

A.2 Steel Piling 2452

A.3 Assembly

Assemble bridge components in accordance with the match markings and erection plans using procedures outlined in the contract. If the contract does not specify assembly procedures, assemble in accordance with recognized practices.

B Handling and Storage of Materials

B.1 Structural Steel

Store girders and beams in an upright position. Keep materials clean, dry, and in a properly drained area. Cover and shelter members that will be stored for greater than 3 months and provide for air circulation around the members.

B.2 High Strength Fasteners

Fasteners include, but are not limited to, bolts, nuts, washers, and DTIs.

Store fasteners in sealed, waterproof containers. Locate the containers in an enclosed structure that is protected from the elements. Submit a fastener storage plan to the Engineer at least 14 calendar days prior to delivery of fasteners. In the plan identify where fasteners will be stored, how fastener condition will be quality controlled, and what measures will be used to prevent corrosion.

Notify the Engineer when shipments of fasteners arrive on the jobsite.

For any work shift, remove from storage only the number of fasteners required for that shift. At the end of the work day, return all fasteners not installed to suitable storage.

Before installation, ensure fasteners meet as-manufactured condition or requalified in accordance with Section 7 of the RCSC "*Specification for Structural Joints Using High-Strength Bolts*".

C Straightening Bent Materials

Straighten plates, angles, and other shapes using methods that will not fracture or damage the metal. Do not heat the metal unless allowed by the Engineer, in conjunction with the Structural Metals Engineer. If allowed and before performing any straightening operations, submit a straightening procedure to the Engineer for review and approval by the Structural Metals Engineer. Do not heat metal to temperatures greater than 1,200 °F [650 °C].

After heating and straightening, allow the metal to slowly cool before inspecting for evidence of fracture or other damage. Repair galvanized and metallized coating in accordance with 2471, "Structural Metals."

D Falsework Design and Construction

At least six weeks before starting construction of the structural steel erection falsework, provide the Engineer with three copies of the detailed plans and specifications and two copies of the associated calculations for the proposed system to construct the falsework. Design the falsework to meet the requirements of AASHTO *Guide Design Specifications for Bridge Temporary Works* and AASHTO *Standard Specifications for Highway Bridges*. Have the falsework plans and specifications prepared by a Professional Engineer, checked by a second Professional Engineer for completeness and accuracy, and certified by one of the aforementioned Professional Engineers licensed in the State of Minnesota. Ensure the documents include details to allow the construction of the proposed system by reference to the plans and specifications only. Show the design criteria on the first sheet of the plans.

Provide the following in the falsework plans, as a minimum:

(1) The size of load-supporting members and transverse and longitudinal bracing,
(2) Connection details for load-supporting members,
(3) Design-controlling dimensions, including the following:
  (3.1) Beam length and spacing,
  (3.2) Post location and spacing,
  (3.3) Overall height of falsework bents,
  (3.4) Vertical distance between connectors in diagonal bracing, and
  (3.5) Other dimensions critical to the design.
(4) The location and method used to adjust falsework to final grade as specified in the Plan.

Do not erect the structural steel until meeting the following requirements:

(1) Provide the Engineer with plans and specifications meeting the above requirements,
(2) The Professional Engineer certifying the falsework plans and specifications has inspected the falsework after erection and has provided written certification to the Engineer stating the as-constructed falsework is approved for use.

Provide timber meeting the following requirements for falsework piles or members;

(1) Sound wood,
(2) Straight, and
(3) Good condition.

Provide straight steel members of adequate strength for the intended use.

Maintain the falsework in place until after permanent bolting of the field connection is complete and the Professional Engineer certifying the falsework erection approves the release of falsework supports. Remove falsework in accordance with 2401, "Concrete Bridge Construction."

Except for attachment of screed rail support pipes, do not weld on primary stress-carrying members of the bridge structure to fasten appurtenances not shown on the plans or on the approved detail drawings. The Contractor may weld screed rail support pipes to the top flange with ¼ in [6 mm] longitudinal fillet welds no greater than 2 in [50 mm] long. Do not weld in the negative moment area, as shown on the plans as "Area A," of the top flange of primary stress-carrying members of the bridge structure.

Prepare the base metal and weld during ambient weather conditions in accordance with 2471.3.F, "Structural Welding."

E Preparation and Erection

Before placing bearing assemblies, survey the bearing seats for accuracy assuring conformance with the Bridge Construction Manual 5-393.372, and present results to the Engineer in writing. Power grind the bearing areas of bridge seats to produce a surface that does not vary by greater than $^{1}/_{16}$ in [1.6 mm] from the required plane for steel base plates or by greater than ⅛ in [3.2 mm] for elastomeric bearing pads.

Immediately before assembly, remove temporary protective coatings from pins and pin holes, and clean the contact surfaces at connections of foreign matter. Clean the contact area between pins and bushings to bare metal for pin holes provided with bronze bushings before assembling.

Paint surfaces inaccessible after erection as required before fit-up.

F Field Fit-up

F.1 Erection Plans, Stability and Safety

Erect structural steel members in a manner that will provide safety to the workers, inspectors, and the public at all time, and without damaging the steel members. Temporarily anchor, brace, and stabilize primary members, such as beams and girders, as erected to prevent sliding, tipping, buckling, or other movement, before placing diaphragms.

If the plans show active vehicular or railroad traffic to travel beneath beams before the complete erection of the beams and diaphragms in a span, submit an erection plan to the Engineer detailing the temporary works required to brace and stabilize beams. Have the erection plan prepared by a Professional Engineer, checked by a second Professional Engineer for completeness and accuracy, and certified by one of the Professional Engineers.

The erection plan will specify the required bolt tension and the numbers of bolts to install in permanent diaphragm connections and in bracing to stabilize the beam. Use struts, bracing, tie cables, and other devices used for temporary restraint of a size and strength capable of withstanding the stresses developed. Erect and brace at least two adjacent beams or girders, including diaphragms and fully tightened bolts, in any one span before suspending operations for the day.

F.2 Assembly

A primary member is defined as any member that carries the primary stresses of the structure. Beams and girders are always primary members unless otherwise noted. When the contract requires full assembly, cross frames and diaphragms are primary members.

Erect primary members using 25% pins and 25% snug tight erection bolts in connections to other primary members.

The Department defines "full assembly" as the method by which the structure was fabricated. It identifies that the structure has had all holes (including transverse members) drilled in a "no load" assembled condition. Field erection practices are required to erect the steel in a manner consistent with how it was fabricated and not induce secondary stresses.

When the contract requires full assembly:

1. Erect all girder lines for simple spans before starting permanent bolting;
2. Do not begin permanent bolting on a continuous span in a continuous series until completion of the full assembly of the immediately adjacent spans in the same series; and
3. Cross frames and diaphragms are also considered primary members.

An exception to the above requirements is where shoring towers are used without interruption to correct alignment, camber, grade, and skew. Shoring towers allow permanent bolting in one span before full assembly of the adjacent spans.

The Engineer may allow permanent bolting of field splices in beams for continuous spans on the ground before full assembly of adjacent spans, provided the beams to be spliced are positioned on firmly supported blocking adjusted and surveyed to confirm the alignment, camber, grade, and skew match those established in the fabrication. Before setting beams for ground splicing, present the survey results to the engineer confirming blocking matches the fabricated condition. Pin ground spliced beams with 25% pins and 25% snug tight bolts and present to the Engineer before permanent bolting. Primary member splice connections that are made up on the ground before erection shall be fully tensioned and inspected, in the no-load condition, prior to any lifting operation.

F.3 Pinning and Bolting

Permanent bolts may be used as erection bolts provided they remain in a condition matching the as-manufactured condition and have not been previously tensioned except as permitted in 2402.G, "Connections." ASTM A325 bolts may be re-tightened in the original location once, provided they have not been tightened beyond limits allowed in 2402.G.2.d, "Inspection."

Provide erection bolts in the same diameter as the permanent connectors. Do not use erection pins larger than the diameter of the hole or smaller than the hole diameter minus 0.030". Unless the contract requires otherwise, use erection washers with erection bolts.

Pins are considered effective for load transfer and geometry control, and erection bolts for maintaining tight steel.

Snug tight is defined as the minimal use of an impact wrench or the full effort of an adult using an ordinary spud wrench to bring all plies of the connection together in firm contact. The term "snug tight" is interchangeable with the field term of "tight steel." Use enough bolts tightened to a "snug tight" condition to bring all parts of the joint into full contact.

Use the following pinning and bolting sequence on all primary stress-carrying members, unless otherwise approved by the Engineer, for establishing the "assembled connection":

1. Install a minimum number of installation bolts to hold the pieces of the connection together during pin installation. Tension of installation bolts cannot restrict alignment of the connection.
2. Install erection pins in 25% of the total number of holes in the connection. Balance the distribution of the pins throughout the connection. With regard to load transfer, a portion of pins may be substituted with erection bolts under the following conditions:
    a. The Erection Engineer, who is a Minnesota registered Professional Engineer, submits signed calculations to the Engineer demonstrating the connection forces during erection may be sustained by the proposed number of pins or be resisted in slip by prescribed number of tensioned erection bolts.
    b. All written comments to the calculations are addressed to the satisfaction of the Engineer.
    c. This exception does not eliminate the need for some amount of pins for the purpose of geometry control.
3. Install erection bolts in a minimum of 25% of the total number of holes in the connection. Balance the distribution of the bolts throughout the connection. Tighten the erection bolts to a snug tight condition.
4. Where required by the Erection Engineer and authorized by the Engineer, tension erection bolts necessary to sustain connection slip resistance. When live loads are carried during erection, use additional bolts and erection pins to compensate for the additional loads.
5. Remove installation bolts installed in step (1)

Check bearing plates and assemblies for contact before placing the permanent connectors. Correct deviations from full bearing between parts, or between the bridge seat and the bearing plates as approved by the Engineer. Readjust diaphragms, cross frames, or splice plates, if required to correct deviations. For extreme deviations, the Engineer may direct re-cambering or other re-fabrication procedures. The Contractor may use properly shaped and sized fills or shims to correct minor deviations as approved by the Engineer.

Make adjustments to erected sections to meet the requirements of section 9.2, "Inspection" of AASHTO/NSBA Steel Bridge Collaboration "Steel Bridge Erection Guide Specifications". Modify field splice plan elevations to account for as-built bearing seat elevation. Shift the spans if required to correct for alignment, skew, and proper anchorage and expansion device locations. Make any adjustments prior to permanent bolting.

Permanent bolting will be authorized after the contractor meets the erection tolerances. Survey the top of beams at the centerline of bearing and centerline of field splice locations. Provide an electronic copy of the X and Y coordinates and elevations to the Engineer. The Engineer will review the survey prior to authorizing permanent bolting. Proceed with permanent bolting at any primary member connection as follows:

1. Install permanent connectors in open connection holes. Tighten the permanent connectors in accordance with G.2.D(1).
2. Tighten bolts systematically working from the most rigid part of the connection to the free edges, in a manner that will minimize relaxation of previously tightened bolts.
3. Tighten fasteners by holding the head of the bolt and turning the nut.
4. Remove pins and any erection bolts not qualified as permanent connectors individually. After removal of an erection pin or erection bolt, replace with a permanent connector and tension before continuing.

Where DTI's are used, perform quality control on permanent bolt tensioning before presenting to the Engineer for final inspection.

Perform permanent connector tensioning before exposure to the elements affects their rotational capacity test characteristics.

F.4 Pin Assemblies

Before assembling pins, coat pins and pinholes, including pinholes with bronze bushings, with a lubricant listed on the Approved/Qualified Products List.

Draw pin nuts tight, except for pin nuts with cotter keys. Upset the exposed thread at the face of the nut by centerpunching to prevent backoff. If tightening pin nuts with cotter keys ensure the cotter key can be freely inserted and the pin is free to turn without binding under the Lomas nut.

G Connections

Unless the contract requires or the Engineer approves otherwise, provide field connections made with high strength bolts or pin bolts. Use the same type of fastener throughout the structure, unless the Engineer approves otherwise.

G.1 Welded Connections

Weld field connections in accordance with 2471, "Structural Metals."

G.2 Connections Using High Strength Bolts

G.2.a General

Install bolts with heads outward for the webs of fascia girders. Install bolts with heads downward for the flanges of beams and girders spanning highways, streets, roadways, and walkways.

G.2.b Bolted Parts

Ensure the slope of surfaces of bolted parts in contact with the bolt head and nut is no greater than 1:20 with respect to a plane normal to the bolt axis. Assemble bolted parts to fit solidly together. Do not separate bolted parts by gaskets or other interposed compressible material.

Assemble joint surfaces, including those adjacent to the bolt heads, nuts, or washers, free of the following:

(1) Scale, except tight mill scale,
(2) Dirt,
(3) Loose scale,
(4) Burrs,
(5) Other foreign material, and
(6) Other defects preventing solid seating of the parts.

Ensure contact surfaces of friction-type joints are free of coating materials such as oil, galvanizing, and rust inhibitors.

G.2.c Installation

G.2.c(1) Bolt Tension

Clean contaminants and corrosion from the threaded portions of bolts and nuts, before installing. Lubricate and dye nuts in accordance with 3391, "Fasteners."

Use the turn-of-nut or direct tension method to tighten nuts on threaded bolts.

If using impact wrenches, provide wrenches capable of performing the required tightening of each bolt in 10 seconds.

Tighten each fastener to provide the minimum bolt tension shown in Table 2402-1 when all fasteners in the joint are tight:

Table 2402-1
Bolt Tension

Bolt Size, *in [mm]*	**Minimum Tension*, *Kips [KN]***
¾ [19]	28 [125]
⅞ [22]	39 [173]
1 [25]	51 [227]
1⅛ [29]	56 [249]
1¼ [32]	71 [316]

* Equal to the proof load meeting the requirements of the length measurement method in ASTM A 325

G.2.c(2) Washers

Provide fasteners with a hardened washer placed under the nut or bolt head being turned during tightening.

Provide high strength bolts with a hardened washer under the bolt head and the nut if used in conjunction with full sized punched holes.

If an outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a smooth beveled washer to compensate for the lack of parallelism.

G.2.c(3) Direct Tension Indicator (DTI) Tightening

When using DTIs to provide the minimum bolt tensions in Table 2402-1, install the indicators, including snug tight fit-up, as recommended by the manufacturer except for the following:

(1) Insert a hardened flat washer between the DTI and fastener if bolting through a short-slotted or oversized hole in accordance with 2471.3.H.1.a, "Line Assembly."
(2) If installing a DTI under the turned element, use a hardened washer to separate the turned element from the DTI meeting the requirements of AASHTO LRFD Bridge Construction Specification 11.5.6.4.7.
(3) Provide compressible washer-type indicators meeting the requirements of ASTM F 959.
(4) Inspect DTIs as recommended by the manufacturer, except as modified in G.2.d(3).

G.2.c(4) Turn-of-Nut Tightening

The Department defines "snug tight" as the minimal use of an impact wrench or the full effort of an adult using an ordinary spud wrench to bring all plies of the connection together in firm contact. Use enough bolts tightened to a "snug tight" condition to bring all parts of the joint into full contact. Complete the initial operation in accordance with 2402.3.F, "Field Fit-up." Place bolts in the remaining holes in the connection and snug tight. Match mark and additionally tighten nuts and bolts by the amount of nut rotation specified in this section, and progress with tightening systematically from the most rigid part of the joint to its free edges. Do not rotate the part not turned by the wrench.

For coarse thread heavy hexagon structural bolts and heavy hexagon semi-finished nuts, rotate nuts from snug tight condition in accordance with the following:

(1) If both faces are normal to bolt axis (with or without use of beveled washers), rotate nuts ⅓ turn for bolt lengths no greater than 4 diameters, ½ turn for bolt lengths greater than 4 diameters to 8 diameters, and ⅔ turn for bolt lengths greater than 8 diameters to 12 diameters.
(2) If one face is normal and the other is sloped no greater than 1:20 (beveled washers not used), rotate nuts ½ turn for bolt lengths no greater than 4 diameters, ⅔ turn for bolt lengths greater than 4 diameters to 8 diameters, and $^5/_6$ turn for bolt lengths greater than 8 diameters to 12 diameters.
(3) If both faces are sloped no greater than 1:20 (beveled washers not used), rotate nuts ⅔ turn for bolt lengths no greater than 4 diameters, $^5/_6$ turn for bolt diameters from 4 diameters to 8 diameters and, 1 turn for bolt lengths from 8 diameters to 12 diameters.

Measure bolt length from the underside of head to extreme end of the bolt. Measure nut rotation as relative to bolt regardless of the element (nut or bolt) being turned. Rotate nuts within the allowable tolerance of $^1/_6$ turn over and zero rotation under the rotation specified in list items (1), (2), and (3) above.

G.2.d Inspection

The Engineer will observe the installation and tightening of bolts to determine that the tightening procedure and bolt tightening tensions comply with the requirements in this section. The Engineer will inspect the bolt tension in accordance with the following procedure unless otherwise specified:

G.2.d(1) Calibration of Inspection Wrench

Provide a manual inspection wrench calibrated in accordance with the following:

Test each combination of bolt production lot, nut lot, and washer lot as an assembly. Test 3 assemblies per combination. Individually place bolts of the same grade, size, and condition, as the bolts under inspection in a calibration device capable of indicating bolt tension. Place a washer under the part turned in tightening each bolt. Provide test bolts in the same length as the bolts used in the structure.

Tighten each test bolt in the calibration device to an initial condition equal to 15 percent of the specified bolt tension and then to the minimum tension specified for its size in accordance with Table 2402-1, "Bolt Tension." Apply the inspecting wrench to the tightened bolt and turn the nut or head 5 degrees, or 1 in [25 mm] at 12 in [300 mm] radius in the tightening direction. Measure the torque applied. Average the torque as measured in the tests of 3 bolts and use this "job-inspecting torque" in accordance with 2402.3.G.2.d(3), "Inspection Procedure for Direct Tension Indicators (DTI)."

Provide the inspection wrench and the bolt tension-indicating device as specified in this section. Allow the Engineer to witness the prescribed calibration tests.

During calibration in accordance with 2402.3.G.2.d(1), ensure the bolt and nut withstand rotation to two times the number of turns as specified in 2402.3.G.2.c(4), "Turn-of-Nut Tightening," without showing visible evidence of stripping the threads or failure of the bolt or nut.

G.2.d(2) Inspection Procedure for Calibrated Wrench

At the Engineer' option, either the Engineer or the Contractor in the Engineer's presence may operate the inspecting wrench as follows:

(1) Inspect the tightened bolts in the structure by applying, in the tightened direction, the inspecting wrench and its job-inspecting torque to a randomly selected 10 percent of the bolts or at least 2 bolts in each connection.
(2) Accept connections as properly tightened if nut or bolt heads do not turn when applying the job-inspecting torque as indicated in item (1) above. If a nut or bolt head turns during the application of job-inspecting torque, apply the job-inspecting torque to all bolts in the connection. Retighten and re-inspect nuts or bolt heads turned by the job-inspecting torque. The Contractor may retighten the bolts in the connection and resubmit the connection for the specified inspection procedure.

G.2.d(3) Inspection Procedure for Direct Tension Indicators (DTI)
Check the performance of the DTIs in the field before bolting.

Use the gap between the protrusions to indicate the tension in the bolt.

At the Engineer's option, either the Engineer or the Contractor in the Engineer's presence may operate the tapered leaf thickness (feeler) gauge as follows:

(1) An initial visual inspection of the DTIs after the bolts are snug tight. Remove and replace DTIs completely crushed during snugging.
(2) Place a feeler gauge into a randomly selected 10 percent of the DTIs or at least 2 DTIs in each connection to inspect the tightened bolts in the structure. Measure the gap between the washer and the bolt head in the spaces between the protrusions using the tapered leaf thickness (feeler) gauge. Tighten the bolt to 1.05 times the required installation tension. Ensure an average gap for coated DTIs of at least 0.005 in [0.125 mm]. Do not tighten DTIs beyond crushing of the protrusion.
(3) If the feeler gauge can be inserted into all of the spaces between the protrusions of a DTI, retighten the bolt and retest.
(4) If the feeler gauge cannot be inserted into any of the spaces between the protrusions of more than 10 percent of the DTIs during the inspection, replace the affected bolts.

G.3 Connections Using Pin Bolts
Install pin bolts in accordance with 2402.3.G.2.a, "Connections Using High Strength Bolts, General," 2402.3.G.2.b, "Bolted Parts," and the following:

Provide a special tool capable of the following to drive the pin bolts:

(1) Partial swaging of the collars to allow for adjustment during erection when pinning and bolting the work,
(2) Producing the required tension in the bolt,
(3) Swaging the collar into the annular locking grooves, and
(4) Forming the collar into the size and shape recommended by the manufacturer before the pin tail breaks.

Provide a device capable of indicating the actual bolt tension to test the pin bolts before use. Provide at least 3 typical bolts of each size and length for tests from the supply of bolts used in the work. Test other bolts during the bolting operation, as directed by the Engineer. Use the same installation tool used for tightening and swaging the bolts for the field connections to apply tension in the bolts during the testing procedures.

Recover the expendable pin tails from the driving tool as the pin tails break from the bolt. Do not allow expendable pin tails from the driving tool to drop and create hazards.

Obtain the Engineer's approval of the testing and installation procedures for pin bolts.

H Setting Anchor Bolts
Unless the contract requires otherwise, drill holes for anchor bolts to the diameter and depth shown on the plans. Accurately set and fix the bolts with portland cement grout that completely fills the holes. During freezing weather, the Contractor may use other products, as approved by the Engineer, to set and fix the bolts.

Set nuts for anchor bolts as shown on the plans and provide for clearance where required. Center punch the bolt thread at the face of the nuts to upset the thread and prevent back-off.

Use templates to accurately set anchor bolts at the proper location and elevation that are to be cast in the concrete.

I (Blank)

J Bearing Assemblies and Hangers
Plumb rocker bearings and hangers at 45 °F [7 °C]. Consider elongation resulting from total load deflection when setting these devices.

K Expansion Joint Devices

Provide expansion joint devices by the type shown on the plans as given in the item name. The type number identifies the required minimum movement capability in inches [millimeters] of the device as installed. The maximum movement capability of the joint device as installed may range up to 50 percent greater than the specified minimum.

Provide shop detail drawings for expansion joint devices in accordance with 2471.3.B, "Shop Detail Drawings." Include detailed instructions for installation and tabulated joint openings for the various temperatures shown on the plans.

The Contractor may use joint devices with movement capability greater than 50 percent of the specified minimum if the joint devices meet the functional requirements and the shop drawings indicate the sizes proposed.

Provide steel components of expansion devices in lengths that will facilitate installation under roadway and traffic conditions existing during placement. Do not splice in the gland except at "tee" intersections requiring vulcanized splices. Provide smooth faced welded gutter sections at the grip surface.

Galvanize structural steel surfaces of the expansion devices, including anchorages, after manufacture in accordance with 3394, "Galvanized Structural Shapes." Provide bolts for roadway sections of the expansion devices that meet the Type 316 requirements in 3391.2.E, "Stainless Steel Bolts." Provide bolts for curb, sidewalk, median, and barrier cover plates that meet the Type 316 requirements in 3391.2.E, "Stainless Steel Bolts," or galvanize in accordance with 3392, "Galvanized Hardware." Straighten steel extrusions and roadway plates after galvanizing to a tolerance of ±⅛ in [3mm] in 10 ft [3 m].

Install expansion devices in accordance with the shop drawings and as directed by the Engineer. Remove joint-forming material from the joint opening.

Provide a watertight expansion joint installation. Test the watertight quality of the complete expansion joint installation at all points by filling the joint opening or portions thereof with water as directed by the Engineer, then observe the test for 1 hour.

L Field Painting

After completing the erection work, clean and paint structural metals in accordance with 2478, "Organic Zinc-Rich Paint System," or 2479, "Inorganic Zinc-Rich Paint System," whichever is applicable.

2402.4 METHOD OF MEASUREMENT

The Engineer will measure structural metals placed in bridges or other structures by weight, length, area, or unit complete in place.

A Weight

The Engineer will calculate the weight of all structural steel shapes, structural steel plates, steel sheets, and steel bars based on the net finished dimensions as shown on the plans using the theoretical density of 490 lb per cu. ft [7,849 kg per cu. m]. The Engineer will not make allowances for the fabrication of girder, cambers, haunches, and sweeps, or for the machining of surfaces. The Engineer will not make deductions for open holes and incidental bevels or chamfers. The Engineer will increase the summation of the weights of structural steel, exclusive of steel piling, by 1.5 percent to compensate for incidental metals such as the following:

(1) Permanent bolts no greater than 6 in [150 mm] long,
(2) Shop or field high strength bolts,
(3) Field shims,
(4) Weld metal deposits,
(5) Extra material used to make weld procedure tests,
(6) Shop galvanizing,
(7) Metallizing, and
(8) Overruns, etc. for which the Engineer does not make measurements.

The Engineer will calculate the weight of bolts greater than 6 in [150 mm] long and tie rods used for connecting structural steel parts, including nuts and washers, from the nominal weight shown in the AISC *Manual of Steel Construction*. The Engineer will include this weight with the measurement of structural steel.

The Engineer will calculate the weight of non-incidental metals, other than steel, using the theoretical densities shown in the AISC *Manual of Steel Construction* using the above measurement limitations, except the Engineer will not measure the weight of bolts, nuts, rivets, washers used in the fabrication and erection, and will not apply a percentage increase to the weight.

B Length

B.1 Metal Railing

Unless otherwise shown on the plans, the Engineer will measure the length based on the sum of the lengths of the various sections as shown on the plans and as measured at the base of the rail.

B.2 Pipe

Unless otherwise shown on the plans, the Engineer will measure the length based on the sum of the lengths of all the runs, measured on the centerline of the pipe and fittings.

B.3 Expansion Joint Devices

The Engineer will measure expansion joint devices of each type by length based on the out-to-out distance along the centerline of each expansion device.

B.4 Other Items

The Engineer will base linear measurement of items not specifically covered herein between the limits as shown on the plans.

C Area

The Engineer will measure the area based on the net finished dimensions unless otherwise shown on the plans. The Engineer will not make deductions for open holes.

D Complete Unit

The Engineer will include the component parts in the measurement of the complete assembly of a unit.

2402.5 BASIS OF PAYMENT

The contract unit price for the specific structural steel item includes the cost of temporary support and restraint in accordance with 2402.3.F, "Field Fit-up."

The contract unit price for structural metals includes the weight of all structural metals in a single total.

The contract unit price for *Furnishing Structural Steel, (Spec. No.)* includes the cost of providing and fabricating in accordance with 2471, "Structural Metals;" surface preparation and shop coat painting in accordance with 2478, "Organic Zinc-Rich Paint System," or 2479, "Inorganic Zinc-Rich Paint System," unless otherwise required by the contract; and delivering the materials to the project site.

The contract unit price for *Erecting Structural Metals* includes the cost of erecting the structural metals complete in place and, if the plans do not include a contract pay item for field coat painting, the cost of field coat painting.

The contract unit price for *Structural Steel, (Spec. No.)* includes the cost of providing and fabricating in accordance with 2471, "Structural Metals;" surface preparation and shop coat painting in accordance with 2478, "Organic Zinc-Rich Paint System," or 2479, "Inorganic Zinc-Rich Paint System," unless otherwise required by the contract; delivering the materials to the project site, and erecting the materials.

The contract unit price for metal railings includes the cost of coating, metal posts, fittings, castings, anchor bolts, and accessories required for erection.

The contract unit price for *Expansion Joint Devices, Type* ___ includes the cost of providing and installing the devices complete in place, including curb, sidewalk, median, barrier sections, coverplates, and waterproof glands.

The contract unit price for *Elastomeric Bearing Pad, Type* ___ and *Elastomeric Bearing Assembly, Type* ___ includes the cost of providing and installing the pads or assemblies complete in place.

The Department will pay for steel bridge construction on the basis of the following schedule:

Item No.:	Item:	Unit:
2402.504	Sheet Metal, (Spec. No.)	pound [kilogram]
2402.521	Structural Steel, (Spec. No.)	pound [kilogram]
2402.532	Furnishing Structural Steel, (Spec. No.)	pound [kilogram]
2402.533	Erecting Structural Metals	pound [kilogram]
2402.546	Floor Drain, Type ___	each
2402.555	Rigid Steel Conduit	pound [kilogram]
2402.560	Metal Pipe (Spec. No.)	pound [kilogram]
2402.583	Ornamental Metal Railing ___	linear foot [meter]
2402.584	Structural Tube Railing Design ___	linear foot [meter]
2402.585	Pipe Railing	linear foot [meter]
2402.586	Plate Railing	linear foot [meter]
2402.590	Elastomeric Bearing Pad, Type ___	each
2402.591	Expansion Joint Devices, Type ___	linear foot [meter]
2402.592	Elastomeric Bearing Assembly, Type ___	each
2402.595	___ Bearing Assembly	each

2403 WOOD BRIDGE CONSTRUCTION

2403.1 DESCRIPTION

This work consists of constructing wood bridge structures, or portions of bridge structures made of timber and lumber.

2403.2 MATERIALS

A Structural Wood Components

A.1 Component Grading and Symbol Designations

Provide stress-rated timber and lumber in accordance with 3426, "Structural Wood," for the grade specified.

Provide lumber for laminating meeting the following requirements:

(1) Graded in accordance with 3426, "Structural Wood;"
(2) Allowable working stress, base resistance, or both values, as required by the contract; and
(3) Meeting the requirements of ANSI/AITC A190.1

A.2 Timber Piling 3471

A.3 Other Lumber 3457

B Preservative Treatment

Provide wood treated with preservative in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products," unless otherwise required by the contract.

C Adhesives

Provide adhesives meeting the requirements for wet-use (waterproof) in accordance with ANSI/AITC A 190.1 and AITC 405.

D Dowels

Provide dowels made of hot rolled steel in accordance with 3306, "Low-Carbon Structural Steel," and galvanized in accordance with 3394, "Galvanized Structural Shapes."

E (Blank)

F Plank for Laminated Floors

Provide plank strips for laminated floors surfaced on one side to a uniform thickness no greater than 3 in [75 mm] (SIS). Unless the plans show otherwise, the Department will not require surfacing to a uniform width.

Provide 50 percent of the strips at least 16 ft [5 m] long. Use strips at least 6 ft [2 m] long, except to fill skews. Provide strips in variable lengths to ensure joints on one stringer are no closer than each third strip.

G (Blank)

H Railings

Provide timber and lumber for railings free from blemishes that detract from the appearance of the finished work. Surface timber and lumber for railings on four sides (S4S).

I (Blank)

J Hardware

Galvanize hardware, including nails, spikes, and wood connectors after fabrication in accordance with 3392, "Galvanized Hardware."

Provide bolts in accordance with 3391.2.C, "Bolts for Wood Construction," unless otherwise shown on the plans.

Provide drift bolts with counter-sunk heads and chisel points, lag screws, and rods in accordance with 3306, "Low-Carbon Structural Steel," for incidental items.

Provide properly proportioned plate washers to develop the full strength of the bolt. Provide round washers with diameters, and square washers with side dimensions, at least 3.5 times the diameter of the bolt and with a thickness of at least one-half the diameter of the bolt, unless otherwise shown on the plans. The Contractor may cut washers for bolts no greater than ½ in [12 mm] in diameter from medium steel plate.

Provide wood connectors of standard manufactured products in the size and type as shown on the plans.

2403.3 CONSTRUCTION REQUIREMENTS

A Cutting and Framing

Cut, frame, and bore treated wood before treatment.

Drive nails and spikes to set the heads flush with the surface of the wood. The Engineer may reject wood pieces or members with deep or frequent hammer marks in exposed wood surfaces.

B (Blank)

C Handling and Storage

Handle, transport, and store wood without damaging portions that will remain in the completed structure. Do not split or damage the surfaces and edges. Do not puncture the treated surface of treated wood with pointed tools, temporary bolts, or spikes.

D Framing

Accurately cut and frame lumber and timber, true and exact to a close fit to construct the joints with an even bearing over the entire contact surfaces. Do not shim the joints or construct open joints.

D.1 Holes in Untreated Wood

Bore holes in untreated wood with diameters in accordance with the following types of hardware:

Table 2403-1
Holes in Untreated Wood

Hardware Type	Bore Hole Diameter
Round driftbolts and dowels	$^{1}/_{16}$ in [2 mm] less than the diameter of the bolt or dowel
Square driftbolts or dowels	Equal to the least dimension of the bolt or dowel
Machine bolts	Same diameter as the bolt
Rods	$^{1}/_{16}$ in [2 mm] greater than the diameter of the rod
Lag screws	No larger than the body of the screw at the root of the thread

D.2 Holes in Treated Wood

Bore holes in treated wood at least $^{1}/_{16}$ in [2 mm] larger than the holes specified in Table 2403-1.

E Field Treatment

Carefully trim and coat the following in treated piles and timbers with a preservative in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products," and meeting the requirements of AWPA Standard M4:

(1) Field cuts (except pile cut-offs),
(2) Daps,
(3) Field bored holes, and
(4) Abrasions.

Wait at least 2 h between each application.

For pile cut-offs, treat the tops of treated timber piles used in wood bridge construction with three applications in accordance with the requirements in this section.

F Piling

Provide timber piling in accordance with 2452, "Piling."

G Sills

Finish concrete pedestals, where required for the support of framed bents, to ensure even load bearing transfer to sills or posts placed on the pedestals. Extend the dowels for anchoring the sills at least 9 in [225 mm] above the tops of pedestals. Set dowels while casting pedestals.

Provide sills with true and even bearing on piles or pedestals. Drift-bolt sills to the piles using bolts extending into the piles at least 9 in [225 mm]. Remove earth from around the sills to provide free air circulation.

Use dowels extending at least 6 in [150 mm] into posts and sills to fasten posts to sills.

H Caps

Place timber caps to obtain an even and uniform bearing over the tops of the supporting posts or piles and to provide an even alignment of their ends. Use driftbolts extending at least 9 in [225 mm] into posts or piles to secure caps, except wing pile caps. Place the driftbolts in the center of each post or pile.

I (Blank)

J Bracing

Fasten bracing to the pile or post and cap using bolts at least ¾ in [20 mm] in diameter in tandem with split or tooth ring connectors. Use wire spikes, boat spikes, or spike grid connectors to bolt and spike intermediate intersections as shown on the plans.

K Stringers and Bridging

Size stringers at bearings. For stringers one panel long, place with knots near the edges in the top portion of the stringers. For stringers two panels long, place with knots near the edges in the compression edges of the stringers and stagger lapped joints over the supports.

Provide outside stringers with butt joints. Provide lapped interior stringers to take bearing over the full width of the floor beam or cap at each end. Toenail or bolt to fasten lapped ends of stringers as required by the contract.

Accurately frame cross bridging members with bevel cut ends. Place cross bridging members providing full bearing at each end against the sides of stringers. Use two nails at each end to hold each cross bridging member securely. Set the cross bridging before placing the floor. Tightly set and nail the top ends home. Nail the lower ends only enough to hold the bridging in place. After placing the floor and wearing surface, readjust the lower ends of cross bridging, draw tight to the face of the stringers, and fully nail as required by the contract.

Place block or header bridging before laying the subfloor. Fully nail the blocks at the top and only temporarily nail at the bottom. After placing the entire floor, complete nailing of the bridging. If using bolts or lag screws to fasten block bridging as shown on the plans, do not final tighten the bolts or lag screws until after placement of the entire floor.

Cut block bridging square and to the accurate length to avoid the need for shims. If end shims are necessary, use zinc or galvanized sheet steel. Use end shims the size of the end of the block, with additional width to allow nailing along one side of block. Use galvanized roofing nails to hold shims in place.

Place cross bridging at the center of each span unless otherwise shown on the plans.

L (Blank)

M (Blank)

N Prefabricated Wood Panels

Provide and install nail or glue laminated wood panels for use in bridge superstructures in accordance with the following:

N.1 Nail Laminated Panels

Cut individual wood members for use in the panels to the proper length and drill dowel holes. Treat members with preservative in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products." Fabricate members into panels.

Provide panels fabricated as shown on the plans and assemble at the fabrication plant before delivery to the project. Match-mark the panels before shipment. Provide panel lengths with a tolerance of ⅛ in [3 mm] of the dimension shown on the plans. Install the panels to provide an overall deck width within ¼ in [6 mm] of the panel dimension shown on the plans.

N.2 Glued Laminated Deck Panels

Provide and install glued laminated deck panels as shown on the plans and meeting the requirements of this section, the American National Standards for Wood Products – Structural Glue Laminated Timber – ANSI/AITC A 190.1, and AITC 405. Provide shop details to the Engineer. Do not begin fabrication work until the approval of the shop details by the Engineer in accordance with 2471.3.B, "Shop Detail Drawings."

N.2.a Appearance Grades

Surface finish the panels meeting the requirements of AITC Industrial Appearance Grade, except the Department will not require finishing the roadway surface of the panels. Place individual planks to achieve the maximum corrugation on the roadway surface.

N.2.b Dowel Holes

Drill dowel holes $^{1}/_{16}$ in [2 mm] greater in diameter than the dowel and ½ in [12 mm] deeper than necessary to provide the planned dowel projection before the preservative treatment process.

N.2.c Marking and Protection

Match-mark the panels before shipment. Do not end seal, surface seal, or wrap the panels.

N.2.d Preservative Treatment

Fabricate glue-laminated desk panels; remove excess glue from all panel surfaces, except on roadway surfaces, before treating with preservative.

N.2.e Inspection.....3491.3
Provide an independent commercial inspection agency's Certificate of Compliance, including the test results, and an approval certification mark on each panel, showing conformance with the requirements of this section (2403).

N.2.f Assembly
Verify dowel projection and conformance with dimensions as shown on the plans at the project site before assembly.

O (Blank)

P (Blank)

Q (Blank)

R Railings
Frame railings as shown on the plans. Ensure accurate railing alignment during erection.

S Hardware
Place driftbolts in the structure with the chisel point at right angles to the grain of the unbored sections of the connected pieces.

Use plate washers for bolts at least ½ in [12 mm] in diameter, unless using bolt heads and nuts that provide an equivalent bearing surface and strength.

Provide wood connectors of the type shown on the plans. Install the split ring and the shear plate in precut grooves of the dimensions as shown on the plans or as recommended by the manufacturer. Use pressure equipment to force the toothed ring and the spike grid into the contact surfaces of the joint. Simultaneously and uniformly imbed connectors of this type at a joint. Install the claw plate using a combination of precut grooving and pressure equipment.

2403.4 METHOD OF MEASUREMENT

A Treated or Untreated Wood
The Department will separately measure treated wood and untreated wood by the unit of measure based on nominal sizes and lengths incorporated in the structure. The Engineer will not provide allowance for waste except beveled ends.

The Department will measure panels by the number of acceptable units of each type provided and installed, including panel hardware.

B Hardware
The Department will measure hardware by weight if the contract includes a specific contract item for hardware. The Department will include of the cost of nails, dowels, or panel hardware with other relevant contract items.

2403.5 BASIS OF PAYMENT
The Department will pay for wood bridge construction on the basis of the following schedule:

Item No.:	Item:	Unit:
2403.501	Untreated Wood	Mbm*[cubic meter]
2403.502	Treated Wood	Mbm*[cubic meter]
2403.506	Hardware	pound [kilogram]
2403.508	Prefabricated Wood Panels, Type ___	each
2403.510	Glued Laminated Deck Panels, Type __	each

* 1,000 board-feet measure

2404 CONCRETE WEARING COURSE FOR BRIDGES

2404.1 DESCRIPTION
The work consists of constructing a portland cement concrete wearing course on a bridge structural slab or approach panel.

2404.2 MATERIALS
Provide a wearing course made of low slump concrete placed at least 2 in [50 mm] deep in accordance with the following:

A Low Slump Concrete

Provide low slump concrete in accordance with 2461, "Structural Concrete," and as modified by the following:

A.1 Mix Requirements

Do not substitute slag cement or fly ash in the low slump concrete.

Provide No. 3U17A concrete mix using the maximum quantity of water-reducer meeting the requirements of the Concrete Manual.

A.2 Slump Requirements

Provide No. 3U17A concrete mix with a slump as specified in 2461, "Structural Concrete."

A.3 Air Content Requirements

Provide No. 3U17A concrete mix with an air content as specified in 2461, "Structural Concrete."

B Bonding Grout

Provide grout consisting of portland cement mixed with water to form a slurry with the consistency of paint to bond the new concrete to the bridge structural slab. Coat the in-place concrete, including vertical joints, immediately before placing the concrete wearing course.

C Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound 3754

2404.3 CONSTRUCTION REQUIREMENTS

A General

Provide equipment to proportion, mix, place, and finish the concrete as approved by the Engineer.

Place the concrete wearing course on the bridge structural slab after the slab has cured for at least 7 days unless the contract requires a longer curing period for the bridge structural slab. Place the concrete wearing course on the approach panels after the panels have cured for at least 72 h.

Mix concrete in accordance with the Concrete Manual requirements for the equipment used. Mix the concrete until uniform in composition and consistency. Provide concrete at a rate allowing the finishing operations to proceed at a steady pace and completion of the final finishing in accordance with 2404.3.D, "Concrete Placement and Texturing." Provide placing and finishing equipment, including adequate hand tools, to place and work the concrete to the correct level for strike-off.

B Finishing Machine

Use a power-operated finishing machine approved by the Engineer and meeting the following requirements:

(1) Designed for normal operating conditions that provide an elapsed time between depositing the concrete on the bridge deck and the final screeding no greater than 15 min.
(2) Capable of obtaining positive machine screeding of the plastic concrete,
(3) Contains a screed capable of extending at least 6 in [150 mm] beyond the edge of a subsequently placed section and capable of overlapping the edge of a previously placed section at least 6 in [150 mm].
(4) Capable of forward and reverse motion under positive control, and
(5) Contains screeds capable of being raised to clear the screeded surface when traveling in reverse.

Demonstrate the capability of the finishing machine to produce results in accordance with 2404.3.D, "Concrete Placement and Texturing," under the project conditions, unless otherwise directed by the Engineer.

Place rails on the outside of the wearing course area to support the traveling finishing machine. Provide rail anchorages for horizontal and vertical stability. Do not ballistically shoot rail anchorages into concrete that will not be overlaid.

After setting the rails to the grade and elevation shown on the plans and before placing the concrete, check the clear distance from the bottom of the screed to the top of the prepared concrete surface in the presence of the inspector. Attach a fill strip or other approved device to the bottom of the screed during this check to detect areas encroaching on the wearing course thickness shown on the plans. Set sufficient screed rails to perform the clearance check in one continuous run over a distance equal to one complete day's placement. Make corrections as directed by the Engineer to obtain the thickness shown on the plans.

When necessary, place longitudinal joints at the edge of traffic lanes as approved by the Engineer.

C Deck Preparation

Within 48 h before placing the concrete wearing course, clean the slab surface and shotblast the entire bridge surface and approaches to be overlaid. Shotblast to remove surface film, laitance, fractured concrete particles, and other materials that may impede the bond of the concrete wearing course. Remove the steel shot before placing the concrete wearing course.

Control and abate the dust generated by the blasting operation meeting the requirements of MPCA Rule 7011.0150. Submit the proposed plan for dust abatement to the Engineer at least 14 calendar days before starting the work.

Power sweep the bridge and approach slabs before blasting. Use the least amount of water necessary to minimize the dust from the sweeping operation.

Provide housing for the blast wheel or blasting nozzles meeting the following requirements and characteristics:

(1) Contains a negative air emission control system that draws the confined air and dust into a filtered collection system.
(2) Contains an exhaust system with the capacity for relieving the pressure generated within the housing by the blasting equipment, and
(3) Sides and corners flexible at the bottom to allow the bottom of the housing to contact the deck surface during blasting operations.

Clean the filter collection system to ensure proper filtration.

Provide a housing and filter collection system constructed, maintained, and operated to eliminate avoidable dust emissions.

After blasting, hand sweep or use a "pickup" type power sweeper equipped with adequate dust storage capacity to sweep the prepared surface. Remove minor debris remaining after the sweeping operation by air blasting. Provide an air supply system with an oil trap placed in the air supply line between the storage tank and the nozzle.

Shotblast, sweep, and clean the bridge structural slab before placing the concrete wearing course. Allow time for the Engineer to inspect the surface during daylight hours.

Within 12 h of placing the concrete wearing course, use potable water to pre-wet the deck surface to a saturated surface dry condition (not absorbing water from or contributing water to the concrete mixture). Maintain the saturated surface dry condition for at least 6 h. Do not allow free water on the surface when placing the bonding agent as stated in 2404.2.B, "Bonding Grout."

D Concrete Placement and Texturing

Place and finish concrete at a linear rate, measured parallel to the centerline of the bridge, of at least 40 ft [12 m] per h under normal working conditions. Do not place concrete wearing course placement widths greater than 24 ft [7.3 m], unless otherwise shown in the special provisions.

Place joints in the concrete wearing course directly above the original joints constructed in the bridge structural slab and in accordance with 2401.3.E, "Joint Construction." Make saw cuts as soon as the concrete can be cut without raveling the surface and expeditiously to minimize the exposure of the uncured concrete to surface drying. Seal saw cuts with joint sealer in accordance with 3723, "Hot-Poured, Elastic Type Joint And Crack Sealer," or 3725, "Hot-Poured, Extra-Low Modulus, Elastic-Type Joint and Crack Sealer."

After consolidating, screeding, and floating the concrete, draw a carpet drag longitudinally along the pavement before the concrete attains its initial set. Adjust the carpet drag to produce a texture as approved by the Engineer.

Use artificial grass type carpet drag meeting the following characteristics and requirements:

(1) Mounted on a work bridge,
(2) A longitudinal length of 3 ft [1,000 mm],
(3) Width equal to the concrete placed,
(4) Artificial grass type,
(5) Molded polyethylene pile face,
(6) Blade length of from ⅝ in to 1 in [15 mm to 25 mm], and
(7) Total weight of at least 70 oz per sq. yd [2.37 kg per sq. m].

In lieu of the carpet drag texturing, the Contractor may use coarse broom texturing as approved by the Engineer.

Immediately following the carpet drag, texture the bridge deck slab surface with a transverse metal-tine pattern produced by using a device meeting the following characteristics and requirements:

(1) Equipped with steel tines from 4 in to 6 in [100 mm to 150 mm] long and from $^{1}/_{12}$ in to ⅛ in [2 mm to 3 mm] thick,
(2) Steel tines arranged to obtain randomized grooves from ⅛ in to $^{5}/_{16}$ in [3 mm to 8 mm] deep, and
(3) Variable spacing between tines from ⅝ in to 1 in [16 mm to 25 mm],

The Contractor may use other texturing equipment that will produce an equivalent texture as approved by the Engineer. Do not texture within 1 ft [300 mm] of curbs.

Do not extend tining into areas within 1 ft [0.3 m] of a gutterline.

Ensure the final surface does not vary by greater than ⅛ in [3 mm] within a 10 ft [3 m] straightedge laid longitudinally on the final surface. This surface tolerance includes areas near expansion devices and other breaks in the continuity of the wearing course.

Remove and replace the surface areas not meeting the tolerances specified above. Alternatively, grind the high spots on the surface areas not meeting the tolerances specified above as directed by the Engineer. The Department defines uncorrected nonconforming areas as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

Perform sealing operations in accordance with 2401.3.I, "Joint and Crack Sealing."

If the National Weather Service predicts a daytime temperature of at least 80° F [27° C] for a scheduled concrete placement, reschedule the placement or begin the concrete placement between midnight and 5:00 a.m. Terminate placements at 5:00 a.m. that are started after midnight, but not completed by 5:00 a.m. if the ambient air temperature is at or above 80° F [27° C]. If the air temperature is below 80° F [27° C] at 5:00 a.m., the placement may continue until such time as the temperature reaches 80° F [27° C]. Do not place concrete wearing course if the air temperature falls below 40° F [5° C] or if the slab surface shows signs of frosting.

Notify the Engineer at least 24 h in advance of scheduling a night operation. Provide artificial lighting to ensure quality workmanship and adequate inspection.

Except if heating and housing the concrete, do not place concrete for wearing courses in accordance with the following requirements:

(1) Before April 15th,
(2) After September l5th, north of the 46th parallel, or
(3) After October 1st, south of the 46th parallel.

The Contractor may place concrete for wearing course before April 15 or after September 15 or October 1 as specified above, if heating and housing the deck and performing the following:

(1) Submit a plan and proposed time schedule for cold weather protection and maintenance of acceptable curing temperatures to the Engineer. Do not begin work until the Engineer approves the cold weather protection plan and all materials identified in the plan are on site.
(2) Provide the concrete with suitable housing immediately after placement allowing free air circulation above the surface and protecting the concrete against freezing, rain, or snow.
(3) Provide pre-heating for the structural slab before concrete placement if necessary. Provide insulation blankets or heating facilities to maintain the curing temperatures in item (4) below.
(4) For low slump concrete, maintain the concrete surface or enclosure temperature at 60° F [16° C] or higher for the first 96 h after concrete placement. Do not expose the concrete to temperatures lower than 40° F [5° C] until at least 26 calendar days after the initial 96 h period; and
(5) Do not remove the housing enclosure until fulfilling the cold weather protection needs as approved by the Engineer.

E Low Slump Concrete

E.1 Mixer Requirements

Provide mixing equipment in accordance with 2461, "Structural Concrete," except use a continuous mixer with metered proportioning capability.

Complete the following:
(1) Provide mixing equipment in accordance with 2461, "Structural Concrete," except use a continuous mixer with metered proportioning capability.
(2) Notify the Engineer at least five (5) calendar days before calibration test so that the Engineer is present during the test.
(3) Calibrate the mixer on site in the presence of the Engineer.
(4) Provide written documentation that the continuous mixer is calibrated before using it on the job, and
(5) Mix concrete at the job site.

E.2 Finishing Machine Requirements

Provide a finishing machine meeting the following requirements and characteristics:

(1) Contains at least one oscillating screed, and
(2) Designed to consolidate the concrete to 98 percent of rodded density by vibration.

Install identical vibrators or pillow blocks with eccentric cams to provide at least one vibrator or source of vibration for each 5 ft [1.5 m] of screed length. If only vibrating one screed, vibrate the front screed. Ensure the bottom face of the screed is at least 5 in [125 mm] wide and contains a turned-up or rounded leading edge to minimize surface tearing. Ensure each screed produces a pressure of at least 75 lb per sq. ft [366 kg per sq. m] of screed area on the bottom face. Provide each screed with positive control of the vertical position, angle of tilt, and shape of the crown. Equip the finishing machine with an adjustable power-operated paddle or auger to strike off concrete in front of the first screed.

E.3 Concrete Placement

Scrub the bonding grout into the deck surface and adjacent contact points at a controlled rate (based on field conditions) to prevent drying before covering with the concrete wearing course.

Mechanically strike off the concrete slightly above final grade before consolidating and screeding to final grade.

Saw the wearing course at transverse and longitudinal joints to a straight, vertical edge. Remove trimmings before placing the adjacent wearing course. Do not operate impact equipment in the adjacent lane during the first 72 h after placing the concrete unless otherwise approved in writing by the Engineer. Use thinned bonding grout to seal vertical joints with adjacent inplace concrete surfaces after finishing and texturing to assure the vertical joint is sealed.

E.4 Curing Requirements

Coat the concrete with membrane curing compound in accordance with 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," within 30 min after placing the concrete. Use an airless spraying machine containing the following:

(1) A recirculating bypass system that continuously agitates the reservoir material,
(2) Separate hose and nozzle filters, and
(3) A multiple or adjustable nozzle system to provide variable spray patterns.

Before application, agitate the curing compound in the shipping containers to obtain a homogeneous mixture. Apply the compound to provide a uniform, solid white opaque coverage equal to a white sheet of paper on exposed concrete surfaces. Respray areas that appear to have a coating that is less than a white sheet of paper. Respray membrane film damaged before the placement of the wet cure.

Apply the membrane curing within 45 min after depositing concrete if revibrating the concrete as directed by the Engineer. If the Contractor fails to apply membrane curing in the required time after depositing concrete, the Department will consider this as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work." Remove and replace concrete in areas not coated with membrane curing compound within the required time at no additional cost to the Department.

As soon as the concrete can be walked on without damage, place wet burlap or curing blankets in accordance with 2401.3.G, "Concrete Curing and Protection," for a minimum of 96 h. Maintain burlap in a wet condition for the entire curing period.

After completion of the wearing course curing period, the Engineer will perform a visual inspection of the wearing course, and will locate all cracks appearing on the top surface. Furnish only one of the materials listed on the Department's "Approved/Qualified Product List of Bridge Surface and Crack Sealers". Fill all located cracks with an approved crack sealer following the manufacturer's recommendations, and as otherwise directed by the Engineer prior to opening the bridge to vehicular traffic.

Furnishing and placing the sealer as specified above will be considered to be incidental work for which no direct compensation will be made.

Do not allow vehicular traffic on the concrete wearing course during the 96 h curing period. If the daily mean temperatures during the 96 h curing period fall below 60 °F [16 °C], provide additional curing time before allowing traffic on the surface as required by the Engineer.

2404.4 METHOD OF MEASUREMENT

The Engineer will measure the concrete wearing course by surface area based on the dimensions shown on the plans. The Engineer will not deduct the surface area of expansion devices or other miscellaneous appurtenances.

2404.5 BASIS OF PAYMENT

The Department will pay for concrete wearing course for bridges on the basis of the following schedule:

Item No.:	Item:	Unit:
2404.501	Concrete Wearing Course ___	square foot [square meter]

2405 PRESTRESSED CONCRETE BEAMS

2405.1 DESCRIPTION

This work consists of providing and installing prestressed concrete beams and double Tee-beams for use in bridge superstructures.

2405.2 MATERIALS

A Concrete 2461

Provide concrete produced in a central-mix plant in accordance with 2461.3.F.3, "Certified Ready-Mix Plant Program." The Contractor may use Type I, Type II, or Type III portland cement.

Use Mix No. 1W36 or Mix No. 3W36 concrete for prestressed beams.

Use Mix No. 3W36 concrete for double Tee-beams.

B Reinforcement Bars 3301

C Structural Steel 3306

D High-Strength Low-Alloy Structural Steel 3309

E Seven-Wire Strand for Prestressed Concrete 3348

F Structural Steel Pipe 3362

G Galvanized Structural Shapes 3394

H Galvanized Hardware 3392

I Zinc-Rich Paint Systems 3520

J Plastic Curing Blankets 3756

2405.3 CONSTRUCTION REQUIREMENTS

Provide beams manufactured from a precast/prestressed concrete plant certified by the PCI or by another organization approved by the State Materials Engineer and in accordance with the following:

(1) 2401, "Concrete Bridge Construction,"
(2) 2471, "Structural Metals,"
(3) 2472, "Metal Reinforcement," and
(4) PCI Manual for Quality Control: Precast and Prestressed Concrete.

A General

The State Materials Engineer is the Engineer with authority concerning all matters of plant fabrication and inspection prior to delivery of the materials to the project. The Engineer has authority concerning all matters of fabrication at the project site.

Submit a written notification to the Engineer immediately after placing orders for prestressed concrete beams. Include the name and address of the supplier and the beam manufacturing location.

Notify the Materials Engineer at least 7 calendar days before the beginning manufacturing operations. If the Contractor casts the beams at the bridge site, notify the Engineer at least 7 calendar days before casting to permit inspection of the forms and reinforcement.

If casting the beams at a plant away from the bridge site, provide an office in accordance with 2031.3.A, "Basic Requirements," with air conditioning and access to sanitary facilities. The Department will not require laboratory space.

If, on any day, the Department inspects beam casting at a plant away from the bridge site and less than two beams are cast, the Department will deduct from any moneys due or becoming due to the Contractor the total cost of inspection for that day.

Provide a PCI Level II Certified Technician on site at the start of fabrication and throughout fabrication of the prestressed beams. Provide PCI Level I Certified Technicians to perform quality control functions. Provide a PCI Level II Certified Technician as a supervisor for the quality control staff.

Take precautions to prevent contamination of prestressing steel with oil, dirt, or other deleterious substances and to prevent damage that may result in weakening the prestressing steel that may result in its failure under stress. The Materials Engineer may reject nicked or kinked prestressing steel. Do not allow sparks or pieces of molten metal from welding or burning equipment to contact the prestressing steel. Do not use prestressing steel as a ground for welding equipment.

Galvanize all steel inserts or devices that will be within 1 in [25 mm] of the exposed surface of the finished structure. Galvanize or coat with zinc-rich primer all other steel inserts or devices included in the beam.

B Forms

Provide forms designed to withstand pressure from concrete, vibration, and impact without distortion. Set and maintain forms mortar tight, free of warp, and on a rigid foundation. Set the side form at right angles to the vertical axis of the beam and with the plane of bearing surfaces flat and true. Set side forms during casting as shown on the plans. Maintain side forms during casting until the concrete sets. Provide a tight fit without offset for joints in sectional forms.

Set forms for prestressed concrete beams so the dimensions of the beam after prestress transfer will conform to the plan dimensions in accordance with 2405.3.H, "Tolerances."

Treat the face of the forms in contact with the concrete with form coating material in accordance with 3902, "Form Coating Material," before setting the form in position. Clean the forms of accumulations of oil and other substances before use.

Provide beam end blocks as shown on the plans. The Contractor may increase the length of the end blocks as much as12 in [300 mm] to accommodate sectional forms. Provide end blocks of the same length for beams of the same length in any one span.

C Steel Units

Place, support, and tie reinforcement bars for prestressed concrete beams in accordance with 2472, "Metal Reinforcement."

Cover the reinforcement bars with concrete at least 1 in [25 mm] thick.

Set sole plates for prestressed beams so that after prestress transfer the sole plate locations match the plan locations within the tolerance specified for the plan length of pretensioned beams. Place the sole plates in contact with the bottom form. Maintain position of the sole plates during placement of concrete.

Position floor drains as shown on the plans. Fasten the floor drains to the forms to ensure that concrete placement does not alter the alignment or location.

Remove loose rust, dirt, oil, and other foreign substances from prestressing tendons before erecting the beam side forms.

The Contractor may construct hold-down devices for deflected strands so that the Contractor can remove the device for a distance of at least 1 in [25 mm] from the face of the concrete and plug the hole with mortar. Use free-rolling devices (hold-down and hold-up) at all deflection points. The device may rest on the bottom form and remain in-place. If resting the device on the bottom form, galvanize the part in contact with the form for a distance of at least 1 in [25 mm] from the form.

D Placement of Concrete

Cast the beams in an upright position. Place the concrete in each beam without interruption. Modify the casting procedure if the length of the beams and placement conditions cause a cold joint to form when continuing each lift full length before placing a subsequent lift.

Vibrate the concrete in each beam internally, externally, or both to produce uniformly dense concrete. Do not displace enclosures or steel units when vibrating. Internally vibrate in accordance with 2401.3.D, "Compaction of Concrete," using a vibrator with a non-metallic vibrating head no greater than 1¼ in [32 mm] in diameter operating at a frequency of at least 100 Hz [100 cps].

After striking off the top surface of the beams to the required level, work and hand float the surface to seal open tears in the surface and depress coarse aggregate. Use transverse brooming to roughen the surface.

E Concrete Curing

E.1 General

Begin curing operations immediately after the concrete initially sets. Continue curing until prestress transfer.

E.2 Curing Methods

Use any of the following to cure the beams:

(1) Covering of burlap or canvas kept continuously wet,
(2) Continuous water spray or mist,
(3) Complete airtight seal using plastic curing blankets, or
(4) The moist air or steam method of curing in accordance with 2405.E.3, "Steam Curing" which will be considered to include any methods using an external heat source.

E.3 Steam Curing

Delay the introduction of steam into the curing enclosure, for curing purposes, until the concrete has taken its initial set and at least 3 h after placing the concrete. During the delay period, maintain a temperature within the curing chamber of at least 50° F [10° C] and no greater than 9° F [5° C] higher than the temperature of the concrete at the time of placement. The Contractor may only use steam to maintain the curing enclosure temperature within the limits.

Do not allow steam jets to impinge directly on the concrete or on the forms. Do not allow the rate of rise in temperature adjacent to the concrete to rise at rates greater than 27° F [15° C] per hour. Provide free circulation around the top, sides, and ends of the concrete units. Do not allow the temperatures adjacent to the concrete greater than 158° F [70° C]. Use saturated steam within the curing enclosure. Maintain a temperature in the concrete unit of at least 50° F [10° C] during the curing period. Do not allow a difference in temperature adjacent to the concrete within the enclosure to be greater than 9° F [5° C].

After the expiration of the steam curing period, reduce the temperature inside the chamber at a rate no greater than 40° F [22° C] per hour until the temperature inside and outside of the chamber equalize. After removing beams from the chamber, protect the beams to avoid cooling at a rate greater than 40° F [22° C] per hour until reaching the air temperature at the storage site.

If removing side forms before the completion of the steam curing cycle (including temperature taper off process), only remove and leave uncovered the minimum area of the curing enclosure at any one time needed to remove each individual form section. Close the open area in the enclosure immediately upon removing each form section or within 15 min after first uncovering the area.

When removing the beams from the casting bed during the cooling-off process, take appropriate measures to keep the beams warm during the moving operations, and immediately resume the cooling-off process at the storage area.

Provide two continuous recording thermometers for each casting enclosure with a casting bed length no greater than 100 ft [30 m]. Provide an additional thermometer for each additional 100 ft [30 m], or fraction thereof, in the length of the casting bed within each enclosure. Locate thermometers in each curing enclosure as approved by the Materials Engineer. Submit complete temperature recording charts for all cures to the Materials Engineer.

Discontinue steam curing and use one of the other approved curing methods, if the records indicate noncompliance with temperature and time element specifications for steam curing.

F Tensioning

F.1 Equipment

Tension prestressing tendons using hydraulic jacks or dynamometers and hydraulic jacks. Equip each jack pump with a hydraulic pressure gauge. Calibrate jacks, gauges, and pumps as a unit under conditions similar to operating conditions. Provide a dated, certified calibration curve for each combination used. Recalibrate equipment presenting erratic results during tensioning operations.

Ensure the hydraulic pressure gauges can accurately determine the actual stress on the jacks within a tolerance of 2 percent of the total indicated stress during final elongation of the prestressing tendons.

Calibrate the dynamometer used to measure an initial tension. Ensure the dynamometer can accurately determine the initial tension within a tolerance of 5 percent.

F.2 General Procedures

Conduct the tensioning procedure so that it is possible to compare the indicated stress on the tendons based on gauge pressures and the indicated stress based on the corresponding elongation of the tendons at any time during the tensioning operation. If the two indicated stresses, corrected for friction loss, differ by no greater than 5 percent, stress the tendons so the lower of the two indicated stresses equals the required tension in the tendon. Do not tension any tendon to an indicated stress greater than 85 percent of its specified yield point strength. If the indicated stresses differ by greater than 5 percent, stop tensioning operations. Determine the source of the discrepancy and correct it before resuming tensioning operations.

When the tensioning operation includes more than two girders with all deflection points included, demonstrate proper tension at both ends. When tensioning more than four girders with all deflection points included, measure and ensure proper elongation on the interior girders that are more than one girder from an end.

Do not tension prestressing strands in the bundled position with direct contact between adjacent strands. Maintain a clear space of at least ¼ in [6 mm] between adjacent strands during tensioning. Depress tensioned strands into a bundled position with contact between adjacent strands after the completion of tensioning.

Record the gauge pressures, indicated stresses, and elongations, and submit the record to the Materials Engineer.

The Contractor may tension strands as a group if the strands in the group are from the same manufacturer and the strands receive the same initial tension. When tensioning, consider initial strand tension no greater than 150 lb [650 N] per strand

to be zero tension. If the contract requires an initial tension greater than 150 lb [650 N] per strand, use a dynamometer to measure the tension. Add the elongation due to the initial tension to the final elongation measurement.

Tension the deflected strands so that final tension is uniform in all parts of the strand. Provide freely turning rollers to reduce frictional forces at the deflection points.

Correct tension-elongation measurements for losses due to slippage of grips or anchorages, and friction to obtain the prestress force shown on the plans.

If a temperature differential in the strands at the time of tensioning and at the time of concrete placement exceeds 15° F [8° C], consider the change in the final elongation measurements to obtain the required prestress force at the time of casting. Base the change in elongation due to temperature on a ⅛ in per 100 ft [1 mm per 10 m] of strand length for each 15° F [8° C] variation in temperature. Tension prestressing tendons when the ambient air temperature is greater than 32° F [0° C] and rising.

G Prestress Transfer

Perform the prestress transfer after the control cylinders indicate that the concrete has reached a compressive strength of at least 4,500 psi [31 MPa] unless otherwise shown on the plans. When breaking the controls cylinders, use a testing machine that prints all test data, including time and date, directly to a printer, and initial the printout. Make the prestress transfer when the concrete is still warm and moist.

During the prestress transfer sequence keep the lateral eccentricity of the prestress to a minimum and prevent cracking in the top flange of the beams. The Contractor may perform the prestress transfer by the gradual release of hydraulic jacks, by heating exposed portions of individual strands to failure, or by a combination of these two methods. If heating the individual strands, heat in accordance with the following:

(1) Heat each individual strand simultaneously on the strand at no less than two locations along the casting bed. Sequence heating each strand along the bed and with the sequence of perform the prestress transfer between individual strands in a manner that will prevent damage, and
(2) Heat with a low oxygen flame played along the strand for a distance of at least 5 in [125 mm]. Control the heat to ensure that failure of the first wire in the strand does not occur for at least 5 sec after the application of heat followed by gradual elongation and failure of the remaining wires.

Completely strip the forms from the beams before beginning prestress transfer.

H Tolerances

After prestress transfer, check the dimensions of the prestressed concrete beam to verify that the dimensions match what the plans show within the tolerances in the PCI, *Structural QC Manual, MNL-116.*

The Engineer will measure differential camber between adjacent members of the same design with the beams erected in the final position.

The Engineer or the Materials Engineer may reject members that do not meet the dimensions shown on the plans or the specified tolerances.

I Rejection

The Materials Engineer may reject beams failing to meet the requirements of this section or beams showing the following after the removal of forms:

(1) Honeycombing,
(2) Stone pockets,
(3) Sand streaks, or
(4) Imperfect mixing and casting.

The Materials Engineer will not reject beams showing minor surface cavities or irregularities that do not impair the service value if repaired as approved by the Materials Engineer. Make repairs after the Materials Engineer inspects the irregularities. Use repair materials and methods approved by the Materials Engineer.

J Marking, Handling, Storage, and Transportation

The Department will allow beams to be moved from the casting bed to a nearby storage area after attaining the minimum compressive strength for prestress transfer. Do not transport or install beams until the beam attains a compressive strength of at least 5,000 psi [35 MPa], as evidenced by control cylinders. When casting off-site, do not ship the beam until it has reached the full design strength shown in the plans.

Mark each beam with the casting date and piecemark. If casting beams away from the bridge site, mark each beam with the name or trademark of the manufacturer and the bridge number. The Materials Engineer will stamp each approved beam with the official mark of the Department before shipment. Complete repairs before the Department stamps the unit. Do not ship beams

without the Department stamp of approval. After completing the repair work, notify the Materials Engineer at least 1 full business day before intent to ship. The Engineer will perform a final inspection of units upon delivery.

Ensure markings remain in evidence after erection, but not readily visible in the completed structure.

Keep prestressed beams in an upright position at all times. Support prestressed beams during storage, lifting, and transportation at two points only. Considering beam stresses and stability, determine the support point locations in accordance with standard PCI methods.

Obtain permits as required by road authorities.

K Installation

Erect prestressed concrete beams in a manner that will provide safety to the workers, inspectors, and the public at all times, as well as reasonable assurance against damage to the prestressed members. Prior to the placement of diaphragms, temporarily anchor, brace and stabilize the prestressed beams as they are erected so as to preclude sliding, tipping, buckling, or other movement that may otherwise occur. If active vehicular or railroad traffic will be permitted to travel beneath beams prior to complete erection of all the beams and diaphragms in a span, submit an erection plan prepared by an engineer, thoroughly checked by a second engineer for completeness and accuracy, and certified by one of the aforementioned professional engineers licensed in the State of Minnesota which details all temporary works necessary to brace and stabilize beams. Ensure struts, bracing, tie cables, and other devices used for temporary restraint are of a size and strength that will ensure their adequacy. Arrange the work schedule so that each beam will be connected to an adjacent beam and at least two adjacent girders will be erected (including diaphragms and bolts fully tightened) and braced and stabilized in any one span before operations are suspended for the day. Install and permanently fasten the prestressed concrete beams as shown on the plans. Provide intermediate diaphragms for prestressed concrete beams as shown on the plans.

Provide structural steel shapes and plates for the steel intermediate diaphragm option in accordance with 3306, "Low-Carbon Structural Steel," or 3309, "High-Strength Low-Alloy Structural Steel." Galvanize structural steel plates and shapes in accordance with 3394, "Galvanized Structural Shapes."

Provide fasteners, including washers, for the intermediate steel option in accordance with 3391, "Fasteners." Provide fasteners meeting the requirements of ASTM A 325, Type 1. When used with galvanized structural steel, use ASTM A 325, Type 3. Galvanize fasteners for use with galvanized structural steel in accordance with 3392, "Galvanized Hardware."

Use cast-in-place anchorages to connect the steel intermediate diaphragms to the fascia beams. Provide anchorages capable of providing an ultimate pull-out strength of at least 65 kN [15 kips] per anchorage.

Provide plastic or galvanized steel material to form holes in beam webs to connect bolts for steel intermediate diaphragms.

Ensure threaded rods used to attach prestressed concrete beams to cast-in-place concrete diaphragms are either galvanized per MnDOT specification MnDOT 3392 or electroplated in accordance with ASTM B633, service condition SC4.

Completely remove or cut off flush any uncoated items, such as used for static safety lines, anchors, lifting loops, etc., prior to casting the deck.

Provide an ordinary surface finish to the exterior faces of the precast elements in accordance with 2401, "Concrete Bridge Construction". Provide a surface finish as per the special provisions with the beams in place and in conjunction with the final finish of the remainder of the structure in accordance with 2401, "Concrete Bridge Construction.

2405.4 METHOD OF MEASUREMENT

The Engineer will separately measure *Prestressed Concrete Beams Type* ___ as individual units regardless of minor variations in Plan details between beams of the same type.

The Engineer will measure *Prestressed Concrete Beams* ___ by summation of the individual lengths, out to out, along the centerlines of beams.

The Engineer will measure intermediate diaphragms for prestressed concrete I-beams by length based on the horizontal distance from centerline to centerline of beam along the axis of the diaphragms.

2405.5 BASIS OF PAYMENT

The contract unit price for prestressed concrete beams includes the costs of manufacturing, transporting, and erecting the beams in the final position, and the cost of temporary bracing in accordance with 2405.3.K, "Installation."

The contract unit price for prestressed concrete beams includes the cost of constructing the intermediate diaphragms complete-in-place and structural steel or concrete and reinforcement bars as shown on the plans.

The Department will pay for prestressed concrete beams on the basis of the following schedule:

Item No.:	Item:	Unit:
2405.501	Prestressed Concrete Beams Type ___	each
2405.502	Prestressed Concrete Beams ___in [mm]	linear foot [meter]
2405.505	Prestressed Concrete Double Tee-Beam Type ___	each
2405.511	Diaphragms for Type ___ Prestressed Beams	linear foot [meter]

2406 BRIDGE APPROACH PANELS

2406.1 DESCRIPTION

This work consists of constructing bridge approach panels.

2406.2 MATERIALS

A Concrete 2461

A.1 Mix Designation ..... Mix No. 3S52

B Reinforcement Bars 3301

C Curing Materials

C.1 Burlap Curing Blankets 3751

C.2 Poly Alpha Methylstyrene (AMS) Membrane Curing Compound 3754

C.3 Linseed Oil Membrane Curing Compound 3755

C.4 Plastic Curing Blankets 3756

D Granular Materials 3149

E. Form Coating Material 3902

2406.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Excavate, shape, and compact the foundation to a firm, uniform bearing surface in accordance with 2105, "Excavation and Embankment." Construct bridge approach panels to the section and grade shown on the plans.

B Forms

Provide forms made of non-reactive metal, wood, or other material capable of maintaining the concrete until the concrete can retain the molded shape. Provide forms with a height at least equal to the approach panel thickness of the formed concrete as shown in the plans. Support the forms on the foundation to maintain the line and grade as shown on the plans.

On curves with a radius of 100 ft [30 m] or less, use flexible or curved forms of the radius as shown on the plans.

Before placing the concrete, coat the contact surfaces of all forms with form coating material.

C Placing and Finishing Concrete

Immediately before placing the concrete, thoroughly wet the foundation and forms.

Place the concrete in a manner that will prevent segregation. Consolidate the concrete to fill voids using internal vibration. Strike off the concrete to the grade shown on the plans, and float the surface smooth.

Provide the same surface texture as the bridge deck and construct in accordance with 2401, "Concrete Bridge Construction," or 2404, "Concrete Wearing Course for Bridges."

Finish edges with a ⅜ in [10 mm] radius edging tool.

Keep side forms in-place for at least 12 h after casting the concrete.

D Joint Construction

Place joints as shown on the plans.

E Metal Reinforcement

Provide and place metal reinforcement as shown on the plans and in accordance with 2472, "Metal Reinforcement."

F Workmanship and Finish

Ensure completed concrete work is uniform in surface contour and texture and conforms to the lines and grades shown on the plans. Finish the flow line surface of gutters as necessary to eliminate low spots and avoid entrapment of water.

The Engineer will measure the surfaces of the panels with a 10-foot [3-meter] straightedge. The Engineer will consider horizontal or vertical deviations in the surface equal to or greater than ⅜ in [10 mm] in any 10 ft [3 m] length of the finished concrete approach panel to be unacceptable work. Remove and replace extensive areas with deviations greater than ½ in [13 mm]. Remove and replace unacceptable work as directed by the Engineer.

If the Engineer does not direct the removal and replacement of the unacceptable work, the Contractor may leave the work in-place and the Engineer will adjust the contract unit price as follows:

(1) For ⅜ in [10 mm] to $^{9}/_{16}$ in [14 mm] deviations, payment at 75 percent of the contract unit price.
(2) For minor areas with deviations over $^{9}/_{16}$ in [14 mm], payment at 50 percent of contract unit price.

G Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 min of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2406.3.G.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 min after permanent removal of the forms or curing blanket, unless the contract requires otherwise.
(2) Place plastic curing blankets or completely saturated burlap curing blankets in accordance with 2406.3.G.1.b, "Blanket Curing Method," as soon as practical without marring the surface.

Failure to comply with these provisions will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the contract does not contain a separate contact unit price for *Structural Concrete*, the Department will apply a monetary deduction of $50.00 per cu. yd [$65.00 per cu. m] or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

G.1 Curing Methods

G.1.a Membrane Curing Method

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound with an approved airless spraying machine in accordance with the following:

(1) At a rate of 1 gal per 150 sq. ft [1 L per 4 m²] of surface curing area.
(2) Apply homogeneously to provide a uniform solid white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some MnDOT approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.

The Engineer will approve the airless spraying machine for use if it is equipped with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

If the Engineer determines that the initial or corrective spraying results in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method at no additional cost to the Department.

G.1.b Blanket Curing Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

G.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 34 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plan in accordance with 2406.3.G.3.a, "Cold Weather Protection Plan."

Protect the concrete from damage, including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.3.a Cold Weather Protection Plan

Submit a written cold weather protection plan to the Engineer for approval. The plan shall include a proposed time schedule for concrete placement and curing, and plans for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer approves the Contractor's cold weather protection plan.

H Backfill Construction and Opening Bridge Approach Panels to Traffic

Cast the control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens." Cure the control specimens in the same manner and under the same conditions as the bridge approach panel represented. The Engineer will test the control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens."

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 h. Resume vibratory and backfilling operations after the concrete has reached a minimum compressive strength of 2,000 psi [13.7 MPa] or a flexural strength of 250 psi [1.7 MPa].

The Contractor may use hand-operated concrete consolidation equipment and walk behind vibratory plate compactors 24 h after placing the concrete, and other equipment as approved by the Engineer, in conjunction with the Concrete Engineer. The Contractor may also use rollers in "static" mode and fine grading machines.

As soon as possible after the curing is complete and without subjecting the concrete work to damaging stresses, perform the backfill or embankment construction to the elevations shown on the plans. If the contract does require a specific backfill material, use suitable grading materials from the excavations in accordance with 2105, "Excavation and Embankment." Place and compact the backfill material in accordance with 2105, "Excavation and Embankment."

Dispose of surplus excavated materials in accordance with 2105, "Excavation and Embankment."

Do not open a bridge approach panel to general public traffic or operate paving or other heavy equipment on it for 7 days, or until the concrete has reached a minimum flexural strength of 500 psi [3.4 MPa], or minimum compressive strength of 3,000 psi [20.6 MPa]; whichever occurs first.

Perform operations on new bridge approach panels as approved by the Engineer and in accordance with the following:

(1) When moving on and off the bridge approach panel, construct a ramp to prevent damage to the pavement slab.
(2) Operate the equipment on protective mats to prevent damage to the bridge approach panel surface and joints. Before placing the protective mats, sweep the surface free of debris.
(3) Operate equipment on the bridge approach panel without causing damage. Do not operate the equipment wheels or tracks within 4 in [100 mm] of the bridge approach panel edge.

If damage results from any of these operations, the Engineer will suspend all operations until the Contractor takes corrective action and the Engineer approves of a new method. The Engineer may subject damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

I Preformed E8H Expansion Joint Sealers

Select preformed expansion joint material for the E8H expansion joints from the Approved/Qualified Products List.

Install expansion joint material in accordance with the manufacturer's recommendations and as shown on the plans.

2406.4 METHOD OF MEASUREMENT

If the contract contains a contract item (or contract items) for the construction of bridge approach panels, the Engineer will measure their construction as complete-in-place items. The Engineer will measure the total area of all panels of the same basic design. If the contract does not contain this contract item, the Engineer will measure their construction under the relevant contract items provided for pavement construction.

The Engineer will measure the length of expansion joints along the joint line as shown on the plans.

2406.5 BASIS OF PAYMENT

The cost of the following is included in the contract unit price for *Bridge Approach Panels*:

(1) Providing and placing concrete, steel, drainage system, and polyethylene sheeting;
(2) Constructing the integrant curb, terminal headers, and concrete sills;
(3) Protecting and curing the concrete, and
(4) Other incidental work not specifically included for payment under other contract items.

The cost of constructing the joints complete in-place as shown on the plans, including the providing and placing of all materials such as filler, and sealer material is included in the contract unit price for *Expansion Joints, Design E8H*.

Item No.:	Item:	Unit:
2406.553	Bridge Approach Panels	square yard [square meter]
2406.531	Expansion Joints, Design E8H	linear foot [meter]

2411 MINOR CONCRETE STRUCTURES

2411.1 DESCRIPTION

This work consists of constructing concrete structures of miscellaneous types and varied designs, with or without metal reinforcement, and including box culverts, retaining walls, culvert headwalls, open flumes, and other cast-in-place items.

2411.2 MATERIALS

A Concrete 2461

Provide mix designations as shown on the plans.

B Reinforcement Bars 3301

C Steel Fabric 3303

D Preformed Joint Fillers 3702

E Geotextile Filter 3733

2411.3 CONSTRUCTION REQUIREMENTS

Construct minor concrete structures in accordance with 2401.3, "Concrete Bridge Construction, Construction Requirements," and the following:

A General

The Department considers the structure locations shown in the plans as approximate only. The Engineer will establish the exact locations in the field. Each structure shall conform to the planned design, but the Engineer may change the dimensions to fit on-site conditions. Do not order materials until the Engineer establishes the exact locations and dimensions.

Construct box culverts in accordance with the standard box culvert plans pertaining to construction joints, reinforcement bar splicing, and computation of quantities except as modified by the following:

(1) Stagger transverse construction joints at least 4 ft [1,200 mm] in relation to any other joint that would result in a plane of weakness through the culvert structure.
(2) Where long culverts result in lengths of reinforcement bars that are impractical for use, but are less than 60 ft [18.3 m] long, the Department will allow additional splices at no additional cost to the Department.
(3) The Engineer will calculate pay quantities for concrete and reinforcement bars using the formulas as shown on the box culvert plans. The Engineer will adjust the formula quantities to account for additional materials due to design modifications made by the Engineer or to provide for a completed structure in accordance with the plans and special provisions.

Dispose of excavated materials not needed for backfilling excavations in accordance with 2105.3.D, "Excavating Operations," at no additional cost to the Department.

B Falsework and Forms

Use form lining on vertical faces exposed to view in the completed work. If required by the special provisions, provide detailed falsework or forming plans.

C Concrete Curing and Protection

Provide curing protection for concrete structures in accordance with 2401.3.G, "Concrete Curing and Protection," until the concrete has attained a strength gain of at least 45 percent.

D Geotextile Filter

Provide and install geotextile as shown on the plans.

2411.4 METHOD OF MEASUREMENT

The Engineer will measure structural concrete using the dimensions as shown on the plans. The Engineer will separately measure each grade or mix of concrete. The Engineer will not make allowances for quantities in excess of the minimum dimensions shown on the plans and will not make deductions for volumes displaced by metal reinforcement, chamfer strips, or other incidentals.

The Engineer will measure metal reinforcement in accordance with 2472.4.A, "Reinforcement Bars." If the Contractor provides additional splices in the reinforcement bars, the Engineer will not include the additional bar for these splices in the pay quantity.

If the contract requires separate items for structure excavation or granular backfill material, the Engineer will measure quantities in accordance with 2451, "Structure Excavations and Backfills," only for structures with estimated quantities as shown on the plans.

2411.5 BASIS OF PAYMENT

The contract unit price for each grade or mix of structural concrete includes the costs of constructing the structures complete and in place. The Department will pay separately for metal reinforcement, structure excavation, and backfill materials if the contract contains specific unit prices for these items.

The contract unit price for concrete structures of each design or type includes the costs of constructing the structures complete and in place. If the contract contains a unit price for a surface area, the Department will pay separately for concrete in accordance with 2461.5, "Structural Concrete, Basis of Payment."

The contract unit prices for other applicable contract items include the cost of providing and installing geotextile fabric.

The Department will pay separately for structure excavation and special backfill materials only when the contract contains unit prices for volume and the plans show an estimated quantity for specific structures. The Department will not provide separate payment for structure excavation and special backfill materials if the contract contains unit prices for structures by individual unit.

The Department will pay for concrete structures on the basis of the following schedule:

Item No.:	Item:	Unit:
2411.501	Structural Concrete (Mix No.)	cubic yard [cubic meter]
2411.503	Concrete (Type of Structure)	square yard [square meter]
2411.505	Concrete Structure, Design ___	each
2411.507	Concrete (Type of Structure) ___	each
2411.511	Structure Excavation, Class ___	cubic yard [cubic meter]
2411.521	Granular Backfill ___ *	cubic yard [cubic meter]
2411.523	Aggregate Backfill ___ *	cubic yard [cubic meter]
2411.541	Reinforcement Bars ___	pound [kilogram]

* Specify the basis of measure (LV or CV) after the item name. See 2451.4.B, "Granular Materials."

2412 PRECAST CONCRETE BOX CULVERTS

2412.1 DESCRIPTION

This work consists of installing precast concrete box culverts.

2412.2 MATERIALS

A Concrete 2461

B Reinforcement Bars 3301

C Steel Fabric 3303

D Granular Materials.....3149

E Geotextile, Type 3 3733

F Precast Concrete Box Culverts 3238

2412.3 CONSTRUCTION REQUIREMENTS

Construct precast concrete box culverts in accordance with 2411, "Minor Concrete Structures," 2451, "Structure Excavations and Backfills," and 3236, "Reinforced Concrete Pipe," and the following:

A Foundations

Prepare foundations in accordance with 2451.3.C, "Foundation Preparations," except provide granular bedding in accordance with 3149.2.F, "Granular Bedding," and at least 6 in [150 mm] thick. Use a template to shape the bedding to a flat base. Use a mechanical hand compactor to compact the bedding adjacent to the bottom corner radii.

B Laying Precast Concrete Box Culvert

Lay precast concrete box culvert sections with the groove end of each section up-grade. Tightly join the sections. Use concrete pipe ties meeting the requirements of MnDOT Standard Plate 3145 to tie individual sections together. Seal the joint on the bottom of the box culvert with an approved product, as listed on the MnDOT Approved/Qualified Products website under "Preformed Mastics," per the manufacturer's instructions. Place a strip of 3733 geotextile, type 3 material at least 24 in [600 mm] wide centered over the top and sides of the joint. Prevent displacement of the geotextile material during backfilling operations.

Join the box sections so that when laid on the granular bedding, they form a smooth, uniform line of sections. Do not adjust the grade by exerting force on the box section with excavating equipment or by lifting and dropping the box section. If the box section is not on the correct grade, unjoin the sections, correct the grade and rejoin the sections.

Prevent construction equipment loads greater than the loads used in the design to be transferred to the box section before, during, or after fill placement, either directly or through the fill.

Use precast concrete plugs to plug lifting holes in the top surface. If lifting holes are located in the sidewall, completely fill the holes with mortar meeting 3107 or cover the hole with bolts, nuts and washers meeting 3392 and large enough to completely cover both ends. After plugging, seal and cover lifting holes with an approved product, as listed on the MnDOT Approved/Qualified Products website under "Mastic," or mortar.

2412.4 METHOD OF MEASUREMENT

A Culvert Excavation

If the contract contains separate pay items for culvert excavation, the Engineer will classify and measure excavation for concrete box culverts in accordance with 2451.4.A, "Structure Excavation."

B Precast Concrete Box Culverts

The Engineer will measure precast concrete box culverts by length. The Engineer will determine the length by adding the nominal laying lengths of the individual sections incorporated into each structure. The Engineer will take separate measurements for each contract pay item size.

The Engineer will measure transition sections between two different box culvert sizes as the larger or more costly size, except for special sections designated for measurement as each.

C End Sections and Other Appurtenant Items

The Engineer will separately measure end sections and other appurtenant items such as flap gates and other specially identified units, having contract pay units described as "each", by the number of complete units of each type and size incorporated into the box culvert structures.

The Engineer will measure cast-in-place concrete work, other than end sections and culvert extensions, in accordance with 2411, "Minor Concrete Structures."

D Granular Materials

The Engineer will not separately measure granular bedding for concrete box culverts.

If the contract includes contract pay items for special backfill or bedding, the Engineer will measure special backfill or bedding for precast concrete box culverts in accordance with 2451.4.B, "Granular Materials."

2412.5 BASIS OF PAYMENT

The contract unit price for *Precast Concrete Box Culvert* and *Precast Concrete Box Culvert End Section* will include the cost of providing and installing culverts and end sections, excavations, lintel beams, drop-wall, foundation preparation, granular bedding material, and backfill, unless the contract includes separate contract pay items for the work. The Department will include the cost of cast-in-place concrete work for extending an existing box culvert with the adjacent precast box culvert. The Department

will include the cost of the 6 in [150 mm] granular bedding for precast concrete box culverts with the relevant contract pay items for precast concrete box culverts.

The Department will pay for precast concrete box culverts on the basis of the following schedule:

Item No.:	Item:	Unit:
2412.511	___ x ___ Precast Concrete Box Culvert	linear foot [meter]
2412.512	___ x ___ Precast Concrete Box Culvert End Section	each

2433 STRUCTURE RENOVATION

2433.1 DESCRIPTION

This work consists of widening, rebuilding, or restoring structures, including removal as shown on the plans and in the special provisions.

2433.2 MATERIALS

Except as otherwise specified, provide materials in accordance with Division III.

2433.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Traffic Provisions

Provide traffic provisions as shown in the special provisions. Unless the contract requires otherwise, provide flaggers, and erect and maintain temporary curbs, rails, extra warning lights, special signs, and other protective devices as required by the Engineer and in accordance with 1710, "Traffic Control Devices," at no additional cost to the Department.

If the contract requires, construct temporary sidewalks for pedestrian use entirely outside of the vehicular traffic lanes. Construct temporary sidewalks for pedestrians at least 4 ft [1,200 mm] wide and with 6 ft [1,800 µm] high protective screening and handrails as shown on the plans.

A.2 Explosives

Do not use explosives to remove any portion of a structure being widened or reconstructed. The Contractor may use explosives to remove material not directly connected to the remaining structure as approved in writing by the Engineer and in accordance with 1711, "Use of Explosives."

A.3 Field Measurements

Consider the dimensions of the old structure as shown on the plans as approximate. Before making shop detail drawings and before manufacturing, take measurements of the old structure to ensure proper joining of the old and new work. Provide the measurements to the Engineer. Show field measurements on the shop detail drawings.

B Removal and Disposal Requirements

Remove and dispose of materials encountered in the renovation of existing structures in accordance with 2442, Removal of Existing Bridges" and meeting the requirements of the web based Building and Bridge Demolition Manual and the following:

Stabilize peeling lead paint by coating with a paint listed on the Approved/Qualified Products List to prevent the peeling paint from flaking during demolition, or scrape and contain the peeling paint. If painting, apply 16 mil [400 µm] of paint. If applying paint on a bridge over water, attach a diaper apron or other containment method if necessary to prevent drips of paint from contaminating the water.

Remove old concrete or stone masonry within the limits shown on the plans and without damaging the remaining structure. Make saw cuts at least 1 in [25 mm] deep on faces exposed to view to produce a straight line between new and old concrete.

Cut keyways into the concrete that remains in place without damaging the remainder of the structure as shown on the plans.

Do not impair the supporting capacity of the foundation soil and do not damage the remaining structure if removing piling located within the new footing area.

If old piles interfere with the planned spacing of new piles, drive the old piling to determine bearing capacity and suitability for use in the new construction, as directed by the Engineer. Unless otherwise required by the contract, the Department will pay for extra pile driving as extra work in accordance with 1402, "Contract Revisions."

C Concrete Construction

Perform concrete construction in accordance with 2401, "Concrete Bridge Construction," and the following:

(1) Place and secure bolt anchors and other fasteners as specified in the special provisions and in accordance with the manufacturer's installation recommendations,
(2) If no surface finishing of old concrete is shown on the plans, provide a surface finish for at least 2 ft [600 mm] of the adjoining portion of the old concrete to blend the finish of the new with the old work, and
(3) Unless otherwise shown on the plans, drill holes and install bolt anchorages to the size and depth in accordance with the manufacturer's recommendations.

D Reinforcement Steel

Place reinforcement steel in accordance with 2472, "Metal Reinforcement," and the following:

(1) Unless otherwise shown on the plans or the special provisions, do not cut reinforcement bars that extend through the cut line closer than 40 diameters to the cut line, and
(2) If any reinforcement bar loses more than 10 percent of its section due to damage from the removal of old concrete, install an approved bolt anchor or clamp capable of developing the strength of the damaged bar, at no additional cost to the Department and as directed by the Engineer.

E Structural Steel Construction

Provide structural steel manufactured in accordance with 2471, "Structural Metals." Erect structural steel in accordance with 2402, "Steel Bridge Construction," and the following:

(1) If practicable, subpunch holes for field connections between new and old steel in the shop. Ream the holes to proper size in the field after assembly. If making the holes for these connections in the field, clamp the parts together and drill the holes using the holes in the old steel as a template. Do not use a flame-cutting torch to make the holes,
(2) Clean rust, scale, and foreign matter from the tops of existing steel stringers and floor beams in contact with new timber or concrete, and coat with primer in accordance with 2478, "Organic Zinc-Rich Paint System," or as directed by the Engineer. Allow the paint to dry for at least 24 h.
(3) Clean foreign matter from the contact surfaces of old steel and coat with the designated primer paint in accordance with 2478, "Organic Zinc-Rich Paint System," before permanently connecting to the new steel.

F Masonry Construction

Construct masonry as shown on the plans.

Make connections to old stone masonry at the old mortar joints. Step the joints to old stone masonry as directed by the Engineer.

Clean mortar and loose or fractured material from old stone masonry at the joint before placing the new masonry. Immediately before placing new concrete or stone masonry, wet the surface of the old masonry.

G Timber Construction

Perform timber construction in accordance with 2403, "Timber Bridge Construction," and the following:

(1) Use new nails, spikes, and hardware throughout the work,
(2) Before placing either new or old timber on the structure, clean the contact surfaces of the timber, and
(3) Apply at least two coats of copper naphthenate or another compatible preservative material meeting the requirements of AWPA M4 to contact surfaces, except treat new treated timber and designated old structure parts with oil paint. Allow each application of preservative to dry for at least 2 h before applying the next coat.

2433.4 METHOD OF MEASUREMENT

A Structure Removals

The Engineer will measure structure removals by lump sum.

B Item Removals

The Engineer will measure removal of specified items by the unit of measure for the contract item as shown on the plans and in accordance with the following:

B.1 Lump Sum

The Engineer will measure item removals by lump sum, including the entire item as required by the contract or as approved by the Engineer.

B.2 Mass

The Engineer will measure removal of structural steel by weight in accordance with 2402.4.A, "Weight."

B.3 Length

The Engineer will measure the length of item removals longitudinally along the center of the unit and within the limits shown on the plans or approved by the Engineer.

B.4 Area

The Engineer will measure item removal by area on the basis of actual width and length measurements and within the limits shown on the plans or as approved by the Engineer.

B.5 Volume

The Engineer will measure item removal by volume, except for timber, on the basis of actual dimensions of the unit as removed. The Engineer will measure timber based on nominal sizes and actual lengths.

B.6 Each

The Engineer will measure item removal by each complete item removed for the required work.

C Anchorages

The Engineer will separately measure *Anchorages* of each type shown on the plans by the number of units complete in place.

D Placing Used Materials

The Engineer will separately measure the placement of used materials by the unit of measure for the contract item as shown on the plans and in accordance with place used items.

2433.5 BASIS OF PAYMENT

The contract unit price for deck removal includes the cost of cleaning and painting, unless otherwise shown on the plans. The Department will pay for structure renovation on the basis of the following schedule:

Item No.:	Item:	Unit:
2433.501	Structure Removals	lump sum
2433.502	Remove*	cubic yard [cubic meter]
2433.503	Remove*	pound [kilogram]
2433.505	Remove*	square foot [square meter]
2433.506	Remove*	linear foot [meter]
2433.507	Remove*	lump sum
2433.509	Remove*	each
2433.510	Place Used*	each
2433.511	Place Used*	pound [kilogram]
2433.512	Place Used*	lump sum
2433.513	Place Used*	Mbm‖ [cubic meter]
2433.515	Place Used*	linear foot [meter]
2433.516	Anchorages, Type___	each

* Specify item name
‖ 1,000 board-feet measure

2442 REMOVAL OF EXISTING BRIDGES

2442.1 DESCRIPTION

This work consists of removing and disposing of existing bridges.

2442.2 MATERIALS

Use explosives for the removal of existing bridges in accordance with 1711, "Use of Explosives," and as approved by the Engineer.

2442.3 CONSTRUCTION REQUIREMENTS

A General

The Department will not require salvage of material during bridge removal, unless otherwise shown on the plans or as required by the special provisions. Remove material, not required for salvage for the Department, using methods that will not damage salvaged members.

Place salvaged material in stockpiles at locations as directed by the Engineer. If the Contract requires delivery of salvaged material to a storage yard or other designated location, place salvaged material on dunnage or sound wooden pallets. Dispose of material not required for salvage in accordance with 2104.3.C, "Removal Operations," and 2104.3.D, "Disposal of Materials and Debris."

Completely remove portions of substructures, including piling and minor obstructions, where removals interfere with the new structure. Remove existing piles under new footings to the bottom of the new footings. Remove existing substructure units located outside the limits of the new structures to the elevation of the stream bed or to an elevation at least 2 ft [600 mm] below

the final ground surface. In established navigation channels, remove existing substructure units located outside the limits of the new structures to an elevation of at least 2 ft [600 mm] below the established bottom of the channel. Remove substructure units and piles located within the roadbed to an elevation at least 4 ft [1,200 mm] below subgrade. If located on a railroad grade, remove substructure units and piles to an elevation of 4 ft [1,200 mm] below base of rail, unless otherwise shown on the plans or in the special provisions.

Remove piles, drift material, sheet piling, and other minor construction located within the right-of-way that are not a part of the existing bridge, if obstructing the stream channel or presenting an unsightly appearance as determined by the Engineer. Remove ice breakers, existing piers, and similar units, as required by the contract. The Department will consider the removal of items not required by the contract and not visible on inspection of the site of the work as extra work in accordance with 1402, "Contract Revisions." The Department will not pay for material removed solely for the Contractor's convenience.

Fill pits or trenches resulting from the removal operations with earth material approved by the Engineer. Place backfill above water level in layers no greater than 1 ft [300 mm] thick. Compact each layer in accordance with the methods in 2105.3.F.2, "Quality Compaction."

If removing a bridge from a location not on the site of the new structure, excavate and dispose of the embankments adjoining the abutments as directed by the Engineer and in accordance with the following:

(1) To slopes conforming to the natural ground surface, or
(2) To a 1V:2H slope beginning at the intersection of the front face of the abutment and continuing until intersecting with the natural ground surface.

Do not constrict the stream channel except as required by the contract or as approved by the Engineer.

If removing part of an existing concrete pavement, remove the pavement to an existing joint or cut the pavement on a straight line at right angles to the centerline of the road. If cutting, use a saw to cut the top surface at least 1 in [25 mm] deep without damaging the pavement remaining in place. During excavation, prevent undermining or disturbing the foundation material under pavement remaining in place.

B Structural Steel

Dismantle salvaged structural steel in sections, individual members, or parts as shown on the plans or as directed by the Engineer. Unless otherwise required by the contract, remove structural steel in the reverse sequence of the original erection. Remove structural steel without damaging any structural members. Only cut field driven rivets. Use pilot nuts to draw pins.

Match-mark members with valve-action opaque paint markers in accordance with a diagram provided by the Department. Similarly mark pins, pin nuts, loose plates, and ring fills to indicate proper location. Securely wire or bolt loose parts to adjacent members, or pack loose parts in properly identified boxes.

Coat pins, pin-holes, and machined surfaces with a lubricant listed on the Approved/Qualified Products List.

Remove rivets with a pneumatic chipping tool. Do not use torches unless specifically required by the contract.

Stockpile structural steel on suitable skids. Arrange dissimilar parts in separate piles. Stack structural steel to avoid damage to the members.

C Timber

Remove timber and lumber with minimal breakage or splitting. Remove nails, spikes, fastenings, and hardware from timber and lumber. Clean timber of dirt and all other foreign matter except paint and bituminous surfacing material.

2442.4 METHOD OF MEASUREMENT

The Engineer will measure each total bridge removal and will not separately measure salvage material types or salvage portions of work for each bridge removed.

2442.5 BASIS OF PAYMENT

The contract unit price for *Removing Existing Bridge* includes the cost of excavation, removal, disposal, backfill, grading of the work area, and removal of obstructing or unsightly piles, drift material, sheeting piling, and minor construction in the right-of-way, unless otherwise required by the contract.

The Department will pay for the removal of existing bridges or material salvage on the basis of the following schedule:

Item No.:	Item:	Unit:
2442.501	Remove Existing Bridge	lump sum
2442.502	Salvage and Haul Material (Bridge)	lump sum

2451 STRUCTURE EXCAVATIONS AND BACKFILLS

2451.1 DESCRIPTION

This work consists of excavating, preparing foundations, and placing backfill for bridges and Structures per 1103, either cast-in-place or prefabricated. This work also consists of constructing and removing cofferdams, making soil bearing tests, and the disposing of surplus excavated materials.

The Department considers cast-in-place structures as bridge substructures, concrete box culvert extensions, concrete retaining walls, footings for structural plate arches, 3 sided concrete boxes, and concrete arches. The Department considers prefabricated structures as precast concrete or prefabricated metal structures including concrete box culverts, pipe culverts and sewers, cattle passes, and subsurface drains.

2451.2 MATERIALS

A Granular Material 3149
B Select Grading Material 2105.1A6

Unsuitable Materials include those materials not meeting 2105.1.A.6, and additional materials deemed unsuitable by the Engineer.

Provide materials for special backfill, bedding, drain, or filter purposes as shown on the plans and in accordance with the following:

2451.3 CONSTRUCTION REQUIREMENTS

A General Requirements

Prepare foundations to the elevations and grades shown on the plans. Use temporary construction to place structures or substructures in open excavations under dry conditions.

A.1 Site Preparations

Clear and grub in accordance with 2101, "Clearing and Grubbing." Clear and grub the entire area bounded by straight lines between the structure extremities. If constructing bridges, extend clearing and grubbing operations to the right-of-way between the bridge extremities. Remove tree branches that overhang the structure and inhibit its function.

Perform preliminary embankment construction in accordance with 2105, "Excavation and Embankment."

A.2 Elevations and Dimensions

The Engineer may make adjustments, in writing, to the approximate elevations and dimensions of footings as shown on the plans.

The Engineer may make adjustments to the approximate location and orientation of box culverts and pipe structures as shown on the plans.

A.3 Temporary Construction

Perform temporary construction work to avoid unnecessary hazard or disruption to the permanent work at no additional cost to the Department. Temporary construction may include sheeting, shoring, bulkheads, dikes, channels, drainage pipes, sluiceways, cofferdams, warning signs, and fencing as necessary.

Obtain the Engineer's approval of detailed construction plans and methods before starting temporary construction work as required by the contract.

A.3.a Cofferdams

Construct cofferdams of sufficient size to allow pumping, and provide waterways outside of the forms. Include provisions to allow lowering the foundation elevation to 3 ft [1 m] below the level as shown on the plans.

Do not place cofferdam bracing against the concrete forms or the structure. The Contractor may extend steel bracing through poured concrete located below the final ground elevation. Do not box out braces or struts unless otherwise approved by the Engineer in writing.

Remove cofferdams located within roadbed embankments when no longer needed, to at least 4 ft [1.2 m] below the subgrade elevation. Remove cofferdams located in streams or lakes to the bottom of the stream or lakebed. Remove cofferdams located in established navigation channels to an elevation at least 2 ft [0.6 m] below the established bottom of the channel. Remove all other cofferdams to an elevation at least 2 ft [0.6 m] below grade.

A.3.b Concrete Foundation Seal

If the plans do not show a concrete seal, the Contractor may install a concrete seal within a cofferdam, if reviewed and accepted for general compliance by the Engineer. Perform the concrete seal construction, including necessary excavation, at no

additional cost to the Department. Submit written notice to the Engineer indicating the planned seal thickness, sources of materials, and method of concrete placement. If the Engineer accepts the proposed seal, the Engineer will provide a mix design for the concrete.

Place the entire seal below the foundation elevation for that particular substructure shown on the plans in accordance with 2401.3.C, "Placement of Concrete."

A.3.c Pumping

While pumping from within foundation enclosures, keep the foundation materials intact and do not draw water through or over the fresh concrete. The Contractor may pump during concrete placement and within 24 h after concrete placement, if using a pump separated from the work by a watertight wall or other means that prevent damage to the foundation.

Do not begin pumping to dewater a cofferdam sealed with concrete until the seal has cured in accordance with the following minimum requirements:

(1) Three days when the temperature of the water within the cofferdam has been maintained at 70 °F [20 °C] or greater,
(2) Four days when the temperature of water has been maintained from 45 °F [7 °C] to 70 °F [20 °C], or
(3) Five days when the temperature of the water within the cofferdam has been no greater than 45 °F [7 °C] during the curing period.

A.4 Restoration Work

Restore portions of the surface and general features of the excavation site after completion of the work to allow use and function as before excavation, as approved by the Engineer.

A.5 Cold Weather Protection

Place permanent or temporary backfill, or other insulating material approved by the Engineer, to protect foundation soils against freezing and related heaving actions after casting footings or driving foundation piles. The Department will waive this requirement if the Contractor has only driven the test pile within the foundation at the time of freezing conditions. If frost heaving is evident, drive the test pile further when installing the rest of the foundation piles, as directed by the Engineer.

B Excavating

B.1 General

Perform structure excavation to allow the erection of forms, temporary construction, and compaction of backfill materials, unless the contract requires or the Engineer directs otherwise.

B.2 Types

The Department will classify excavation types in accordance with the following:

(1) Class U: Material within the excavation unclassified by the material encountered or the conditions of removal.
(2) Class E: Material within the excavation except for Class R material.
(3) Class R: Ledge rock, boulders, detached rock, or concrete pieces, with a volume of at least ½ Yd^3 [0.4 m^3].
(4) Class W: The upper limit of excavation designated by the elevation of low water as shown on the plans for waterway bridges.

The Department will consider the volume of removed structures as a separate contract pay item and will not include the volume of structure removals within the excavation limits as part of the excavation volume. The Department will include the cost of structure removals with other relevant pay items, unless otherwise required by the contract.

B.3 Cast-In-Place Structures

The Engineer may reject the work if water accumulates within the excavation and detrimentally affects the structure or the stability of the backfill.

Confine excavation in streams or lake beds within caissons or cofferdams. Repair disturbances to streams or lake beds using materials approved by the Engineer.

Complete necessary areas of excavation within sealed cofferdams before placing items, such as walers, struts, and other framework items, that may restrict the access to the excavation equipment.

B.3.a Earth Excavations

If placing concrete on natural soil foundation without piling, as shown on the plans, shape the bottom of the excavation to the dimensions and elevations shown on the plans. Use vibratory methods to compact the foundation soils as directed by the Engineer. Replace unsuitable foundation soils with firmly compacted acceptable material as shown on the plans and as directed by the Engineer. Replace materials unnecessarily removed below the foundation elevation at no additional cost to the Department.

Complete excavation before beginning pile driving operations for each unit. After driving the piles, shape the bottom of the excavation to the elevation shown on the plans. Use granular materials meeting 3149.2.D.1, "Granular Backfill," to backfill excavations below the established elevation of the foundation at no additional cost to the Department.

B.3.b Rock Excavation

Do not remove Class R and Class WR materials encountered in the excavation, unless the Department classifies the excavation as Class U, until the Engineer measures the pay quantities for Class R and Class WR materials.

For footing foundations located in solid rock, remove the rock to the elevation as shown on the plans for the entire area bounded by vertical planes through the neat lines of the footing. If the plans do not show a footing elevation, remove the rock to an elevation no higher than the established elevation for the bottom of the footing or as directed by the Engineer.

Remove rock without affecting the quality of the foundation.

B.4 Prefabricated Structures

B.4.a Earth Excavations

If the contract does not contain provisions for foundation preparation, excavate to provide uniform support under the entire structure, to allow the placement of the structure to the staked grade and line, and to allow for the installation of backfill materials.

If the contract contains provisions for foundation preparation, excavate to provide the foundation thickness shown on the plans and uniform structure support.

B.4.b Rock Excavations

Expose, but do not remove Class R and Class WR materials encountered during Class E or Class WE excavation, until the Engineer measures the pay quantities for Class R and Class WR materials.

Remove and replace unyielding materials such as bedrock, boulders, or concrete located within 1 ft [300 mm] from the sides or the bottom of the structure in accordance with 2451.3.D, "Backfilling Excavations," and 2451.3.C, "Foundation Preparations."

C Foundation Preparations

Prepare the structure foundations in accordance with the following, except as modified by structure specifications and as shown on the plans.

Provide temporary construction, pumping, or other means to construct the structure in a dry excavation at no additional cost to the Department.

C.1 Cast-In-Place Structures

Remove disintegrated material, loose material, and thin strata rock from rock foundations. Clean and fill rock seams with concrete, cement mortar, or grout as directed by the Engineer.

If the character of the natural foundation soil is unsuitable, provide additional excavation below the planned footing elevation as directed by the Engineer. The Engineer will direct the limits of the excavation and the placement of special backfill.

C.2 Prefabricated Structures

For structure foundations in new embankment, construct the embankment to an elevation 1 ft [300 mm] above the low point of the structure in accordance with 2105, "Excavation and Embankment." Remove natural topsoil beneath the structure site when the height of embankment to the bottom of the structure is no greater than 3 ft [1 m].

Remove and replace unsuitable foundation materials encountered at or below the foundation elevation using suitable replacement materials as directed by the Engineer. Excavate the sub-foundation with near vertical sides and a bottom width equal to the structure width plus twice the depth of excavation. Unless the contract requires otherwise, provide replacement material in accordance with 2451.3.D, "Backfilling Excavations." Install the replacement material in layers 6 in [150 mm] thick. Compact each layer to uniform density.

Before installing the structure, shape the foundation to fit the bottom of the structure and provide uniform support.

Compact granular materials used for bedding and foundation backfill at pipe installations in accordance with 2105, "Embankment Materials," except place the material within the 6 in [150 mm] layer immediately below and parallel to the bottom surface of the pipe per treatment details included in the plans, sufficient to produce uniform pipe support.

D Backfilling Excavations

Backfill excavations for structure construction to the required extent shown on the plans and at the appropriate time. Uniformly distribute suitable backfill materials in layers no thicker than 8 in [200 mm] loose measurement. Compact the backfill to the required density before placing successive layers.

Compact backfill in accordance with 2105, "Excavation and Embankment," to the specified density for materials not meeting 3149.2.D.1, "Granular Backfill," and to the Penetration index method for material meeting 3149.2.D.1, "Granular Backfill," unless modified by Plan.

If the contract does not specify special backfill materials, use materials meeting 3149.2.D.1, "Granular Backfill," placed within 18 in [450 mm] of the sides and 12 in [300 mm] above the top of the structure. For the remainder of the backfill, use embankment material meeting 2105.1.A.6, "Select Grading Material." If outside the roadbed construction, use suitable material meeting 2105.1.A.6, "Select Grading Material," found in the excavation.

Do not place backfill material on a frozen foundation or when the material may freeze during the placement or compaction work.

Step the sides of the excavation if steeper than 4:1 and if potential wedging action of the backfill may be detrimental to the structure. If the contract does not require specific maximum dimensions for the excavation, the Contractor may enlarge the excavation and flatten the side slopes for convenience of backfill and compaction operations, at no additional cost to the Department.

Backfill uniformly in horizontal layers throughout the excavation area. Maintain the sides of the excavation and prevent voids in the backfill when removing shoring or bracing from the excavation.

E Surplus Materials

Excavated materials not necessary for backfill are the property of the Contractor. Dispose of surplus materials in accordance with the disposal form submitted to and approved by the Engineer.

2451.4 METHOD OF MEASUREMENT

The Engineer will determine quantities of excavation and embankment in accordance with 1901, "Measurement of Quantities," except as modified by this section. Provide sufficient time for the Engineer to determine quantities.

A Structure Excavation

The Engineer will not adjust (P) designated quantities unless otherwise specified in 1901, "Measurement of Quantities," or for excavation materials reclassified by the Engineer.

The Contractor may dispute an excavation quantity. If the Engineer considers the dispute, the Engineer will recalculate the excavation quantity for the entire structure. If the Contractor completes the excavation before the Engineer directs a change, the Engineer will not make deductions or additions for resulting changes in the excavation volume if no enlargement of the excavation is required.

The Engineer will consider additional quantities determined by recalculation as separate from the contract pay item quantities for structure excavation for bridges.

The Engineer will measure rock within the structure excavation and recalculate the volume for each excavation pay item classification considering the quantity of exposed rock measured. The Engineer will proportionately increase or decrease excavation pay item quantities based on the measured volume of rock to maintain the planned total excavation quantity.

The Engineer will not adjust low water elevations as shown on the plans or for safety concerns, working clearances, or stability of soils, regardless of existing conditions.

The Engineer will calculate the volume of structure excavation in accordance with the following limits except as modified for the type of structure and unless otherwise required by the contract:

(1) Vertical planes that encompass the structure, located 1½ ft [450 mm] beyond the outermost limits of the structure or its projections within the excavation,
(2) A top elevation that is either the natural ground surface or the designated elevation, in embankment or excavation, establishing the beginning of structure excavation, and
(3) The bottom of the structure and its projections.

If the plans include a separate contract pay item for the removal of an existing structure from the excavation limits of the new structure, the Engineer will reduce the structural excavation quantity by the measured volume of the existing structure.

If the Contractor excavates material to expedite the work and the contract includes the material removal in a different contract item or indicates removal by others, the Engineer will not include this material in the structure excavation quantities.

A.1 Cast-in-Place Structures

For the horizontal limits of excavation for footings for cast-in-place structures in ledge rock, the Engineer will use the footing limits as shown on the plans.

The Engineer will measure excavation for timber pile abutments and timber bents using the limits as shown on the plans.

A.2 Prefabricated Structures

For foundation construction requiring a greater surface dimension than provided in 2451.4.A, "Structure Excavation," the Engineer will measure the excavation using the greater dimension.

A.2.a Induced Trench

For excavation by the induced trench method performed in accordance with 2501.3.E, "Induced Trench Installation," the Engineer will measure additional excavation required for loose backfill over the structure in accordance with the following:

(1) Within the planned grading section,
(2) Between vertical planes separated by a distance equal to the outside width of the structure, and
(3) To a depth equal to the outside height of the structure.

B Granular Materials

The Engineer will measure granular materials for special backfill, bedding, or filter purposes by loose volume or compacted volume in accordance with 1901, "Measurement of Quantities," and as required by the contract.

2451.5 BASIS OF PAYMENT

If the contract does not contain a contract item for clearing or grubbing, the Department will consider clearing and grubbing to be extra work in accordance with 1402, "Contract Revisions."

The Department will pay for preliminary embankment construction in accordance with 2105, "Excavation and Embankment."

The contract unit price for *Foundation Preparation Pier___* includes the cost of excavation for seal construction.

If the contract does not include a contract item for the restoration work on the surface of the excavation site, the Department will include this cost with other relevant contract pay items.

The Department will pay for cleaning and filling seams in rock foundations as extra work in accordance with 1402, "Contract Revisions," unless otherwise required by the contract.

The contract unit price for the relevant structure excavation and backfill contract items include the cost of disposing of surplus excavated materials.

For cast-in-place structures, if the plans do not include limits for the excavation of timber pile abutments and timber bents, the Department will include this cost with other relevant contract items.

If the plans do not include a contract pay item for Class R and Class WR excavation, the Department will pay for these materials if encountered during Class E or Class WE excavation in accordance with the following:

(1) Class R at 5 times the contract unit price of Class E and
(2) Class WR at 3 times the contract unit price of Class WE.

Unless otherwise modified in the contract, the Department will pay for the excavation for cast-in-place structures in accordance with the following:

(1) For additional required excavation depth, the Department will increase the contract unit price by 25 percent for additional excavation to 3 ft [1 m] below excavation as shown on the plans. For excavation required to a depth greater than 3 ft [1 m] below the planned elevation, the Department will pay for this portion of the additional excavation as extra work in accordance with 1402, "Contract Revisions," unless the Department and Contractor agree on a unit price increase not exceeding 25 percent.
(2) For additional excavation required by changes in the structure dimensions, and the Contractor objects to the contract unit price, the Department will pay for the additional excavation as extra work in accordance with 1402, "Contract Revisions."
(3) For disputed plan quantities, if the Contractor requests a recalculation of structure excavation for bridge structure, and the recalculation shows an additional quantity, the Department will separately pay for additional structure excavation for bridge construction at 50 percent of the contract unit price.

The contract cubic yard [cubic meter] price for *Granular Backfill* and *Granular Bedding* will include the cost of placing and compacting the materials.

If the plans do not include a separate contract pay item for structure excavation, the Department will include this cost with the contract cubic yard [cubic meter] price for *Granular Backfill* and *Granular Bedding*.

If the plans do not include specific contract pay items, the Department will pay for granular materials used for bedding, backfill, or filter purposes as shown on the plans, in accordance with this section, and as directed by the Engineer as extra work in accordance with 1402, "Contract Revisions."

The Department will pay for structure excavation and backfill in accordance with the following schedule:

Item No.:	Item:	Unit:
2451.501	Structure Excavation, Class ___	cubic yard [cubic meter]
2451.503	Granular Backfill ___*	cubic yard [cubic meter]
2451.505	Aggregate Backfill ___*	cubic yard [cubic meter]
2451.507	Granular Bedding ___*	cubic yard [cubic meter]
2451.509	Aggregate Bedding ___*	cubic yard [cubic meter]
2451.511	Coarse Filter Aggregate ___*	cubic yard [cubic meter]
2451.513	Fine Filter Aggregate ___*	cubic yard [cubic meter]

* For all granular material items, specify the basis of measure (loose volume or compacted volume) after the item name in accordance with 2451.4.B, "Granular Material."

2452 PILING

2452.1 DESCRIPTION

This work consists of providing and driving piling as required by the contract.

2452.2 MATERIALS

A Timber Piling 3471

B Preservative Treatment 3491

C Steel H-Piles 3372

D Cast-in-place (CIP) Concrete Piles

D.1 CIP Steel Pile Shells 3371

D.2 Concrete Pile Fill, Mix No. 1C62 2461

E Reinforcement Bars 3301

2452.3 CONSTRUCTION REQUIREMENTS

A Delivery and Inspection of Piling

If the contract requires test piles, provide the number and lengths of piles as shown in the contract, unless otherwise directed by the Engineer. The Engineer may designate that piles authorized for one unit of a structure be driven in another unit of the same structure or any unit of another structure constructed under the same contract.

If test piles are not specified in the contract, provide the number and lengths of piles as shown in the contract.

Before delivery, establish the quality of the material in steel H-piles and in steel shells for cast-in-place concrete piles. Submit the mill test reports and mill shipping papers in accordance with 3371, "Steel Shells for Concrete Piling," and 3372, "Steel Piling," to the Engineer.

The Contractor may request the Engineer's written approval to use small quantities (less than 5 percent in a substructure unit) of piling from the Contractor's surplus of cut-offs and overruns. Certify the small quantities of piling as remaining quantities of materials previously submitted with accompanying mill test reports and approved for use on other projects. The Department will not pay for pile splices used to make up approved piles for the Contractor's convenience. Splices made for the Contractor's convenience are not eligible for extra compensation in accordance with 2452.5.B, "Piling Delivered."

Do not drive piling before the Engineer accepts the material on the basis of mill test reports.

The Engineer will visually inspect piling at the site before driving to verify the quality of welds and to determine the piles contain no physical defects that would cause the pile to fail during driving and are capable of performing as intended.

B Handling, Transportation and Storage

Handle, transport, and store piling without damaging piles intended for use in the completed structure.

C Equipment for Driving

C.1 Requirements for Pile Hammers

Use pile driving equipment approved by the Engineer. The Engineer will use the contractor-provided Driving System Submittal (C.1.1) as the basis for approval of equipment. Acceptance of the pile driving equipment does not relieve the Contractor of the responsibility to properly install the piling. If in the opinion of the Engineer the accepted driving system fails to perform satisfactorily during actual driving, the Engineer reserves the right to revise the driving criteria and/or require change of equipment.

C.1.1 Driving System Submittal

The driving system submittal must be sealed and signed by a professional engineer, licensed in the State of Minnesota. Allow 10 business days for the Department's review. Allow an additional 10 business days for the review of any resubmittals. No variations in the driving system will be permitted without the Engineer's written approval. Submit a Revised Driving System Submittal if the hammers or other driving system components change from those shown in the original approved submittal. Use the same pile hammer to drive test piles and to drive the piles authorized by the Engineer based on the results of the test pile driving. Any variation needs to be authorized by the Engineer.

For the Driving System Submittal, perform drivability studies as follows for each hammer and pile type:

1. Model the proposed driving system including hammers, striker plate, hammer cushion, helmet, and pile cushions based on a wave equation analysis.
2. Include in the analysis pile length variation to account for driven length variation, stickup length, and other considerations appropriate to construction requirements. As appropriate, include soil parameter variations to account for geotechnical uncertainties at the project site as well as possible range of hammer energy.
3. Use an authorized computer program (GRLWEAP or similar program).
4. When a follower is used, include (1) an analysis of the driving system with the follower and (2) an analysis of the driving system without the follower.

Include in the Driving System Submittal:

1. Results of the drivability analysis showing that all proposed driving systems will install piles to the specified tip elevation or nominal pile bearing resistance shown on plans. The system should be adequate to overcome the greatest expected driving resistance or a minimum of 155% of the factored design load and account for end of initial driving and restrike conditions, as appropriate. Driving systems must generate sufficient energy to drive the piles with compressive and tensile stresses not more than 90 percent of the yield strength of a steel pile as driven.
2. The Engineer will only accept pile driving equipment, as determined by the wave equation analysis, capable of operating from 30 blows per ft to 180 blows per ft [10 blows per 0.1 m to 60 blows per 0.1 m] at the above conditions.
3. Include with relevant ranges when applicable scaled graphs depicting:
   - 3.1 Pile compressive stress versus blows per foot.
   - 3.2 Pile tensile stress vs. blows per foot.
   - 3.3 Nominal driving resistance vs. blows per foot for expected typical and range of driving energy.
4. Complete description of:
   - 4.1 Soil parameters used for pile tip and skin, including soil quake and damping coefficients, skin friction distribution, and ratio of shaft resistance to total resistance.
   - 4.2 Assumptions made regarding the formation of soil plugs, drilling through the center of open ended steel shells, pre-augering, pre-boring, jetting, use of vibratory or other systems to advance the pile other than impact hammers, and the use of closure plates, shoes, and other tip treatment.
5. List of all hammer operation parameters assumed in the analysis, including fuel settings, stroke limitations, and hammer efficiency.
6. Copies of all test results from any previous pile load tests, dynamic monitoring, and all driving records used in the analyses.
7. Completed Pile and Driving Data Form along with manufacturer's specifications for pile driving system components. Driving system components will be confirmed by the Engineer upon delivery of the hammer to the project site.
8. An electronic copy of the WEAP input files.
9. The penetration (blows per foot [300 mm]) as calculated by the MPF12 at the nominal pile bearing resistance required for the test piles and at 85% of the manufacturer's maximum rated energy for the proposed hammer.
10. When the MnDOT Pile Formula 2012 will be used as field control, the Engineer will only accept pile driving equipment capable of operating at 180 blows per ft [300mm] or less at the above conditions.

C.2 Pile Driving Caps

Equip the top of the pile with a driving cap in the size and type, as approved by the Engineer, to protect the pile against damage during driving. Use a shock block of the type and size as approved by the Engineer on the upper side of the driving cap, when driving conditions warrant. Provide drive caps and shock blocks as recommended by the pile hammer manufacturer.

C.3 Pile Driver Leads

Provide pile driver leads meeting the following requirements and characteristics:

(1) Capable of holding the pile and the pile hammer in alignment during driving operations,
(2) Long enough to preclude the use of punches or chasers, and
(3) Meeting the requirements of the pile hammer manufacturer.

C.4 Water Jets

Provide jets capable of delivering water in the volume and pressure required to freely erode the material adjacent to the pile. Provide a water source capable of maintaining at least 100 psi [690 kPa] of pressure at two jet nozzles, ¾ in [19 mm] in diameter.

D Pile Driving

Notify the Engineer at least 24 h before beginning pile driving operations. The Engineer will reestablish the working points for each substructure unit after the Contractor completes the excavation for that unit. Stake the pile locations.

Excavate to the bottom of footing elevation as shown on the plans before driving foundation piles or test piles in any substructure. During pile driving operations, keep the water level in the excavation below the top of the pile. Do not perform underwater pile driving unless a concrete foundation seal is required to dewater cofferdam.

For each foundation pile, perform continuous pile driving operations unless otherwise directed by the Engineer.

Sharpen timber piles to a square point with dimensions at least 5 in [127 mm] at the tip. Provide timber piles with blunt ends for soils with SPT below counts less than 20 as shown in plan borings or for piles having point bearing on hard stratum.

Do not use punches or chasers for pile driving if the contract requires a concrete foundation seal in a cofferdam. If driving piles in a cofferdam, provide the extra length of piling to drive the piles to the cutoff elevation, at no additional cost to the Department. Accurately locate and space the piling as shown in the bridge plans with tolerances per 2452.3.D.4, "Foundation Piles," 2452.3.D.5, "Pile Bents," and 2452.3.F.2, "Pile Bents."

Provide pile material and appurtenances capable of withstanding driving to substantial refusal defined in accordance with 2452.3.E.1, "General." The Department considers failure of piles during pile driving operations to include buckling, bending, kinking, splitting, or rupturing that will impair the strength of the pile or reduce the effectiveness of the energy delivered by the pile hammer, as determined by the Engineer.

If the Engineer determines that the piling material and appurtenances cannot withstand driving to substantial refusal, discontinue pile driving and correct or change the pile driving operations, equipment, or material as approved by the Engineer.

If failure of the pile occurs after the Engineer directs the Contractor to continue driving after obtaining substantial refusal, the Department will pay for the cost of the failure.

D.1 Jetting and Preboring

The Contractor may perform water jetting if needed, or as required by the contract, to aid in driving displacement type piles. Do not perform jetting in embankments or in areas where the jetting may damage the existing soils. Before reaching a preset depth approved by the engineer but not less than 5 ft [2 m] of the final tip elevation, withdraw the jets and drive the piles with the hammer to secure the final penetration. Control and dispose of jet water, as approved by the Engineer.

Perform preboring for displacement type piles driven through embankments if the embankment depth, measured below the bottom of the footing, is greater than 8 ft [2.4 m]. Perform preboring through the depth of the embankment. Continue preboring through shallow, dense crust at the surface of the original ground as directed by the Engineer.

Perform preboring through embankments less than 8 ft [2.4 m] if the material may damage the piles during driving, as directed by the Engineer. Perform preboring for displacement type piles if the material below the bottom of a footing precludes driving to a penetration of 10 ft [3.0 m] below the bottom of the footing without damaging the piles, as directed by the Engineer. If the pile does not penetrate greater than 0.03 in [0.75 mm] per blow for each 1000 foot pounds [1,356 J] of rated energy, the Engineer will consider this, the weight of the ram, and the type and size of the piles to determine the probability of damage.

Make prebored holes of a diameter that will admit the largest cross-sectional diameter of the pile without creating friction between the faces of the pile and the prebored hole.

D.2 Test Piles

Provide test piles as required by the contract. Drive test piles at the locations shown on the plans unless otherwise approved or directed by the Engineer.

Place full lengths of test piles in the leads and continuously drive, unless otherwise approved by the Engineer. The Contractor may perform sectional driving if the Engineer determines from the survey sheet or from previous pile driving in the area that the test piles can be driven in sections without the danger of "set-up" during the splicing period.

Assist the Engineer in obtaining data (examples: lay pile in a safe location, marking pile with 10 blow count, attach gauges as instructed) for bearing for the full length of the pile driving. Redrive the test piles as required by the Engineer and in accordance with 2452.3.D.8, "Pile Redriving."

If the Engineer determines that steel test piles have not developed adequate bearing capacity per 2452.3.E.1, "Penetration and Bearing, General," provide additional lengths and splice as directed by the Engineer.

D.3 Static Pile Load Tests

Provide Axial Static Compressive Load Testing (ASTM D 1143M) , Axial Static Tension Load Testing (ASTM D 3689), Lateral Static Load Testing (ASTM D 3966), Quasi-Static Load Testing (ASTM D 7383), O-Cell Load Testing, or similar testing for evaluation of either axial or lateral compressive or tensile load and deformation analysis.

a) Coordinate test program with Construction, Bridge, and Materials offices.
b) Provide materials, furnish labor, and conduct the test program as required by the contract. Install temporary and permanent instrumentation as required by the contract or as directed by the Engineer.
c) Analyze and report data both in hard-copy format and electronic format in a timely manner.
d) Adjust test program as directed by the Engineer based on conditions encountered in the field.
e) If the test program is used for construction control, provide appropriate analysis and field inspectors' charts, as described in section K, for assessment of the capacity of foundation piling.

D.4 Foundation Piles

Guide piles during driving. Complete pile driving with piles having the required batter or plumbness within ½ in per ft [40 mm per m], and having a final position within 6 in [150 mm] of plan location within the footing area. The Engineer may reject or reduce payment per 1512 for improperly positioned piles, as determined by the Engineer.

If the Engineer determines that some piles in a unit have heaved during the driving of other piles in the unit, redrive the piles as directed by the Engineer to complete the pile driving.

D.5 Pile Bents

The Department defines pile bents as piles meeting the following characteristics and requirements:

(1) Driven in single rows,
(2) Capped with timber, steel, or concrete caps, and
(3) Driven to closer tolerances than for general pile driving, as described below.

Guide piles during driving. Complete pile driving with piles having the required batter or plumbness within ¼ in per ft [20 mm per m], and having a final position within 3 in [75 mm] of plan location within the bent. The Contractor is responsible for any increase in pile cap dimensions or reinforcing caused by inaccurately placed piles. The Engineer may reject or reduce payment for improperly positioned piles, as determined by the Engineer. For timber pile bents, select piles having a uniform diameter.

D.6 Cast-in-Place Concrete Piles

Equip the bottom of each pile with a driving shoe meeting the following requirements:

(1) Welded watertight, and
(2) Dimensions no greater than ¼ in [6 mm] larger than the dimensions of the periphery of the pile shell.

Provide pile points, if required by the contract, at specified locations or as directed by the Engineer. Provide the pile points for cast-in-place concrete piles in lieu of flat driving shoes. Equip the bottom of each shell with a commercially manufactured conical pile point of cast steel welded watertight, as approved by the Engineer. Attach the conical pile point to the pile as recommend by the manufacturer.

Inspect each pile with the Engineer after driving, for depth to the driving shoe and for condition of the shell. Notify the Engineer upon observation of impairment or damage. The Engineer, considering the bearing requirements and driving conditions, will determine the acceptability of the pile. Provide a light for a visual inspection of the full length of pile.

The Department will not require the Contractor to provide reinforcement bars unless otherwise shown on the plans.

Vibrate concrete in the portion of pile shells containing reinforcement cages.

Do not perform pile driving and other operations that will cause detrimental vibrations near concrete-filled piles until the concrete has been in place for at least 3 calendar days. Refer to 2401.3.G, "Concrete Curing and Protection," for vibration limits on newly placed concrete.

Do not place concrete for footings and caps until the day after concrete placement for the piles.

Protect concrete in the piles against freezing temperatures for at least 3 calendar days after placement. If placing concrete in piles during freezing temperatures, provide 30 percent additional cement to the concrete mix for concrete above 10 ft [3 m] below the ground line or waterline.

D.7 Steel H Piles

Provide pile tip protection, if required by the contract, at the specified locations or as directed by the Engineer. Provide H-pile tip protectors, as listed on the MnDOT Approved Products website under, "H-Pile Tip Protection". Attach the cast steel points to the piles as recommended by the manufacturer.

The Contractor may provide thick wall pipe on a performance basis and meeting the following requirements and characteristics in lieu of steel H piling as approved by the Engineer:

(1) Meeting the requirements of ASTM A252 Grade 3,
(2) Wall thickness of at least ½ in [13 mm],
(3) Tensile properties of at least 110,000 psi [760 MPa],
(4) Cross-sectional area at least equal to H piling,
(5) Section modulus at least equal to the weakest axis of the H piling,
(6) Diameter at least equal to the H pile depth less 3 in [75 mm],
(7) Driven open ended and filled with granular material or 1C62 concrete mix.

The Engineer will consult with the Regional Bridge Construction Engineer or Metals Quality Engineer for special welding requirements.

D.8 Pile Redriving

Redrive of test or foundation piles determines the capacity that can be obtained by including pile "set up." "Set up" is the time-dependent increase in pile resistance.

If the contract includes a pay item for "Pile Redrive," perform pile redrive at the direction of the Engineer a minimum of 24 h after initial driving unless otherwise required by the contract. If driving conditions allow, continue to drive test pile to the length shown on the plans and in accordance with 2452.3.E.1, "Penetration and Bearing, General." Redrive additional foundation piles to verify the bearing capacity as determined and directed by the Engineer.

Do not drive other piles in the same substructure during the waiting period. Perform redriving with a warm pile hammer. Apply at least 20 blows to a previously driven pile or timber mats to warm the pile hammer before using it for the redrive. When redriving, do not strike each pile with greater than 20 blows. When using MPF12 as field control, mark the penetration of every blow and measure penetration using the average of the first 5 blows in which the hammer has good energy. Do not trim piles to the cut-off elevation shown on the plans until the Engineer has determined the need for redriving. Do not fill CIP concrete piles in any substructure unit with concrete until the Engineer determines that the driven piles in the unit meet the required bearing resistance shown on the plans and the pile shells were trimmed to the cut-off elevation.

Weld extensions to piles authorized and subsequently driven or drive additional piles as directed by the Engineer.

E Penetration and Bearing

E.1 General

The Department calculated the nominal pile bearing resistances as shown on the plans using design loadings. The Department will use the nominal pile bearing resistance as determined by 2452.3.E.2, "Determination of Nominal Bearing Resistance," to establish the minimum criteria for pile acceptance in which the driving resistance is not less than the required nominal bearing resistance as shown on the plans. If necessary, drive the foundation piles beyond the resistance shown on the plans until the piles reach the required penetration as shown on the plans or until the piles have been driven to the penetration determined by the Engineer and based on the test pile results.

Drive the test pile full length unless substantial refusal is encountered at a lesser penetration. If the test pile has been driven full length and if the test pile has not attained 115 percent of the nominal resistance for the foundation piles as shown on the plans, drive the test pile further as directed by the Engineer and in accordance with 2452.3.D.2, "Test Piles," and 2452.4.A, "Test Piles." Perform pile redriving as shown on the plans with the penetration and time delays in accordance with 2452.3.D.8, "Pile Redriving."

The Engineer will consider that substantial refusal is attained, in accordance with 2452.3.D, "Pile Driving," when the penetration rate equals 0.05 in [1.3 mm] per blow.

E.2 Determination of Nominal Bearing Resistance

The Department bases the required nominal resistance as shown on the plans for each field control method. Determine the driven pile nominal resistance in accordance with the following using the appropriate corresponding field control method as shown on the plans. Unless the contract requires otherwise, if more than one field control method is shown on the plans, determine the method used in accordance with the following:

(1) If the contract includes a "Pile Analysis" contract item for a substructure, provide the Pile Driving Analyzer (PDA) for the field control, or

(2) If the contract does not include a "Pile Analysis" for a substructure, the Contractor may choose the field control method. The Department will include the cost of the PDA with the relevant contract item for piling driven.

E.3 MnDOT Pile Formula 2012 (MPF12) Used as Field Control Method

Determine the nominal pile bearing resistance using the following dynamic formula for CIP concrete piles and steel H piles driven with power-driven hammers:

$$R_n = 20\sqrt{\frac{W \times H}{1000}} \times \log(\frac{10}{S})$$

Where:

R_n = Nominal Pile Bearing Resistance in tons
W = Weight of the striking part of the hammer (ram) in pounds (see note below)
H = Height of fall in feet (see note below)
S = Average penetration in inches per blow for the last 10 blows or 20 blows, except if the pile may be damaged by this number of blows.

The MPF12 is not suitable for use in pile driving conditions where the average penetration during driving (S) is greater than 0.5 inches per blow (less than 24 blows per foot). The Contractor shall immediately notify the Engineer if the specified nominal pile bearing resistance shown in the plans is obtained with an average penetration greater than 0.5 inches per blow.

The Contractor may choose any of the following options to reduce the average penetration during driving to less than 0.5 inches per blow and achieve the specified nominal pile bearing resistance shown in the plans:

1. Reduce the fuel setting of the hammer for the test piles and foundation piles.
2. Perform redrives on the test piles and 10% of the foundation piles at a reduced fuel setting of the hammer. Perform redrives on the foundation piles that had the highest penetration at the end of initial drive or as determined by the Engineer.
3. Continue driving the pile until the average penetration is less than 0.5 inches per blow.
4. Use a qualified smaller hammer.

The above options will be performed at no additional cost to the Department, with the exception that additional driven and delivered length will be paid for by the Department up to the estimated length shown in the plans.

Regardless of the value measured during driving, the value of (S) used in the dynamic formula shall not be less than 0.066 inches per blow (more than 180 blows per foot). If the measured average penetration for the last 10 blows is less than 0.066 inches per blow, use 0.066 in the dynamic formula to determine the bearing resistance.

Note: (W x H) is measured during pile driving and is also commonly referred to as the "energy", E, hence E = W x H, for single acting power-driven hammers and is measured in foot-pounds. The value of (W x H) used in the dynamic formula shall not exceed 85 percent of the manufacturer's maximum rated energy for the hammer used.

In addition to the limits stated above, apply the dynamic formula only if:

(1) The hammer has a free fall,
(2) The head of the pile is free from damage,
(3) The penetration of the pile is at a uniform rate, and
(4) There is no bounce after the blow. If a bounce occurs, deduct twice the bounce height from H to determine the value of H in the formula.

For the requirements of this section, double-acting hammers include hammers utilizing a power source for acceleration of the down-stroke of the ram.

E.4 Pile Driving Analyzer (PDA) Used as Field Control Method

Determine the nominal pile bearing resistance using the pile driving analyzer and the Case Pile Wave Analysis Program (CAPWAP) as stated below, "Dynamic Monitoring of Pile Driving." Use the refined WEAP bearing graph as required in as stated below, "Wave Equation Analysis," to determine the bearing resistances recorded on the pile driving report. Attach a copy of the bearing graph to the pile driving report. Calculate and record the bearing resistances for informational and comparison purposes on the report in accordance with 2452.3.E.3, "MnDOT Pile Formula 2012 (MPF12) Used as Field Control Method."

E.4.1 High-Strain Dynamic Monitoring of Pile Driving

E.4.1.1 Description of Work

Provide and use a Pile Driving Analyzer (PDA) to perform high-strain dynamic monitoring of driven piles meeting the requirements of ASTM D4945. Perform the dynamic pile testing on the initial driving and re-driving of designated piles as shown in the plans or directed by the Engineer. Test additional piles or designated piles at additional times as directed by the Engineer.

E.4.1.2 Pile Preparation

Prepare each pile to be tested by marking and attaching instrumentation to the piles. During initial driving of steel shell piles, attach instrumentation after the pile has been placed in the leads. In all circumstances, extra care should be exercised to protect the instrumentation from distress throughout the pile installation. Wireless pile instrumentation may be attached to the pile, if approved by the engineer, prior to placing the pile in the leads provided that the instrumentation is adequately protected against damage by contact with the leads, abrasion, or shear from the rope, chain, or fabric, used to pick up the pile.

During the test, provide assistance as necessary, e.g. access, tightening gages, re-setting or replacing gages, or replacing cables as necessary for the successful conduct of the dynamic monitoring program. Alert the Engineer to any unanticipated or unusual conditions including such items as severed cables, loose gages, or unusual pile, or pile hammer performance.

E.4.1.3 Signal Matching and Refined Wave Equation Analysis

Following dynamic testing of the driven piling, perform a refined wave equation analysis based on driving data obtained from the high-strain dynamic monitoring program using the Case Pile Wave Analysis Program (CAPWAP) or other approved signal matching software. This work shall be performed by an engineer pre-qualified for work type 6.5 as defined by the MnDOT Geotechnical Manual. Complete the analysis on all piles dynamically tested, or as directed by the Engineer. Furnish PDA and CAPWAP electronic data and summary hardcopy outputs to the Engineer.

After the wave matching analysis is performed, use the GRLWEAP or similar program and the signal matching program (e.g. CAPWAP) data to produce a refined Wave Equation Analysis bearing graph and inspector's chart for the basis for pile acceptance. Prepare similar charts if soil set-up and pile re-strikes are being evaluated. Submit the refined WEAP bearing graph and Inspector's Chart for use in construction control for each substructure. Use the bearing graph to determine the foundation pile's nominal bearing resistance to be recorded on the pile driving report.

Prepare and submit a summary plot of the performance of each pile in the pile group where each pile is plotted on the Inspector's chart by its observed set and the corresponding stroke of the pile hammer. Adjust this procedure as directed by the engineer for non-diesel hammers. Any piles not plotting in the acceptable range will be rejected.

E.4.1.4 Deliverables

Provide the results from each dynamic test performed with the PDA and analyzed with the CAPWAP program meeting the following requirements to the Engineer within the time specified:

1. Results from each high-strain dynamic test performed with the PDA and analyzed with the CAPWAP program. The results are to be transmitted in the form of the electronic raw data files and a hard copy of columnar data produced with the PDIPLOT program or similar. The data shall consist of blow counts, stresses in the pile, pile capacities, hammer energies and hammer strokes for each one-foot depth increment. This information will be used by the engineer to develop the construction control criteria, authorize pile length, and establish minimum penetration resistance. In addition, provide expert advice regarding the analysis of the PDA and CAPWAP data.

2. Bearing graphs showing blow count-versus-pile resistance and inspector's charts depicting stroke-versus-blow count to be used for confirming the Nominal Pile Bearing Resistance of the foundation piles. The graph/charts are to be developed based on the results of the PDA, CAPWAP, and pile load test data where static load tests are conducted as part of the construction control. These graphs/charts are also to be documented in the report listed below. These graphs and charts are required for each foundation group, or as specified in the contract documents, or as directed for the engineer. Submit this information both in hard-copy and electronically (Adobe PDF or similar).

3. A brief report for the piles at each substructure tested including a summary of the PDA and CAPWAP results; this report will include appropriate information for the evaluation of test data from standard "test" piles as well as Static Load Test (SLT) test piles, Static Load Test reaction piles, and foundation piles.

4. Supply one or more CDs (or other electronic storage media) containing all data for the piles tested for each substructure. The data shall be in the form of W01 (PDA file), PIL (PDIPLOT file), and CWW (CAPWAP file) and be properly labeled. The contractor shall send these electronic files to the Engineer no later than three working days after dynamic pile tests have been completed at any given substructure unit.

5. A final project report which summarizes the findings from the PDA and the associated CAPWAP computer program, the developed bearing graphs, and the pile load test results.

6. One or more CDs (or other electronic media) containing all data for the complete project as an archive copy including information for all piles tested, including any pile static load test data. The data from the dynamic tests shall be in the form of W01 (PDA file), PIL (PDIPLOT file) files, and shall be properly labeled. Include the CAPWAP analysis results and CWW (CAPWAP) files. Include all reports and electronic copies of bearing graphs and inspectors charts. Include any pre-construction WEAP analysis data sheets and WEAP submittal information and electronic files modeling the contractor's hammer system. Include subsequent refined wave equation analysis, and summary plots showing foundation pile performance with respect to the acceptance criteria. Include electronic copies of field notes and other information pertinent to the high-strain dynamic monitoring and any related static load testing (including gage locations, test dates, performance notes, etc.) Transmit this electronic archive to the Engineer within 5 working days after completion of the project dynamic (and or static) pile test program.

E.5 Static Load Test (SLT) Used as Field Control Method

Determine the nominal pile bearing resistance using the results from the Static Load Test and related analysis from high-strain dynamic monitoring and the Case Pile Wave Analysis Program (CAPWAP) in accordance with 2452.3.K, "Dynamic Monitoring of Pile Driving." Use the refined WEAP bearing graph as required in 2452.3.K.3, "Wave Equation Analysis," to develop the inspector's chart as the basis for foundation pile acceptance and use the bearing graph to report the bearing resistances, to be recorded on the pile driving report. Attach a copy of the bearing graph to the pile driving report. Calculate and record the bearing resistances for information and comparison purposes on the report in accordance with 2452.3.E.3, "MnDOT Pile Formula 2012 (MPF12) Used as Field Control Method." Provide the deliverables as required in 2452.3.K.4.

F Pile Cut-off

F.1 Piles

Cut off timber piles at the elevation shown on the plans within a tolerance from −1 in [25 mm] to ½ in [13 mm]. After cutting off the timber pile, leave the head of the pile with sound, undamaged wood.

Cut off steel piles to within ±1 in [25 mm] of the cut-off elevation using an approved method that preserves the shape of the pile at the elevation shown on the plans

F.2 Pile Bents

After aligning and bracing the pile bent, cut off the tops of timber piles at the elevation shown on the plans to provide uniform bearing for the cap without using shims or fills.

Cut off steel piles using an approved method that preserves the shape of the pile at the elevation shown on the plans to allow concrete forming or framing in brace members.

G Disposal of Pile Cut-Offs

Use pile cut-offs belonging to the Department in substructure units for piling lengths not authorized for the same structure or for other foundations within the same contract, as required by the Engineer.

Stockpile remaining steel H-pile, steel shell pile cut-offs, and timber cut-offs designated for salvage by the Engineer on skids at a location convenient for truck loading. Dispose of cut-offs not designated for salvage as approved by the Engineer.

H Extensions, Splices, and Studs

Make splices for steel H-piles and CIP steel shell piles as shown on the plans, except make splices for cold rolled fluted steel shells as recommended by the manufacturer and as approved by the Engineer.

Provide pile welders meeting the qualifications of AWS D1.1 with continuity records proving performance in the last 6 months.

Make splices on piles driven in pile bents at points not exposed to view, unless otherwise approved by the Engineer. If making splices in pile bents exposed to view as approved by the Engineer, finish the splices by grinding in such a way that the ground area blends in smoothly with the contour of the CIP pipe. Verify the complete removal of the defect by visual inspection and the wall thickness shall not be adversely affected. If shear studs are required on the piles, perform the welding in accordance with AWS D1.5, clauses 7.5.1-7.5.4.

The Contractor may provide commercial drive-fit splices for CIP piles on a performance basis as approved by the Engineer. Do not use splices in the following conditions:

(1) In pile bent-type piers or abutments,
(2) Where foundation soils are soft or unstable,
(3) In foundations where uplift is anticipated (concrete seals, etc.),
(4) Within 10 ft [3 m] of the pile cut-off,
(5) Where down drag is indicated in the pile load table, or
(6) Where Pile Driving Analyzer or Static Load Test is specified in contract as field control method.

I (Blank)

J Coating Steel H-Piles and Steel Pile Shells

J.1 Painted Piles

Provide paint and perform painting in accordance with 2478, "Organic Zinc-Rich Paint System." Provide CIP steel pile shells painted in accordance with 3371, "Steel Shells for Concrete Piling."

Paint the outside of steel H-piles and CIP steel pile shells that are not encased in concrete but extending above ground surface or water surface with epoxy zinc-rich primer for the entire length, except for sections below splices at least 2 ft [600 mm] below the final ground surface or low water elevation. Apply the primer preferably before shipping or at least 2 days before driving the piles.

After driving, paint the piles with intermediate and finish coats on exposed portions above the water level, existing at the time of paint application or above an elevation 6 in [150 mm] below the final ground surface. Paint the finish coat for piles in bridges with concrete superstructures in a color matching the Federal Standard 595C No. 37200 (lusterless aluminum) and paint the finish coat for piles in bridges with painted steel superstructures with the topcoat color of the superstructure. Paint the finish coat for piles in bridges with unpainted 3309, "High-Strength Low-Alloy Structural Steel," steel or timber superstructures in a color matching the Federal Standard 595C No. 10075 (brown) with a semi-gloss finish.

J.2 Galvanized Piles

Provide galvanized steel H-piles and CIP steel pile shells in accordance with 3394, "Galvanized Structural Shapes." Provide H-piles galvanized in accordance with 3372, "Steel Piling." Provide CIP steel pile shells galvanized in accordance with 3371, "Steel Shells for Concrete Piling." Continuously coat steel H-piles and the outside of CIP steel pile shells that are not encased in concrete. Coat the pile from the cut-off elevation to an elevation extending a minimum of 10 ft [3 meters] below the defined ground surface or the bottom of water channel with hot-dipped galvanizing. Do not hot-dip galvanize within 1 ft [300 mm] of a splice. Based on test pile length, if a splice is required, adjust location of splice so that it is not visible after driving is completed.

Protect the galvanizing from abrasion or discoloration beginning immediately after the coating process. The special care shall include, but not be limited to:

(1) Use of nylon slings for handling,
(2) Shipping and storing on blocking with isolation from adjacent shells,
(3) Carrying in lieu of dragging,
(4) Use of timber blocking in leads while pile driving, or
(5) Prompt washing of concrete leakage.

Design forms and falsework for the substructure in a manner not requiring clamping or welding to any portion of the piling that are exposed after the cap construction is complete.

Repair all damaged galvanized areas by the metalizing process described in AASHTO M 36, at no additional cost to MnDOT. Zinc rich paint is NOT an acceptable repair.

2452.4 METHOD OF MEASUREMENT

A Test Piles

If the plans show specific contract pay items for test piles, the Engineer will measure the number of test piles provided as required by the contract and driven as directed by the Engineer. The Engineer will not eliminate test piles from the contract, unless all piles for the unit are eliminated or unless mutually agreed upon by the Contractor and the Engineer.

If the plans do not show a specific contract pay item for test piles, the Engineer will include the measurement of test piles with the measurement for piling delivered and piling driven.

If the Engineer determines that steel H-test piles or steel shells for cast-in-place concrete test piles provided in the lengths required by the contract do not develop sufficient nominal pile bearing resistance or do not provide information per 2452.3.D.2, "Test Piles," for ordering foundation piles, splice extensions onto test piles or deliver longer piles as required by the Engineer.

The Engineer will measure splice extensions onto test piles or longer piles, as required by the Engineer when driving beyond plan test pile length, in accordance with the relevant contract pay items for piling delivered and piling driven.

B Piling Delivered

If test piles are not required, the Engineer will measure piling delivered as shown on the plans for acceptable piling provided and delivered in the lengths and sizes of the relevant contract pay items. If the contract requires test piles, the Engineer will measure the lengths approved by the Engineer.

C Piling Driven

The Engineer will measure piling driven by the length of acceptable piling below cut-off.

D Pile Load Tests

The Engineer will measure pile load tests by the number of piles load tested as required by the contract and as directed by the Engineer.

E Reinforcement Bars

The Engineer will measure reinforcement bars used in cast-in-place concrete piles by weight in accordance with 2472, "Metal Reinforcement."

F Pile Redriving

The Engineer will measure pile redriving by the number of piles redriven as required by the contract and as directed by the Engineer. The Engineer will recalculate the estimated plan quantity to agree with the actual number of piles redriven at the project site, estimated not to exceed 25% of the total number of planned piles. The Engineer will consider any pile redriving completed without the direction of Engineer as unauthorized work and the Department will not compensate the Contractor for that work.

G Dynamic Monitoring of Pile Driving

The Engineer will measure Pile Driving Analyzer field control by the number of piles that required the pile driving analysis as required by the contract. The Engineer will consider initial analysis and redrive analysis on an individual pile as one pile analysis. The Engineer may increase or decrease the number of piles to be dynamically monitored.

If the contract does not require the Pile Driving Analyzer field control method, the Contractor may perform the Pile Driving Analyzer field control method at the Contractor's option and at no additional cost to the Department.

2452.5 BASIS OF PAYMENT

The contract unit prices for *Test Pile* include the fixed costs of piling delivered and piling driven. If the plans do not include a contract pay item for test piles, the Department will include the fixed costs of piling delivered and piling driven with the relevant contract unit price for mobilization.

A Test Piles

The contract unit price for the test pile contract item of each kind and length include the cost of providing and driving test piles, providing and placing driving caps, concrete for cast-in-place concrete piles, painting steel H-piles and CIP steel shell piles, and performing analysis for hammer qualification submittals.

The Department will pay for splice extensions onto test piles or longer piles, as required by the Engineer when driving beyond plan test pile length, with the contract pay items piling delivered and piling driven.

B Piling Delivered

The Department will not pay full contract unit prices, but may make partial payments based on actual cost, for stock lengths of steel H-piles and steel shells for cast-in-place concrete piles delivered before the Engineer authorizes final lengths based on test pile driving. The Department will only pay contract unit prices for *Piling Delivered* in the lengths authorized by the Engineer. Remove delivered unauthorized piles at no additional cost to the Department.

The Department will not pay for piles or portions of piles damaged during handling. The Department will pay for piles damaged during driving if the Engineer determines that the damage was not caused by the Contractor's carelessness or negligence. The Department will not pay for piles rejected by the Engineer due to the use of an excessively heavy hammer.

The Department will pay for splicing of steel H-piles and CIP steel shell piles meeting the following requirements and characteristics at six times [two times] the relevant contract unit price for piling delivered, if the splice is actually made and:

(1) The Engineer directed the change after the Contractor cut the piles to lengths previously approved;
(2) Only for any extra splices required for a particular unit, if Engineer approved lengths longer than the length of the longest test pile of a specific kind as shown on the plans; and
(3) The Engineer ordered cut-offs, belonging to the Department, to be spliced together or onto other sections, except if made solely for the Contractor's convenience.

For a CIP steel shell pile made entirely from Department-owned cut-offs as required by the Engineer, the Department will consider providing and attaching the end plate as an additional splice and will pay for the additional splice with the relevant contract unit price.

C Piling Driven

The relevant contract unit prices for *Piling Driven* include the cost of preparing the piles for driving, preboring, jetting, providing and placing the driving shoes, concrete for cast-in-place piles, cutting and trimming, and coating steel H-piles and steel shell piles.

In the event foundation conditions are found to exist at the site of a structure, or a portion thereof, that are quite different from those upon which the foundation design was based, resulting in changes in foundation design or resulting in

requirements for foundation pile lengths substantially different from those upon which the contract unit prices were established, the Engineer will, upon presentation of documentary evidence by the Contractor, enter into a Supplemental Agreement to reimburse the Contractor for any additional pile driving expense incurred as a result of those changes.

The Department will pay for driving pile cut-offs, from previously driven piles in the same contract that are the property of the Department, at the following percentages of the contract unit price for piling driven:

(1) Timber and Steel H-Piles, 150 percent, and
(2) Cast-in-Place Concrete Piles, 200 percent

The Department will include the cost of splices per 2452.5.B, "Piling Delivered," in the relevant contract unit prices for piling delivered.

D Pile Load Tests

The contract each price for *Pile Load Test* includes the cost of providing and driving reaction piles at locations that preclude their use in the structure as foundation piles.

E Pile Redriving

The contract unit price for *Pile Redriving* includes the cost of redriving test piles and foundation piles, and providing and driving additional pile lengths as directed by the Engineer.

F Dynamic Monitoring of Pile Driving

The contract each price for *Pile Analysis* includes the cost of dynamic testing of a pile during initial driving and redriving, additional time needed in driving operations, labor, consultants, and equipment.

The Department will include the cost of the actual redrive with the contract each price for *Pile Redriving.*

The Department will not adjust the contract each price for increased or decreased contract quantities for *Pile Analysis.*

G Pile Points

The contract each price for *Pile Points* includes the cost of providing and attaching the points to the piles.

H Pile Tip Protection

The contract each price for *Pile Tip Protection* includes the cost of providing and attaching the tips to the piles.

I Pay Items

The Department will pay for piling on the basis of the following schedule:

Item No.:	Item:	Unit:
2452.501	Untreated Timber Piling Delivered	linear foot [meter]
2452.502	Untreated Timber Piling Driven	linear foot [meter]
2452.503	Treated Timber Piling Delivered	linear foot [meter]
2452.504	Treated Timber Piling Driven	linear foot [meter]
2452.507	Cast-in-Place Concrete Piling Delivered ___*	linear foot [meter]
2452.508	Cast-in-Place Concrete Piling Driven ___*	linear foot [meter]
2452.510	Steel H-Piling Driven ___*	linear foot [meter]
2452.511	Steel H-Piling Delivered ___*	linear foot [meter]
2452.516	Untreated Timber Test Pile, ___ ft [m] long	each
2452.517	Treated Timber Test Pile, ___ ft [m] long	each
2452.519	Cast-in-Place Concrete Test Pile, ___ ft [m] long ___*	each
2452.520	Steel H-Test Pile, ___ ft [m] long ___*	each
2452.525	Reinforcement Bars	pound [kilogram]
2452.526	Pile Load Test, Type ___	each
2452.527	Pile Redriving	each
2452.528	Pile Analysis	each
2452.529	Pile Points ___ in [mm]	each
2452.530	Pile Tip Protection ___ in [mm]	each

* Nominal size in in [mm]

2461 STRUCTURAL CONCRETE

2461.1 DESCRIPTION

This work consists of producing, providing, placing, curing, and protecting cast-in-place portland cement concrete for placement in structures, pavements and incidental construction.

2461.2 MATERIALS

A Cementitious Materials

Provide cementitious materials from certified sources listed on the Approved/Qualified Products list.

Use Type I, I/II, IS, IL, or IP cement to produce Type 1 non-air-entrained concrete.

Use Type I, I/II, IS, IL, or IP cement and an air-entraining admixture listed on the Approved/Qualified Products List to produce Type 3 air-entrained concrete.

Use Type III portland cement as allowed by the contract or the Engineer.

A.1 Portland Cement **3101**

A.2 Slag Cement **3102**

A.3 Blended Hydraulic Cement **3103**

A.4 Fly Ash **3115**

B Fine Aggregate **3126**

C Coarse Aggregate **3137**

D Water **3906**

E Concrete Admixtures **3113**

For all Concrete Grades shown in Table 2461-6, use any of the following admixtures on the MnDOT Approved/Qualified Products list:

(1) Type A, Water Reducing Admixture
(2) Type B, Retarding Admixture
(3) Type D, Water Reducing and Retarding Admixture
(4) Type F, High Range Water Reducing Admixture
(5) Type G, High Range Water Reducing and Retarding Admixture
(6) Type S, Specific Performance Based Admixture

Use of any of the following MnDOT Approved/Qualified admixtures requires approval of the Concrete Engineer, unless otherwise allowed in the Contract:

(1) Type C, Accelerating Admixture
(2) Type E, Water Reducing and Accelerating Admixture

F Contractor Concrete Mix Designs

F.1 Classification of Concrete

The Department will classify concrete by mix number to identify type, grade, consistency and aggregate size, if any, in accordance with Table 2461-1.

Table 2461-1 Mix Number Identification				
First Digit	**Second Digit**	**Third Digit**	**Fourth Digit**	**Additional Digits**
Type Designation	Grade Designation	Maximum Slump	Coarse Aggregate Designation	Additional Digits Allowed

F.1.a Type Designation

Provide Type 1 or Type 3 concrete in accordance with Table 2461-2:

Table 2461-2 Concrete Type Designation	
Concrete Type	**Target Air Content ***
1	2.0 %
3	6.5 % †
* For concrete mix design purposes only. † Unless otherwise required by 2301 or elsewhere in the contract.	

F.1.b Grade Designation

The Department will designate concrete grade in accordance with Table 2461-6 and Table 2461-7 using a letter designating the following:

(1) Intended Use
(2) Maximum water/cement (w/c) ratio
(3) Cementitious Content Range
(4) Maximum Supplementary Cementitious Substitution (SCM)
(5) Slump range
(6) Minimum 28-day compressive strength, f'c
(7) Coarse Aggregate Quality in accordance with 3137

F.1.c Slump Designation

The Department will designate the upper limit of the slump range as defined by the Grade Designation in accordance with Table 2461-6 and Table 2461-7.

F.1.d Coarse Aggregate (CA) Designation

The Department will designate the allowable gradations using the coarse aggregate designation in accordance with Table 2461-3 based on the intended use and the gradation requirements in 3137, "Coarse Aggregate for Portland Cement Concrete."

Table 2461-3 Coarse Aggregate Designation for Concrete	
Designation	**Coarse Aggregate Gradation Table 3137-4 ***
0	Job Mix Formula (JMF) †
1	#467
2	#67
3	#7
4	#89
* Nominal maximum size of aggregate particles in accordance with ACI 318-08 and structure † Job Mix Formula (JMF) is defined as the combined coarse and fine aggregate gradation..	

F.1.e Additional Concrete Mix Designation Digits

The Contractor may add additional digits to the right of the required digits in the concrete mix number. If identifying the class of coarse aggregate, use one of the following designations as shown in Table 2461-4. If identifying the type of supplementary cementitious material, use one of the following designations as shown in Table 2461-5.

Table 2461-4 Class of Coarse Aggregate Designation for Concrete	
Designation	**Spec. 3137.2.B, "Coarse Aggregate Classification"**
A	Class A Aggregate
B	Class B Aggregate
C	Class C Aggregate

Table 2461-5 Supplementary Cementitious Material Designation for Concrete	
Designation	**Type**
F	Fly Ash
S	Slag
M	Microsilica
T	Ternary (Blend of two supplementary cementitious material)

F.2 Concrete Mix Design Requirements

The Contractor assumes full responsibility for the mix design and performance of the concrete. The Engineer determines final acceptance of the concrete for payment based on test results, satisfactory field placement and performance.

F.2.a General Concrete Mix Design Requirements

The Department defines the concrete mix design requirements for Contractor Designed Mixes in accordance with Table 2461-6.

Table 2461-6
Concrete Mix Design Requirements

Concrete Grade	Mix Number	Intended Use ‖	Maximum w/c ratio ‡	Maximum Cementitious Content (lbs/cy)	Maximum %SCM (Fly Ash/ Slag/ Ternary)	Slump Range	Minimum Compressive Strength, f'c (28-day)	3137 Spec.
B †	3B52 *	Bridge substructure, abutments, diaphragms, walls	0.45	750	30/35/40	2 - 5″	4500 psi	2D1
F	3F32 *	Slipform Curb and Gutter	0.42	750	30/35/0	½ - 3″ #	4500 psi	2D1
	3F52	Sidewalk, curb and gutter, slope paving, median sidewalk, driveway entrances, ADA pedestrian sidewalk, exposed aggregate	0.45	750	25/30/0	2 - 5″	4500 psi	2D1
G †	1G52 *	Footings and Pilecap	0.55	750	30/35/40	2 - 5″	4500 psi	2D1
	3G52	Walls, manholes and catch basins, fence posts, signal bases, light pole foundations, erosion control structures, cast-in-place box culverts, culvert headwalls, open flumes, base	0.45	750	30/35/40	2 - 5″	4500 psi	2D1
M	3M12	Slipform Median barrier, non-bridge railing	0.42	750	30/35/40	½ - 1″ #	4500 psi	2D1
	3M52	Median barrier, non-bridge railing	0.45	750	30/35/40	2 - 5″	4500 psi	2D1
P	1P62 *	Piling	0.60	750	30/35/40	3 - 6″	3000 psi	2D1
R	3R52 *	CPR - Full Depth Concrete Repairs	0.45	750	30/35/40	2 - 5″	3000 psi	2D3
S †	3S12	Slipform bridge railing	0.42	750	30/35/40	½ - 1″ #	4500 psi	2D2
	3S52	Median barrier, posts, curbs, sidewalks, approach panels, formed bridge railings, end posts	0.45	750	30/35/40	2 - 5″	4500 psi	2D2
Y †	3Y42 *	Bridge decks	0.45	750	30/35/40	2 - 4″	4000 psi	2D2

* The Contractor may choose to use the Coarse Aggregate Designation "1″ for the 4th digit in accordance with Table 2461-3.
‖ If the intended use is not included elsewhere in the Specification or Special Provisions, design concrete mix 3G52.
† These mix design requirements do not apply to high performance bridges and mass concrete.
‡ The minimum water/cement (w/c) ratio is 0.30.
\# Adjust slump in accordance with 2461.3.G.7.a for slipform concrete placement.

2461.2

F.2.b High-Early Concrete Mix Design Requirements

The Department defines the concrete mix design requirements for High-Early concrete in accordance with Table 2461-7.

Table 2461-7
High-Early (HE) Concrete Requirements ‡

Mix Number	Minimum Time to Opening	Maximum w/c ratio	Maximum Cementitious Content (lbs/cy) ‖	Slump Range	Minimum Strength †	Allowed Admixtures
3F52HE* 3G52HE* 3M52HE* 3R52HE	48 hrs	0.42	750	2 – 5″	3000 psi	Any

* Requires approval of the Engineer prior to incorporation into the work.
‡ The Department defines High-Early (HE) concrete as concrete designed to achieve the minimum strength to opening at 48 hours.
‖ Supplementary Cementitious Materials allowed.
† Control cylinders required for determining strength; in lieu of control cylinders the Contractor may use the maturity method in accordance with 2461.3.G.6, "Estimating Strength by the Concrete Maturity Method."

F.2.c Additional Contractor Designed Mixes

In addition to the Contractor Designed Mixes within this section, the Contractor will design other concrete mixes in accordance with the following:

(1) Grade A Concrete Pavement Mixes in accordance with 2301, "Concrete Pavement."
(2) Grade R Concrete Pavement Rehabilitation Mixes as modified in 2302, "Concrete Pavement Rehabilitation" in the Special Provisions of the Contract.
(3) Grade W and Y Precast Concrete Mixes in accordance with 2462, "Precast Concrete."
(4) High Performance Bridge Concrete and Mass Concrete Mixes in accordance with 2401, "Bridge Construction" and the Special Provisions of the Contract.
(5) Cellular Concrete Grout in accordance with 2519, "Controlled Low Strength Material (CLSM)."

F.3 Contractor Submittal Requirements

At least 21 calendar days before initial placement of the concrete, submit a Contractor Mix Design Submittal package to the Concrete Engineer for approval. The Contractor Mix Design Submittal package is available from the MnDOT Concrete Engineering Website.

Design the concrete mix to an absolute volume of 27.00 cu. ft [1.0 cu. m]

The Concrete Engineer will:

(1) Provide specific gravity and absorption data using oven dry (OD) weights for mix design calculations.
(2) Review the mix design submittal and approve the materials and mix design for compliance with the Specifications.

Table 2461-8 defines the mix design submittal requirements for Level 1 and Level 2 Mixes.

Table 2461-8 Mix Design Submittal Requirements					
	SCM Substitution Limits	Fine Aggregate Limit	Gradation Requirements	Preliminary Test Data Requirements	Submittal Package
Level 1 Mixes	Fly Ash: 0 – 15% Slag: 0 – 35%	40 – 45% of total aggregate by volume	3126 and 3137	None	Contractor Mix Design
Level 2 Mixes	Fly Ash: > 15% Ternary: Any	None	Use Either: • 3126 and 3137 • Job Mix Formula (JMF)	2461.2.F.3.a	Use Either: • Contractor Mix Design • Contractor Mix Design (JMF)

F.3.a Preliminary Test Data Requirements for Level 2 Mixes

For Level 2 Mixes, submit the proposed Mix Design Proportions on the *Contractor Mix Design Submittal Package* including the *Test Data* spreadsheet based upon one of the following methods:

(1) A suitable experience record, or
(2) Conventional trial mixtures.

F.3.a(1) Suitable Experience Record

The Concrete Engineer considers the following Preliminary Test Data acceptable to use when determining the Mix Design Proportions if:

(a) At least 30 consecutive tests or two groups of consecutive tests totaling at least 30 tests within the previous 18 months; in no case less than 10 test results representing a time period of at least 45 days;
(b) Where a concrete production facility has test records for the specified grade or within 1000 psi of that specified for the proposed work;
(c) Test results represent materials, proportions, quality control procedures, and conditions similar to those expected for the proposed work;
(d) Test results representing SCM contents at the proposed mix design proportions.

F.3.a(2) Conventional Trial Mixtures

If the Contractor does not have test data as required in 2461.2.F.3.a(1) above, establish concrete proportions from trial mixtures, utilizing an AMRL accredited laboratory in accordance with the following:

(a) Use combination of materials similar to those for proposed work;
(b) Use proportions and consistencies required for proposed work using at least three different w/c ratios or cementitious materials content that will produce a range of strengths encompassing the required average strength *(f'cr)*;
(c) Design trial mixtures to produce slump within ± 0.75 in. of maximum permitted;
(d) For air-entrained concrete, design trial mixtures to produce air content within ± 0.5 percent of maximum allowable air content;
(e) For each w/c ratio or cementitious materials content, make and cure at least three test cylinders for 28-day breaks in accordance with ASTM C 192. For HE concrete mixes, in addition to the 28-day cylinders, make a set of three test cylinders for 48-hour breaks in accordance with ASTM C 192.
(f) Plot a curve of the cylinder test results at 28-days age (48-hours age for HE) showing the relationship between w/c ratio or cementitious materials content and compressive strength
(g) Use maximum w/c ratio or minimum cementitious materials content shown by the curve to produce the average strength required (f'cr).

F.3.b Determining the Required Average Strength

Based upon the following information select the Mix Design Proportions required to produce f'cr.

Using the *Test Data* spreadsheet, determine the following:

(1) The Standard Deviation (S), and
(2) The Required Average Strength (f'cr) in accordance with Table 2461-8A.

Table 2461-8A Required Average Strength (f'cr) Equations*	
	Required Average Strength
f'c ≤ 5000 psi*	f'cr = f'c + 1.34S **OR** f'cr = f'c + 2.33S – 500
f'c > 5000 psi	f'cr = 0.90f'c + 2.33S
*When f'c ≤ 5000 psi, f'cr is the larger value computed from the equations.	

F.4 Contractor Mix Design Adjustments

The Department will allow mix design adjustments based upon the criteria as defined in Table 2461-9:

Table 2461-9 Mix Design Adjustments Requirements		
	Type of Change or Adjustment	Mix Design Resubmittal Requirements
Level 1 Mixes	• Cementitious Sources • Admixture Sources • Admixture Dosage Rate	No resubmittal required
	• Aggregate Sources • ≤ 10% in any aggregate proportion • Any cementitious or SCM proportion (≤ 15% max fly ash)	Resubmittal of Mix Design
	• > 10% Aggregate Proportions • Any cementitious or SCM proportion (> 15% max fly ash)	Resubmittal in accordance with 2461.2.F.3.a
Level 2 Mixes	• Admixture Dosage Rate • Cement or SCM sources	No resubmittal required
	• Aggregate Source, no change in Aggregate Class • ≤ 5% in any cementitious or SCM proportion* • ≤ 10% in Aggregate Proportions	Resubmittal of Mix Design
	• Aggregate source and Class of Coarse Aggregate • > 5% in any cementitious or SCM proportion • > 10% Aggregate Proportions • Admixture Sources	Resubmittal in accordance with 2461.2.F.3.a
* Only one (1) increase in cementitious or SCM allowed per mix design, next adjustment requires resubmittal in accordance with 2461.2.F.3.a		

F.5 MnDOT Review for Continual Acceptance of Contractor Mix Designs

The MnDOT Concrete Engineering Unit will review all test results relating to each individual Contractor approved mix design. MnDOT will review the following test results:

(1) Plant and Field Test Results
(2) Compressive Strength at 28 days
(3) Monthly Aggregate Quality Testing

Provided the concrete met the requirements of the Contract, had satisfactory placement and performance, the Contractor will have that mix design available for use during the next calendar year.

G Department Designed Concrete Mixes

The Department will provide the mix proportions for the following concrete uses:

(1) Cofferdam Seals and Rock Sockets (1X62) in accordance with Table 2461-10,
(2) Riprap (Grout) in accordance with Table 2461-11,
(3) Low Slump Concrete Overlays (3U17A) in accordance with the back of Form 21412, "Weekly Report of Low Slump Concrete,"
(4) Lean Mix Backfill in accordance with 2520, "Lean Mix Backfill," and
(5) Patching Mix (3U18) in accordance with 3105, "Bagged Portland Cement Concrete Patching Mix Grade 3U18."

Table 2461-10 Concrete Mix Design Requirements for Cofferdam Seals and Rock Sockets 1X62										
Mix Number	**Maximum w/c ratio**	**Water Content (pounds)**	**Cement Content (pounds)**	**Fly Ash (pounds)**	**Fine Aggregate Content (pounds)**	**Coarse Aggregate Calculation (pounds)**	**%Air Content**	**Slump Range**	**Minimum 28-day Strength (psi)**	**3137 Spec.**
1X62	0.43	314	730	0	1265	627 x Specific Gravity	3.0%	3 - 6″	5000	2D1
1X62F	0.43	314	584	146	1265	617 x Specific Gravity	3.0%	3 - 6″	5000	2D1

Table 2461-11 Concrete Mix Design Requirements for Grout Mixes							
Grout Mix Number*	**Maximum w/c ratio**	**Water Content (pounds)**	**Cement Content (pounds)**	**Fine Aggregate Calculation † (pounds)**	**%Air Content**	**Maximum Slump**	**Minimum 28-day Strength (psi)**
1CGROUT	0.64	379	596	1082 x Specific Gravity	3.0%	As needed	3000
3CGROUT	0.55	379	691	933 x Specific Gravity	10.0%	As needed	3000
1AGROUT	0.50	379	758	1031 x Specific Gravity	3.0%	As needed	4000
3AGROUT	0.44	379	865	878 x Specific Gravity	10.0%	As needed	4000
3WGROUT	0.36	379	1072	812 x Specific Gravity	10.0%	As needed	5000

* Do not provide grout containing coarse aggregate.
† If the plans do not specify grout mix, provide 3A GROUT.

H Concrete Yield

The Department defines concrete yield as the ratio of the volume of mixed concrete, less accountable waste, to the planned volume of the work constructed. The Department will not assume responsibility for the yield from a given volume of mixed concrete.

2461.3 CONSTRUCTION REQUIREMENTS

A Batching Equipment

A.1 Mixer Requirements

Provide stationary mixers or truck mixers.

A.2 General Condition

Maintain mixers as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examine to detect wear of blades.

Replace or recondition pickup and throwover blades in mixers with a rated capacity less than 14 cu. ft [0.40 cu. m] showing a blade wear loss of greater than ½ in [13 mm], and pickup and throwover blades in mixers of greater capacity, showing a blade wear loss of no greater than ¾ in [19 mm] from the original factory dimensions.

A.3 Manufacturer's Rating Plate

Provide mixers that include the manufacturer's rating plate, showing the following information:

(1) Serial number of the unit,
(2) Mixing speed of the drum or paddles, and
(3) Maximum capacity in terms of volume of mixed concrete.

A.4 Drum Speed for Stationary Mixers
Operate the drum speed in the mixer as specified by the manufacturer or as directed by the Engineer.

A.5 Auxiliary Equipment Requirements
Provide mixers equipped with the following:

(1) Timing device,
(2) Discharge locking device,
(3) Water measuring device that operates mechanically and automatically during each batching cycle, and
(4) A graduated adjustable indicator device to represent the volume of discharge in increments no greater than ¼ gal [1 L] in full view.

A.6 Mixer Capacity
Do not exceed the manufacturer's rated capacity of the mixer when mixing a single batch of concrete.

Batch concrete in volumes the mixer can accommodate without spilling, leaking, or segregating during the charging, mixing, or discharging operations. Provide mixers with a capacity of at least 1 sack [0.25 cu. m].

A.7 Mixing Time
The Department defines the mixing time as the time period beginning when the cement and aggregates enter the mixer drum and ending when the discharge begins.

Refer to the manufacturer's recommended minimum mixing time for single drum and dual drum mixers. In the absence of manufacturer's recommendation, the Engineer will designate the minimum mixing time. The minimum mixing time for any concrete batch is 60 s. The Contractor may reduce the manufacturer's recommended minimum mixing time or the Engineer designated mixing time if the Contractor obtains uniform mixing in accordance with 2461.3.E, "Mixing Requirements," and as approved by the Engineer, in conjunction with the Concrete Engineer.

If there is evidence of inadequately mixed concrete (unmixed or partially mixed materials) during concrete placement, the Engineer may direct an increase in the mixing time.

A.8 Turbine Type Mixers
Provide turbine type mixers meeting the applicable requirements for conventional type mixers (2461.3.A.1 through 2461.3.A.7) and in accordance with this subsection (2461.3.A.8). Maintain the mixer drum in a cylindrical shape within ¾ in [19 mm] from the original factory dimensions at any point. Maintain the mixer discharge gate in a mortar tight condition in the closed position. Replace or recondition mixer paddles showing a wear loss greater than ½ in [13 mm] from the original factory dimensions.

Add the mixing water to the batch materials in a manner that distributes the water to the inner or central areas of the drum. Start the flow of water before introducing the solid batch materials into the mixer drum.

During mixing, operate the paddles at a speed between 20 revolutions and 30 revolutions per minute. After adding the batch materials to the drum, mix the concrete for an additional 60 s.

A.9 Horizontal Axial-Revolving Blade Type Mixers
Provide horizontal axial-revolving blade type mixers in accordance with the applicable requirements for conventional type mixers (2461.3.A.1 through 2461.3.A.7) and in accordance with this subsection (2461.3.A.9).

Charge the water, aggregates, and cement in the sequence recommended by the Manufacturer. Test the concrete uniformity as directed by the Engineer. The Engineer will use concrete uniformity tests to determine the minimum mixing time.

B Transportation Units

B.1 General Requirements
Equip transportation units intended for both mixing and agitating with watertight revolving drums mounted and powered and fitted with properly designed mixing blades in accordance with 2461.3.A.1 through 2461.3.A.7. Provide units capable of combining all the ingredients into a homogeneous mixture and designed to provide two drum speeds, one for mixing and the other for agitating. Provide units capable of delivering the concrete without segregation or loss of any of the batch materials.

Equip the mixer drum with a working counting device to record the number of revolutions.

Equip dump trucks and agitator trucks with vibrators to aid in discharge, are mortar tight, capable of complete discharge of the concrete and in accordance with 2301.3.F.

B.2 Capacity of Transportation Units

Refer to the truck mixer manufacturer's certification plate attached to the unit for the maximum capacity of the unit. If the unit will not satisfactorily mix the maximum volume shown, reduce the batch volume to allow proper mixing or discontinue use of the mixing unit as directed by the Engineer until the problem is corrected.

C Handling and Storing Materials

C.1 Batch Material Requirements

Do not change the source, kind or gradation of batch materials after the start of concrete production for the work unless otherwise approved by the Engineer. If the Engineer approves use of different material, completely exhaust the supply on hand before changing to the different material.

If delivering freshly washed aggregates to the batching plant, drain the aggregates for at least 12 h before using in the batching operation. If draining freshly washed aggregates at the site of the batching plant, completely separate the drained material from the undrained materials, and provide for the disposal of water that accumulates from the drainage of materials.

Provide smooth, firm, and well-drained stockpile sites cleared of vegetation and extraneous matter. Where the natural foundation is unsatisfactory, as determined by the Engineer, construct the stockpiles on suitable platforms. Construct suitable bulkheads or partitions to separate different kinds of aggregate, gradation, or water content.

Construct stockpiles by methods that hold segregation and degradation to a minimum. If the Engineer sees segregation or degradation, the Engineer may designate that pile as unacceptable for use.

Do not use aggregates used to construct runways for loading or hauling equipment in concrete batches.

Use of aggregates from the bottom 1 ft [0.3 m] of a stockpile placed on an unprepared surface in concrete batches is allowed only under the Engineer's direct supervision and if the material meets all requirements of 3126, "Fine Aggregate for Portland Cement Concrete," and 3137, "Coarse Aggregate for Portland Cement Concrete."

Provide aggregates in accordance with the specified gradation requirements.

The Engineer will consider aggregates unacceptable if the variation in moisture content carried by any of the aggregates causes a marked variation in the consistency of successive batches of the mixed concrete, and will suspend operations until corrected.

C.2 Concrete Temperature Control

Produce concrete at temperatures from 50 °F to 90 °F [10 °C to 30 °C] and maintain temperatures until deposited in the work.

If necessary to maintain placement temperature, uniformly heat or cool the water, aggregates, or both, before introduction into the mixer. Control the temperature of the mixing water during heating or cooling.

Use aggregate at temperatures from 32 °F to 130 °F [0 °C to 55 °C]. Do not allow cementitious material to contact other batch material when the aggregate temperature exceeds 130 °F [55 °C].

Do not heat the cement, add salt, or add chemical admixtures to the concrete mix to prevent freezing.

Use a heating system to heat batch materials as approved by the Engineer. Do not use steam jets to spot heat the material as the work progresses.

Do not place mixer heaters intended for heating the batch materials in the mixer drum.

D Batching Requirements

Calibrate weighing equipment in accordance with 1901, "Measurement of Quantities." Inspect and calibrate the scales in accordance with section 5-694.400 of the Concrete Manual.

D.1 Batching by Weight

D.1.a Proportioning Methods

Proportion concrete batch materials by weight in a central plant or by volume as directed by the Engineer, in conjunction with the Concrete Engineer.

D.1.b Weighing Equipment and Tolerances

Weigh or measure concrete mixture ingredients using load cells or meters for ready-mix and paving concrete to within the targeted batch weight in accordance with the following:

(1) Water – 1 percent,
(2) Cement – 1 percent,
(3) Other cementitious materials – 3 percent,
(4) Aggregates – 2 percent, and
(5) Admixtures – 3 percent.

D.1.c Batching of Mixing Water

Measure the mixing water on scales or water metering devices containing the following:

(1) A discharge indicator capable of being set to within 1 gal [5 L] of a predetermined quantity,
(2) A positive automatic shutoff valve, and
(3) An approved inspection seal on the scale or water metering device dating the time of the previous calibration and adjustment

An authorized service agency will calibrate the water meter every 6 months and make adjustments as necessary before use meeting the requirements of the weighing procedure in section 5-694.400 of the Concrete Manual.

Check the water meter for accuracy at least once each month as the work progresses.

D.1.d Batching of Cementitious Materials

Weigh the cementitious material independently of the aggregates in separate compartments or on separate scales.

If the Contractor weighs the cement first and then separately records the weights of each individual cementitious material, the Contractor may weigh the cementitious materials cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.e Batching of Aggregates

If the Contractor records each individual fraction weight of aggregates separately, the Contractor may weigh aggregates cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.f Admixture Proportioning

If using two or more admixtures in a single concrete batch, add each admixture separately to prevent interaction of the different admixtures before mixing with other batch materials. Agitate admixtures to ensure homogeneous concentrations in accordance with the manufacturers recommendations.

Incorporate admixtures to the batch mix in liquid form. Maintain admixture solutions at a uniform concentration at all times. Use the solution concentration and proportions designated by the manufacturer.

If using a mechanical dispenser for proportioning Class I or Class II admixtures, provide a site gauge or meter. Have the admixture manufacturer check admixture dispensers yearly to determine accuracy and ensure unobstructed flow.

D.2 Batching by Volume

Proportion concrete for bridge deck overlays by volume or as required by the contract.

If the Contractor calibrates the mixer for the specific batch materials in use, the Contractor may proportion concrete on other items of work by volume as approved by the Engineer in writing.

The Engineer will approve all methods and equipment used in volumetric proportioning.

Determine all material proportions and calibration settings on the basis of 100 lb [45 kg] of cementitious material.

Provide and use only sacked cement in the original mill containers unless the Contractor calibrates the mixer for the specific materials in use. Do not use fractional sacks.

Increase the cementitious content by 10 percent in the computation of volume proportions unless the Contractor calibrates the mixer for the specific materials in use.

E Mixing Requirements

The Engineer may check the water measuring equipment for accuracy before mixing operations begin and at any other time the Engineer considers necessary.

Mix concrete by one of the following methods:

(1) A central plant (stationary plant),
(2) Entirely or in part in truck mixers, or
(3) At the construction site.

Do not allow the mixing batch to merge or intermix with the subsequent dry batch during mixing.

Discharge water remaining in the drums before batching.

Mix concrete to provide a mixture that is homogeneous and uniform in color. The Engineer will reject concrete batches that show a marked variation in consistency or evidence of improper mixing as unacceptable work in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

After completely mixing the concrete, either in a central plant mixer or truck mixer, continuously agitate while in transit to the point of placement until the concrete is discharged from the unit, unless otherwise allowed by the Engineer, in conjunction with the Concrete Engineer.

If the mixing does not appear uniform, perform slump tests at the 15 percentage point and the 85 percentage points during unloading. If the results show a slump variation greater than 1½ in [38 mm], stop work and correct the mixing unit.

Produce concrete in such quantity and at such a rate as proper placement and finishing will permit. Do not re-temper partially set concrete.

Do not hand mix concrete.

E.1 Mixing In Truck Mixer

Charge the materials into the truck mixer drum by introducing sufficient water before adding solid materials. Perform charging operations without losing materials.

Leave the truck mixer at the plant site for a minimum of 5 min or 50 revolutions during the mixing period. Transport the concrete at agitating speed to the point of placement.

F Certified Ready-Mix Concrete

Provide concrete produced by a certified ready-mix plant. Ensure the Producer performs quality control of concrete production under a certification program for ready-mix concrete plants.

Provide batches for a delivered load of concrete in sizes of at least 1 cu. yd [1 cu. m].

The Engineer may reject ready-mix concrete delivered to the work site that does not meet the specified requirements for delivery time, consistency, quality, air content, or other properties, as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

F.1 Certified Ready-Mix Plant Program

The Producer will perform Quality Control (QC) as part of the production process under the certification program for ready-mix concrete plants. QC is the process control of the operations related to gradation and moisture control of the aggregates at the ready-mix plant. Provide and maintain a QC program for ready-mix production, including mix design, process control inspection, sampling and testing, and adjustments in the process related to the production of concrete. The Engineer will perform Quality Assurance (QA) as part of the acceptance process. QA is the process of monitoring and evaluating various aspects of the Producer's responsibilities related to the sampling, testing and production of concrete.

F.1.a Plant Certification

Prior to the production of Department concrete each construction season, a Department Representative shall perform a thorough on-site inspection of the concrete plant with a MnDOT Certified Plant Level 1 or Level 2 Technician, representing the Producer.

In order to obtain certification, complete the following:

(1) Identify all persons responsible for testing and overseeing plant operations including their email and cell phone number on the MnDOT Form 2163, *Concrete Plant Contact Report*.
(2) The Producer and Engineer will mutually complete and sign MnDOT Form 2163, *Concrete Plant Contact Report*.
  (a) A MnDOT Certified Concrete Plant Level 1 or 2 Technician, representing the Producer, signs the report certifying compliance with the Certified Ready Mix requirements and continual maintenance of the plant to assure that the plant can produce concrete meeting MnDOT Specifications.
  (b) A MnDOT Certified Concrete Plant Level 1 or 2 Technician, representing the Department, signs the report signifying that the plant complies with all requirements prior to concrete production.
(3) Include a site map showing stockpile locations.
(4) Provide cementitious and admixture samples.
(5) Provide a computerized batching system capable of meeting the requirements of 2461.3.F.2, "Certificate of Compliance."
(6) Provide continuous access on-site to the Concrete Manual available from MnDOT's website.
(7) Supply a working email address, including an active internet connection, at the certified ready-mix plant.
(8) Keep plant reports, charts, and supporting documentation on file at the plant site for 5 calendar years.

(9) Provide electronic scales for weighing all materials.
(10) Provide facilities in accordance with 1604, "Plant Inspection – Commercial Facility," for the use of the plant technician in performing tests.

F.1.b Maintaining Plant Certification

After completing the Concrete Plant Contact Report, any procedural changes that cause non-compliance with this program may result in de-certification of the plant and cessation of further production of Department concrete as determined by the Concrete Engineer in accordance with 2461.3.F.4.h, "Decertification."

The Producer will maintain plant certification by documenting the production and testing of the certified ready-mix concrete. Sample and test the materials in accordance with this section and the requirements of the Schedule of Materials Control.

F.2 Certificate of Compliance

Provide a computerized Certificate of Compliance with each truckload of ready-mixed concrete at the time of delivery. The Department defines computerized to mean a document that records mix design quantities from load cells and meters.

If the computer that generates the Certificate of Compliance malfunctions, the Engineer may allow the Contractor to finish any pours in progress if the Producer issues a handwritten MnDOT Form 0042, *Certificate of Compliance* with each load. Do not allow the Producer to begin new pours without a working computerized Certificate of Compliance.

Provide a computerized Certificate of Compliance that includes all of the following information:
(1) Name of the ready-mix concrete plant,
(2) Name of the Contractor,
(3) Date,
(4) State Project Number (SP) or (SAP),
(5) Bridge Number (if applicable),
(6) Time concrete was batched,
(7) Truck number,
(8) Quantity of concrete in this load,
(9) Running total of each type of concrete, each day for each project,
(10) Type of concrete (MnDOT Mix Designation Number),
(11) Cementitious materials using MnDOT Standard Abbreviations,
(12) Admixtures using MnDOT Standard Abbreviations,
(13) Aggregate sources using 5 digit State Pit Numbers,
(14) Admixture quantity in fluid ounces per 100 lb [milliliters per kilogram] of cementitious materials or ounces per cubic yard [milliliters per cubic meter],
(15) Batch weights in columns in accordance with Table 2461-12:
  (15.1) Print in order a through k.
  (15.2) Use formula to calculate weights.
  (15.3) Head columns with Standard Labels.

Table 2461-12
Standard Certificate of Compliance Labels

	Formula Letter	Formula	Standard Label
a	Ingredients (aggregate, cementitious, water, admixture type)	—	Ingredient
b	Product Source (MnDOT Standard Abbreviation)	—	Source
c	Total Moisture Factor (in decimals to 3 places)	—	MCFac
d	Absorption Factor (in decimals to 3 places)	—	AbsFac
e	MnDOT mix design oven dry (OD) weights, *lb/cu. yd [kg/cu. m]*	—	OD
f	Absorbed moisture in the aggregates, *lb/cu. yd [kg/cu. m]*	(e × d)	Abs
g	Saturated surface dry (SSD) weights for aggregates, *lb/cu. yd [kg/cu. m]*)	(e + f)	SSD
h	Free moisture, *lb/cu. yd [kg/cu. m]*	(c - d) × e	Free Mst
i	Target weights for one cubic yard [cubic meter] of concrete, *lb/cu. yd [kg/cu. m]*	(g + h)	CY Targ [CM Targ]
j	Target batch weights, *lb [kg]*	(cu. yd × i) [cu. m × i]	Target
k	Actual batch weights, *lb [kg]*	—	Actual

NOTE: Actual cubic yards [cubic meters] batched may vary due to differences in air content, weight tolerances, specific gravities of aggregates, and other variables.

(16) Total Water (Batch Water + Free Moisture) in pounds [kilograms],
(17) Water available to add [(Mix Design Water × Batch Size) – Total water] in gallons [liters],
(18) Space to note the water adjustment information, including:
  (18.1) Water in gallons [liters] added to truck at plant (filled in by Producer, enter zero if no water is added),

(18.2) Water in gallons [liters] added to truck at the jobsite (filled in by Producer or Engineer, enter zero if no water is added), and
(18.3) Total actual water in pounds [kilogram] (Total Water from Certificate of Compliance plus any additions).

(19) The following information printed with enough room beside each item to allow the Engineer to record the test results:
(19.1) Air content,
(19.2) Air temperature,
(19.3) Concrete temperature,
(19.4) Slump,
(19.5) Cylinder number,
(19.6) Location or part of structure,
(19.7) Time discharge, and
(19.8) Signature of Inspector.

(20) Location for the Producer signature

F.3 Definitions

The Department defines ready-mix concrete as one of the following:

(1) Central-mixed concrete proportioned and mixed in a stationary plant and hauled to the point of placement in revolving drum agitator trucks or a truck mixer, or
(2) Truck-mixed concrete proportioned in a stationary plant and fully mixed in truck mixers.

Table 2461-13 defines commonly used certified ready-mix terms.

Table 2461-13
Certified Ready-Mix Terminology

Term	Definition
Mix design water	The maximum allowable water content for 1 cu. yd [1 cu. m] of concrete in accordance with MnDOT Form TP 02406, *Estimated Composition of Concrete Mixes*.
Total moisture factor	Factor used to determine total amount of water carried by a given wet aggregate.
Absorption factor	Factor used to determine the water contained within the pores of the aggregate and is held within the particles by capillary force.
Free moisture	The water that is carried on the surface of the aggregate that becomes part of the total water.
Batch water	Water actually batched into the truck by the batcher.
Total water	Batch water added to free moisture. Total water may also include the water used in diluting admixture solutions.
Temper water	Water added in mixer to adjust slump.
Total actual water	The water in the concrete mixture at the time of placement from any source other than the amount absorbed by the aggregate. It includes all batch water placed in the mixer, free moisture on the aggregate and any water added to the ready mix truck prior to placement.
Ready-Mix Producer or "Producer"	Party that is producing the concrete for the Contract. It is understood that the Ready-Mix Producer is the agent of the Contractor.
Water/Cement (w/c) Ratio	W/C ratio is defined as the ratio of the total water weight to the total cementitious weight, which includes cement and supplementary cementitious materials.

F.4 Contractor Quality Control (QC)

The Producer's responsibilities include the following:

(1) Maintain all plant and laboratory equipment within allowable tolerances as set forth in the MnDOT Specifications.
(2) Provide qualified personnel when producing certified ready-mix concrete.
(3) Spot check the actual batching of concrete to assure desired batch weights and tolerances comply.
(4) Check the bins and piles for segregation, contamination, or interblending of the aggregates.
(5) Check accuracy of scales and verify scale calibrations are up-to-date.
(6) Check that mix trucks are clean, blades are not worn, and revolution counters are working properly.
(7) Take cementitious and admixtures samples as directed by the Engineer.

F.4.a Personnel

Provide a competent MnDOT Certified Concrete Plant Level 2 Technician who is responsible for all certified ready-mix plant operations and QC testing. The MnDOT Certified Concrete Plant Level 2 Technician is required to remain on-site during concrete production or have cellular phone availability.

Provide a MnDOT Concrete Plant Level 1 or Plant Level 2 Technician to perform all testing and quality control requirements of 2461.

F.4.b Sampling and Testing

Take all samples randomly in accordance with ASTM D 3665, Section 5, at a rate defined in accordance with the Schedule of Materials Control.

Perform gradation and moisture testing at the certified ready-mix plant site. Perform additional testing as directed by the Engineer.

Perform all sampling and testing in accordance with section 5-694.100 of the Concrete Manual. The Engineer may oversee the QC sampling and testing process.

Provide equipment and perform calibrations meeting the requirements of the following:

(1) AASHTO T 27, "Sieve Analysis of Fine and Coarse Aggregates,"
(2) AASHTO T 255, "Total Moisture Content of Aggregate by Drying,"
(3) AASHTO M 92, "Wire-cloth Sieves for Testing Purpose," and
(4) AASHTO M 231, "Weighing Devices Used in the Testing of Materials."

F.4.c Gradations

Determine the gradation of the aggregates as required by the Contract. Use mechanical shakers for sieve analysis. The Engineer will not allow a Verification Companion Gradation as a substitute for a Quality Control Gradation.

Identify quality control companion samples with the following information:
(1) Date,
(2) Test number,
(3) Time,
(4) Type of material,
(5) Plant, and
(6) Sampling location.

Using the Concrete Ready-Mix Plant QC Workbook, document gradation results on Form 2449, *Weekly Concrete Aggregate Report*.

F.4.d Aggregate Gradation QC Charts

For each aggregate size and aggregate source:
(1) Chart all Producer gradation and Department verification gradation results using the MnDOT *Aggregate Gradation Control Charts*
(2) Calculate the moving average of the last four test results for each sieve size.

F.4.e Moisture Content

The Producer will perform the following:
(1) Determine the moisture content using the oven-dry method in all fractions of the aggregate.
(2) Using the Concrete Ready-Mix Plant QC Workbook, document moisture tests on MnDOT Form 2152, *Concrete Batching Report*.

F.4.f Plant QC Workbook

Complete the *Concrete Ready-Mix Plant QC Workbook* which includes all of the following documents:
(1) Diary
(2) Batching Report
(3) Concrete Aggregate Worksheet
(4) Weekly Concrete Aggregate Report
(5) JMF Concrete Aggregate Worksheet
(6) JMF Weekly Concrete Aggregate Report

The Producer will electronically submit the QC Workbook to the Engineer by the Tuesday immediately following the previous week's production.

F.4.g Signing the Certificate of Compliance

The Producer's MnDOT Certified Plant Level 1 or Level 2 technician will:

(1) Review the first Certificate of Compliance for each mix type, each day, for accuracy; and
(2) Hand sign the Certificate of Compliance at a location designated for Producer signature signifying agreement to the terms of this program and to certify that the materials comply with the requirements of the Contract.

F.4.h Decertification

The Concrete Engineer, with coordination from the Engineer, may decertify the plant and halt production of concrete under any of the following conditions:

(1) Unauthorized procedural, material, or equipment changes made after the completion of the Concrete Plant Contact Report,
(2) Failure to meet the required testing rates,
(3) Failure to complete required documents,
(4) Disregards any of the requirements of this section, and
(5) Falsification of test records or certificates of compliance.

The Department may also perform any of the following:

(1) Revoke Technical Certification for the individual or individuals involved, as determined by the Construction Engineer,
(2) Revoke bidding privileges as determined by the Construction Engineer, and
(3) Prosecute for fraud as determined by the Attorney General.

F.5 Quality Assurance (QA)

The Engineer's responsibilities include the following:

(1) Verify cement, fly ash, and admixtures are certified and approved,
(2) Sample cement, fly ash, and admixtures per the Schedule of Material Control,
(3) Spot check the actual batching of concrete to assure desired batch weights and tolerances comply,
(4) Check Certificate of Compliance for completeness and accuracy,
(5) Check the bins and stockpiles for segregation, contamination, and interblending of the aggregates,
(6) Obtain Aggregate Quality samples per Schedule of Materials Control,
(7) Observe Producer's Certified Technician obtain aggregate samples and run gradation and moisture tests, and
(8) Confirm the Producer's QC Workbook and Quality Charts are accurate and up-to-date.

F.5.a Personnel

The Department will utilize technicians with certification at least meeting MnDOT Concrete Plant Level 1 to perform all of the duties of 2461.3.F.5.

F.5.b Verification Gradations

The Engineer will:

(1) Obtain Verification gradation samples per Schedule of Materials Control.
(2) Record the Verification gradation results on the MnDOT Form 24143, *Weekly Certified Ready-Mix Plant Report* or *Concrete Ready-Mix Plant QA Workbook*.
(3) Provide Verification gradation results to Producer in a timely manner, so they can enter into *Producer's QC Workbook*.
(3) Compare results with Verification Companion sample run at the plant for compliance with lab/field tolerance in accordance with Table 2461-16.

F.5.c Diary

The Engineer will provide plant diaries in accordance with section 5-694.700 of the Concrete Manual.

F.5.d Batch Weight Verification

Each time the Department obtains a verification gradation, the Engineer will observe the actual water batched in a single load of concrete in accordance with the following:

(1) Watching the ready-mix truck reverse the drum after washing,
(2) Verifying use of the current moisture test,
(3) Verifying that any additional water added to adjust the slump is recorded, and
(4) Validating water weights on the load batched and comparing the total water with the design water.

The Engineer will document the actual water batched on MnDOT Form 24143, *Weekly Certified Ready-Mix Plant Report* or *Concrete Ready-Mix Plant QA Workbook*.

F.5.e QA Workbook

In lieu of completing a diary and the MnDOT Form 24143, *Weekly Certified Ready-Mix Plant Report*, the Engineer has the option of using the *Concrete Ready-Mix Plant QA Workbook*.

F.5.f Non-compliance with Certified Ready-Mix Plant Program

If the Engineer observes the Producer not complying with the requirements of the Certified Ready-Mix Plant Program, the Engineer may perform any or all of the following:

(1) Notify the Producer of observed deficiencies promptly, both verbally and in writing, and provide a time deadline to correct the non-compliance.
(2) Stop production until the Contractor takes corrective action.
(3) Order the Contractor to remove the non-competent person in accordance with 1802, "Qualification of Workers."

F.6 Acceptance of Concrete Materials

Only place concrete meeting the materials requirements in the work. If the Contractor places concrete not meeting the materials requirements into the work, the Engineer will not accept non-conforming concrete at the contract unit price.

F.6.a Aggregate Gradation (Does not apply to Job Mix Formulas)

The Engineer will base material acceptance on individual and moving average test results in accordance with Table 2461-9 and the following:

Table 2461-14
Acceptance Criteria for Aggregate Gradations

	Contractor Action	
	Within Gradation Limits of MnDOT 3126 or 3137	**Outside of Gradation Limits in MnDOT 3126 or 3137**
Individual gradation test	Continue testing as required	(1) Immediately take second gradation (a) If second gradation passes, resume testing as required (b) If second gradation fails, stop production and contact Engineer (2) Resume production when corrective action results in a passing gradation and continue testing as required ‖
Moving average of 4 consecutive tests*	Continue testing as required	(1) Stop production and contact Engineer (2) Determine the cause of continual borderline or failing material (3) Resume production when corrective action results in a passing gradation (4) Increase gradation testing at a rate of 1 per 100 cubic yards until the moving average is within the gradation limits
	* If any aggregate size or source does not establish a moving average of 4 consecutive tests, use the average of all tests taken to determine acceptance. ‖The Engineer may increase the testing rates if gradation issues persist.	

(1) If the gradation tests on split samples from quality control or verification samples result in a variation between the Producer and the Department greater than that set forth in Table 2461-16, the Department will substitute QA and/or Verification test results into the moving average calculation to determine acceptance.
(2) If Producer test results are consistently coarser or finer than Department test results, the Engineer will review in accordance with 1503, "Conformity with Contract Documents."
(3) The Department will determine the monetary adjustment due to the moving average gradation failure.
  (a) Calculate the quantity of non-complying material placed, beginning with the first individual gradation test within the moving average failure and ending with the first passing individual gradation test after the moving average failure.
  (b) Based on the total quantity of non-compliant concrete placed, the Engineer will apply the monetary reduction outlined in Table 2461-15.
  (c) If a moving average failure occurs on multiple sieves, the Department will only reduce the price based on a single monetary deduction.

Table 2461-15
Moving Average Gradation of Specification Sieves

Total Concrete Quantity Cubic Yards [Cubic Meters]	**Lump Sum Monetary Reduction**
0 to 8 [0 to 10]	$125.00
> 8 to 15 [>10 to 20]	$250.00
> 15 to 20 [>20 to 25]	$375.00
> 20 [>25]	$500.00 or $5.00 per cubic yard, whichever is greater

F.6.b Lab Field Tolerance

If the gradation tests on split samples from quality control or verification samples result in a variation between the Producer and the Department greater than that set forth in Table 2461-16, the parties shall follow the procedures for test result dispute resolution available from the MnDOT Concrete Engineering website.

Table 2461-16
Allowable Variations on Percent Passing Sieves

Sieve Size	Allowed Percentage
2 in – ⅜ in [50 mm – 9.5 mm]	± 6
No. 4 – No. 30 [4.75 mm – 600 µm]	± 4
No. 50 [300 µm]	± 3
No. 100 [150 µm]	± 2
No. 200 [75 µm]	± 0.6

F.6.c Coarse Aggregate Quality

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted contract unit prices for coarse aggregate quality failures in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

F.6.d Cementitious Materials

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted contract unit prices for cementitious failures in accordance with 1512, "Unacceptable and Unauthorized Work."

F.6.e Admixtures

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted contract unit prices for admixture failures in accordance with 1512, "Unacceptable and Unauthorized Work."

G Concrete Placement

Assume full responsibility for the acceptable production, placement, finishing, and curing of all concrete under the conditions prevailing, regardless of the restrictions imposed. Provide any artificial lighting, rain or cold weather protection necessary at no additional cost to the Department.

Place concrete after the Engineer inspects and approves the foundation preparations, forms and falsework erection, placement of reinforcement steel, materials, equipment condition, and cold weather protection.

Do not place concrete if portions of the base, subbase, or subgrade layer are frozen, or if the excessive moisture levels make the grade unstable. Maintain the surface temperature above freezing for forms, steel, and adjacent concrete that will come in contact with the poured concrete before concrete placement.

Protect the concrete from freezing.

Protect the concrete against damage from construction operations or traffic.

The Engineer will evaluate any defects in concrete or concrete surfaces resulting from weather conditions, inadequate lighting, or other causes in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.1 Notice of Inspection

Notify the Engineer at least 24 h before beginning concrete production to allow the Engineer time to provide inspection forces needed for the work and to approve preparations for concrete placement. If the Contractor fails to provide 24 h notice, the Engineer may delay concrete placement in accordance with 1503, "Conformity with Contract Documents" and 1512, "Unacceptable and Unauthorized Work."

If the producer needs to change plants during placement, notify the Engineer and obtain approval before changing the plant.

G.2 Placement Temperatures

Unless approved cold-weather provisions are in-place, do not place concrete when the air temperature is either of the following at the point of placement:

(1) Below 36 °F [2 °C], or
(2) The National Weather Service predicts the temperature to fall below 36 °F [2 °C] within the following 24 h period.

Maintain concrete at a temperature from 50 °F to 90 °F [10 °C to 30 °C] until placement.

G.3 Delivery Requirements

Place concrete into the work in accordance with the following:

(1) Type 1 Concrete—within 90 min of batching, and
(2) Type 3 Concrete—within 90 min of batching when all admixtures are added at the plant at the manufacturer's recommended dosage rates listed on the Approved Products list. If the haul time does not facilitate mixing and placing the concrete within 90 min, test the concrete in accordance with 2461.3.G.3.a, "Delivery Time Beyond 90 Minutes."

The Contractor may transport Type 3 concrete in non-agitating equipment if the concrete is discharged within 45 min of batching.

Batch time starts when the batch plant or the transit mix truck adds the cement to the other batch materials.

G.3.a Delivery Time Beyond 90 Minutes

If the haul time does not facilitate mixing and placing the concrete within 90 min, perform the following procedures for pre-qualifying a concrete mix to extend the delivery time to 120 min. Extending the delivery time beyond 120 min will require additional testing at 30-minute intervals up to the maximum desired delivery time as directed by the Concrete Engineer.

(1) Provide a contractor mix design in accordance with 2461.2.F, "Contractor Concrete Mix Designs," for each combination of materials;
(2) Laboratory trial batching on the proposed mix includes the following testing requirements:
  (a) Perform all laboratory trial batching at an AMRL accredited laboratory;
  (b) Perform all plastic concrete testing after adding all admixtures to the concrete mixture;
  (c) Perform slump, air content, unit weight, and temperature testing immediately after batching, at 90 min, and at 120 min;
  (d) Fabricate concrete cylinders for compressive strength at 90 min and at 120 min (sets of 3) and cylinders for hardened air content testing at 90 min and at 120 min (sets of 5);
  (e) Test the cylinders for compressive strength at 28 days;
  (f) Determine the hardened air content (ASTM C457) at a minimum of 7 days. The Contractor is required to test 2 samples representing 90 min and 2 samples representing 120 min and provide MnDOT with the other 6 samples for testing at their discretion. Retain any hardened concrete test specimens for a minimum of 90 days for MnDOT to examine at their discretion;
  (g) Ensure the admixture manufacturer's technical representative is present during the trial batching;
  (h) Contact the MnDOT Concrete Engineering Unit a minimum of two (2) days before mixing. This same two (2) day notification is required before any physical testing on hardened concrete samples; and
  (i) Once accepted by the Concrete Engineer, the Department will consider the laboratory trial batching acceptable for use for five (5) years; unless they determine the material sources have changed significantly since the initial laboratory testing and acceptance. The Engineer will require field trial batching on all projects.
(3) Field trial batching on the proposed mix for each specific project shall include batching in the presence of the Engineer and the following:
  (a) Provide a QC Plan for extending the delivery time beyond 90 min;
  (b) Mix and transport the concrete using the same materials used in the laboratory trial batching;
  (c) Batch a minimum 5 cubic yards [4 m^3] of concrete utilizing the same methods intended for use when supplying concrete placed into the permanent work;
  (d) Maintain the ready mix truck in transit; by either driving around the yard or on the roadway; and maintain the drum speed at 5 to 7 revolutions per minute for the entire 120 min;
  (e) Perform all plastic concrete testing after adding admixtures to the concrete mixture;
  (f) Perform slump, air content, unit weight, and temperature testing at 90 min and 120 min;
  (g) Fabricate concrete cylinders for compressive strength at 90 min and 120 min (sets of 3) and cylinders for hardened air content testing at 90 min and 120 min (sets of 2);
  (h) Test the cylinders for compressive strength at a minimum of seven (7) days;
  (i) Determine the hardened air content (ASTM C457) at a minimum of seven (7) days. The Contractor is required to test one (1) sample representing 90 min and one (1) sample representing 120 min and provide MnDOT with the other two (2) samples for testing at their discretion. Retain any hardened concrete test specimens for a minimum of 90 days for MnDOT to examine at their discretion;
  (j) Incorporate the trial batch concrete into other work with the approval of the Engineer; and
  (k) The Contractor must demonstrate to the Engineer the ability to properly mix, control, and place the concrete.
(4) The Concrete Engineer will review the trial batch results and all related concrete testing for compliance with the QC Plan and the Contract. Final approval of the mixture is based on satisfactory field placement and performance.

G.4 Field Adjustments

For all grades of concrete, do not add additional mixing water unless the Certificate of Compliance states there is water available to add or once the concrete has attained an age 60 min from the initial batch time stated on the Certificate of Compliance.

For all grades of concrete with slumps of greater than 1 inch [25 mm] do not make water adjustments after discharging approximately 1 cubic yard [1 m^3].

For slip-form concrete median barrier and railing mixes with slumps of 1 inch [25 mm] or less, the Engineer will allow water adjustments as necessary to facilitate placement not to exceed the available amount of water to add stated on the Certificate of Compliance.

The Engineer will test the concrete for compliance with 2461.3.G.7, "Consistency," and 2461.3.G.8, "Air Content," in accordance with the following:

(1) If the first test taken by the Engineer passes, the Engineer will continue verification testing in accordance with the Schedule of Materials Control.
(2) If the test taken by the Engineer fails, make adjustments and perform any quality control testing before the Engineer performs a final test. Acceptance or rejection of the truck is based on the Engineer's final test result.
(3) The Engineer will test up to two additional trucks in accordance with items (1) and (2) above, and
(4) If the concrete does not meet the specification after those three trucks, the Engineer will reduce their verification testing rate to once per truck for acceptance for the remainder of the pour.

For concrete mixes 3U17A and 3U18, allow mix to hydrate 5 min before slump test to assure all cement is saturated.

Mix the load a minimum of 5 min or 50 revolutions at mixing speed after addition of any admixture.

G.5 Test Methods and Specimens

Perform random sampling and testing in accordance with section 5-694.500 of the Concrete Manual and determine testing rates meeting the requirements of the Schedule of Materials Control. When required by the Engineer, record field measurements, including strength specimen identifications on MnDOT Form 2448, *Weekly Concrete Report*, to provide to the Engineer.

The Engineer performs random sampling and testing in accordance with section 5-694.500 of the Concrete Manual, determines testing rates meeting the requirements of the Schedule of Materials Control, and records field measurements, including strength specimen identifications on MnDOT Form 2448, *Weekly Concrete Report*, to provide to the Engineer.

Anyone testing concrete cylinders is required to hold either a current ACI Strength Testing Technician Certification or a MnDOT Strength Testing Technician Certification.

The Engineer will furnish molds based on the maximum size aggregate for the test specimens in accordance with the following:

(1) 4 in × 8 in [100 mm × 200 mm] cylinder molds,
(2) 6 in × 12 in [150 in × 300 mm] cylinder molds for maximum aggregate sizes greater than 1¼ in [31.5 mm], and
(3) 6 in × 6 in × 20 in [150 in × 150 in × 500 mm] beam molds; use other beam mold sizes as approved by the Engineer.

G.5.a Standard (28-day) Strength Cylinders

The Department will perform the following for standard strength cylinders:

(1) Cast cylinders (sets of 3) for testing at 28 days in accordance with the Schedule of Materials Control.
(2) Mark cylinders for identification of the represented unit or section of concrete in accordance with the following: (1.1, 1.2, 1.3, 1.4/ 2.1, 2.2, 2.3, 2.4/ 3.1, 3.2, etc.). In order to differentiate between portions of a project, prefixes and suffixes are allowed.
(3) Cure the cylinders meeting the requirements of the 2461.3.G.5.b.
(4) Complete the MnDOT Concrete Cylinder Identification Card including the results for air content, slump (if required), concrete, and air temperature testing from the same load.

G.5.b Curing and Transporting Standard (28-day) Strength Cylinders

The Concrete Engineer defines the curing period as the following:

(1) **Initial curing period** as immediately after molding and finishing for a period of up to 48 hours in a temperature range from 60 °F to 80 °F [16 °C and 27 °C]."
(2) **Intermediate Curing Period** as the time between initial curing and delivery to the laboratory for final curing.
(3) **Final Curing Period** as the time when cylinders are cured in the laboratory.

Provide moist curing environments of adequate size and number for initial curing period in accordance with ASTM C31 and in accordance with 2031.3.C, "Special Requirements."

After the initial curing period, the Engineer will both transport and further cure the test specimens in the provided curing tanks for intermediate curing up to 7 days from the time of casting.

Provide curing tanks of adequate size and number for curing all of the concrete test specimens in accordance with 2031.3.C, "Special Requirements." Maintain the water in the curing tanks to a water temperature of 60 °F to 80 °F [16 °C and 27 °C] for the intermediate curing period.

The Engineer will deliver the test specimens to the laboratory for final curing and compressive strength testing.

G.5.c Control Strength Cylinders

The Engineer will use control cylinders to determine when the sequence of construction operations is dependent upon the rate of concrete strength development. The Engineer will cast control cylinders to determine when the concrete attains the required strength for all desired control limitations. The Contractor is responsible for any additional control cylinders beyond the requirements of 2461.3.G.5.c (1).

The Engineer will perform the following for control strength cylinders:

(1) Cast up to three (3) control cylinders per structure.
(2) Mark control cylinders for identification of the represented unit or section of concrete in accordance with 2461.3.G.5.a(2). Mark Control Cylinders with the letter C after the numbering sequence (X.5C)
(3) Cure the cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of section 5-694.500 of the Concrete Manual,
(3.1) For High-Early (HE) Concrete as defined in Table 2461-7, the Engineer will allow the Contractor to cure control cylinders using insulated cylinder storage compartment. Provide insulated storage compartments and any equipment necessary to continually monitor temperatures of both the newly poured concrete structure and the insulated cylinder storage compartment. Maintain the insulated storage compartment at a temperature no greater than 5 °F [3 °C] above the newly poured concrete structures temperature. When the temperature exceeds 5 °F [3 °C] or the temperature monitoring system fails, the Engineer will not accept control cylinder results.
(4) Complete the MnDOT Concrete Cylinder Identification Card including the results for air content, slump (if required), concrete, and air temperature testing from the same load.

During the Departments normal laboratory operating hours, the Engineer will perform compressive strength testing on the control cylinders. If Project scheduling requires testing outside of the Departments' laboratories normal operating hours or the Department's nearest laboratory is greater than 30 miles from the project; Provide certified and calibrated hydraulic cylinder-testing machine within 30 miles of the project and at a location approved by the Engineer. Test the control cylinders in the presence of the Engineer in accordance with ASTM C39.

The Engineer will allow the Contractor to submit a strength-maturity relationship curve for use in lieu of control cylinders in accordance with 2461.3.G.5.e.

G.5.d Strength Specimens for Concrete Paving

Use flexural beams to determine strength or provide cylinders as allowed by the contract or approved by the Engineer.

Cast standard beams or cylinders for testing at 28 days.

Cast a sufficient number of control beams or cylinders to determine when the concrete attains the required strength for all desired control limitations.

Cure the standard beams or cylinders meeting the requirements of section 5-694.500 of the Concrete Manual.

Cure the control beams or cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of the Concrete Manual.

The Engineer will test the flexural beams and record the results on MnDOT Form 2162, *Concrete Test Beam Data*.

If using cylinders, the Engineer will submit cylinders and a completed identification card to the Department's Laboratory.

G.5.e Concrete Compressive Strength

The Concrete Engineer defines a **strength test** as the average (28-day) strength of three (3) cylinders fabricated from a single sample of concrete and cured in accordance with section 5-694.500 of the Concrete Manual.

The Engineer will consider concrete acceptable in accordance with Table 2461-17 provided **both** conditions are met for a required f'c.

Table 2461-17 Acceptance Criteria for Standard 28-day Cylinders Concrete Grades B, F, G, M, P, and S		
	All strength tests	**Moving average of 3 consecutive strength tests ***
f'c ≤ 5000 psi	> (f'c – 500 psi)	≥ f'c
f'c > 5000 psi	> 0.90 * f'c	≥ f'c
* If a project does not establish a moving average of 3 consecutive strength tests, use either the single strength test or the average of 2 strength tests to determine acceptance.		

G.5.e(1) Strength Test Below Acceptance Criteria

If any single strength test (3 cylinders) falls below the criteria established in Table 2461-17, the Engineer, in conjunction with the Concrete Engineer, will determine the following:

(A) If the concrete has attained critical load-carrying capacity;
(B) If investigation is required; The investigation may consist of, but is not limited to reviewing the following:
  (B.1) Sampling and testing plastic concrete,
  (B.2) Handling of cylinders,
  (B.3) Cylinder curing procedures,
  (B.4) Compressive strength testing procedures,
  (B.5) Certificate of Compliances
(C) If dispute resolution coring is required in accordance with 2461.3.G.5.e(3).

G.5.e(2) Moving Average Below Acceptance Criteria

If the moving average of three (3) consecutive strength tests falls below f'c, the Concrete Engineer will require a new mix design in accordance with Table 2461-6.

G.5.e(3) Dispute Resolution Coring

The Engineer and Contractor will mutually agree on an Independent Third Party to core and test the concrete in accordance with ASTM C42.

(A) The Engineer will identify a minimum of three (3) locations for the Independent Third Party to core.
(B) The Independent Third Party will take one (1) core at each location.
(C) The Contractor will complete all coring within 14 days of notification of the low strength concrete.
(D) The Contractor is responsible for ensuring the core holes are repaired.

The Engineer, in conjunction with the Concrete Engineer, will review the core test results and evaluate in accordance with Table 2461-18, providing all other concrete tests meet requirements.

Table 2461-18 Evaluation of Core Test Results			
Core (average of 3 cores) Test Results:	**Engineer considers concrete:**	**Cost of Coring and Testing:**	**Resolution:**
≥ 85% of f'c	Acceptable to remain in place	Engineer Responsibility	No monetary adjustment for single strength test failure.
< 85% of f'c	Unacceptable	Contractor Responsibility	Remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in place, the Engineer may not pay for the concrete or will pay at an adjusted Contract Unit Price and consider any additional actions in accordance with Table 2461-19.

G.5.e(4) Non-Conforming Material

If the Contractor inadvertently places concrete not meeting the strength requirements into the work, the Engineer will not accept nonconforming concrete at the contract unit price. For concrete not meeting the moving average of three (3) consecutive strength tests, the Engineer will adjust the contract unit price for the contract item of the concrete in accordance with Tables 2461-19.

Table 2461-19
Concrete Grades F, G, M, and P*

Moving average of 3 consecutive strength tests	Adjusted Contract Unit Price ‖
> 93.0% of f'c	The Department will pay 87.5 percent of the relevant contract unit price for materials placed as approved by the Engineer.
≥ 87.5% and ≤ 93.0% of f'c	The Department will pay 75 percent of the relevant contract unit price for materials placed as approved by the Engineer.
< 87.5% of f'c	Remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in place, the Engineer will not pay for the concrete.

* The Engineer, in conjunction with the Concrete Engineer, will determine adjusted contract unit prices for Concrete Grade B and Grade S strength failures in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."
‖ When there is not a separate contract unit price for *Structural Concrete* for an item of work or the concrete is a minor component of the contract unit price, the Department will reduce payment based on a concrete price of $100.00 per cu. yd [$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

G.6 Estimating Concrete Strength by the Maturity Method

The Engineer will allow the maturity method to determine development of concrete strength. Use of this method requires the establishment of a relationship between concrete strength and the computed maturity index (using the Nurse-Saul method) for a specific concrete mixture prior to construction. Use this method, in accordance with this specification and section 5-694.560 of the Concrete Manual to estimate the in-place strength of the concrete.

G.6.a Development of Maturity-Strength Relationship

Prior to any concrete placement, develop a strength-maturity relationship (maturity curve) for any concrete mix design utilizing the maturity method. The Contractor shall notify the Engineer prior to developing the maturity curve. Submit a completed *Concrete Maturity-Strength Development* form to the Concrete Engineering Unit and to the Engineer in the field for each concrete mixture utilizing the maturity method.

The Engineer will allow development of the maturity curve in either the laboratory or in the field, provided the precautions for field curing and testing are followed, as described in section 5-694.500 of the Concrete Manual. Test the concrete strength specimens for development of the maturity curve.

Determine the strength development criteria based on the type of concrete in accordance with the following:

(1) For concrete pavement: 2301.3.O, "Opening Pavement to Traffic,"
(2) For concrete pavement repairs: 2302.3.B.4, "Opening to Construction Equipment and Traffic,"
(3) For concrete structures: 2401.3.G, "Concrete Curing and Protection"
(4) For sidewalks, driveway entrances and curb and gutter, a minimum of 3000 psi [20.6 MPa] is required.

Until an acceptable strength-maturity relationship is established, verify strength using concrete beams or cylinders.

G.6.a(1) Procedure

Estimate the in-place concrete strength using the maturity method as described in ASTM C 1074, except as noted in this specification as follows:

(a) Using 15 beams or 17 cylinders;
(b) The Nurse-Saul method of computing maturity;
(c) A datum temperature of -10°C;
(d) Maintain specimens at temperatures greater than 50° F [10° C] for the duration of the maturity curve development.

Test strength specimens in accordance with section 5-694.500 of the Concrete Manual for the type of concrete at the intervals specified in Table 2461-20.

Table 2461-20 Chronological Testing Ages of Strength Specimens	
Type of Concrete	**Testing Intervals**
Normal Strength Concrete as defined in 2301 and 2461	1, 2, 3, 7 and 28 days
High-Early (HE) Concrete as defined in 2301 and 2461	12 hours, 1, 2, 7 and 28 days
Ultra High-Early (UHE) Concrete as defined in 2302	3, 4 and 8 hours, 1 and 14 days

G.6.a(2) Equipment

Provide the following equipment for determining the maturity:

(1) Maturity meter or temperature sensor and data logger with a secure means of collecting data that is unalterable, and conforms to the requirements in ASTM C 1074.

(2) Beam or cylinder molds for development of the maturity curve and other concrete making and testing equipment.

G.6.b Estimating In-Place Strength Using Maturity

Place concrete maturity meters or temperature sensors within the concrete in accordance with Table 2461-21.

Table 2461-21 Maturity Meter or Temperature Sensor Placement and Frequency		
Maturity Application	**Placement**	**Frequency**
Concrete Paving	Embed at approximately mid-depth and approximately 18 (but no less than 12) inches from the edge of the pavement.	Place at least one for every 1,500 lineal feet of paving, including one in the last 50 feet of each day's paving.
Full Depth Concrete Pavement Repairs	Embed at approximately mid-depth and approximately 18 (but no less than 12) inches from the edge of the pavement.	Place at least two for each day of concrete placement with one at the end of the day.
Partial Depth Concrete Repairs	Embed at least 2 inches from the surface.	Place at least two for each day of concrete placement with one at the end of the day.
Sidewalk, Driveway Entrances, Curb and Gutter	Embed at approximately mid-depth and approximately 18 (but no less than 12) inches from the edge of the pavement.	Place at least two for each day of concrete placement with one at the end of the day.
Concrete Structures	Attach to the reinforcing steel near the edge of the exposed surface using a non-metallic fastener.	Place at least two for each concrete element.

The computed maturity results from each sensor will only apply to concrete placed under the following conditions:

(1) The same mix designation and the same project as the test location,

(2) Placed on the same day and on, before, or within 50 feet after placement of the sensor,

(3) Cured under conditions similar to those of the test location.

Record the temperature readings and calculate the maturity values on the *Maturity-Field Data* form.

G.6.c Verify Strength-Maturity Relationship

At least once every seven (7) calendar days during normal plant production, perform a verification strength test to ensure the in-place concrete strength correlates with the maturity-strength relationship as follows:

(1) Notify the Engineer at least 24 hours in advance of the time and location of both the verification specimen's casting and strength testing.

(2) Cast 3 beams or 4 cylinders for each verification strength test.

(3) The Engineer will test the concrete strength specimens for verification of the maturity curve as close to the maturity value determined to represent the opening, loading or form removal strength criteria in accordance with section 5-694.500 of the Concrete Manual.

(4) Record the results of verification test on the *Concrete Maturity-Strength Verification* form and submit an updated copy with the newest test result to the Engineer the day that the verification test is completed.

(5) The Engineer may direct additional verification testing as necessary.

(6) Submit electronic data from the maturity meters or temperature loggers in a comma-delimited (.txt or .csv) file format to the Engineer, which includes at least the project number, date and location.

The Engineer will review and interpret the verification strength test results and determine if the verification testing validates the maturity curve in accordance with Table 2461-22.

Table 2461-22
Interpreting Verification Strength Test Results

If the actual verification strength test falls:	Result	Action
Within the 10% limits of the maturity curve	Maturity curve verified	Continue using the current maturity curve
> 10% higher than the maturity curve	The Engineer will not consider the maturity curve verified, but may consider acceptable for future use if verified.	Develop a new maturity curve at the discretion of the Contractor.
> 10% lower than the maturity curve	The relationship will no longer be acceptable and a second verification test is required, or the Contractor can develop a new maturity-curve, at their discretion.	1. Perform a second verification test. 2. If the second verification test does not fall within 10% of the maturity curve, develop a new maturity-strength relationship. 3. The Engineer will not allow the maturity method for that concrete mix until a new relationship is developed.

G.6.d Changes in Concrete Mixture

The Engineer may require development of a new maturity-strength relationship if any of the following changes occur:

(1) Change in mixture proportions greater than 5% by weight
(2) Increase in the water-cementitious materials ratio by 0.02
(3) Change in the source of any material in the approved mix design
(4) Changes to the curing method or conditions of the concrete
(5) Change in average daily ambient temperatures greater than 30° F (17°C)
(6) Change in concrete mixing equipment or methods of concrete mixing

If any of the changes in this subsection (2461.3.G.6.d) occur for a particular concrete mix, perform a verification test in accordance with 2461.3.G.6.c, "Verify Strength-Maturity Relationship."

G.6.e Maturity Meter Calibration

Calibrate maturity meters yearly to ensure proper operation and temperature sensing.

Verify proper operation of maturity sensor every 30 days during normal plant production in accordance with section 5-694.500 of the Concrete Manual.

G.7 Consistency

The Engineer will test the concrete for consistency using the slump test during the progress of the work. The Department may reject concrete batches with consistencies outside of the slump range limits in Table 2461-6, Table 2461-7, Table 2461-10 and Table 2461-11.

If any test shows the slump outside of the slump range requirements, the Engineer will reject the concrete represented by that test. In order to bring the mixture back into the slump range requirements, the Engineer will allow adjustments to the concrete in accordance with 2461.3.G.3, "Delivery Requirements" and 2461.3.G.4, "Field Adjustments.

Adjust the slump not to exceed the slump range allowed to optimize both placement and finishing. Contact the Engineer if encountering unusual placement conditions that render the maximum slump unsuitable.

G.7.a Concrete Placed by the Slip-Form Method

Place concrete that does not slough and is adequately consolidated at a slump value that optimizes placement for the designated mixture and in accordance with 2461.3.G.4, "Field Adjustments."

G.7.b Non-Conforming Material

Only place concrete meeting the slump requirements in the work. If the Contractor places concrete not meeting the slump requirements into the work, the Engineer will not accept non-conforming concrete at the contract unit price.

For concrete not meeting the required slump, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the contract unit price for the contract item of the concrete in accordance with Tables 2461-23, 2461-24, 2461-25, and 2461-26.

When there is not a separate contract unit price for *Structural Concrete* for an item of work or the concrete is a minor component of the contract unit price, the Department will reduce payment based on a concrete price of $100.00 per cu. yd [$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-23
Concrete Grades B, F, G, M, P, R, S(Non-Bridge Deck)*

Outside of Slump Range	Adjusted Contract Unit Price
Below slump range*	No deduction for materials placed as approved by the Engineer.
≤ 1½ in [40 mm] above slump range	The Department will pay 75 percent of the relevant contract unit price for materials placed as approved by the Engineer.
1¾ in [45 mm] – 2¼ in [55 mm] above slump range	The Department will pay 50 percent of the relevant contract unit price for materials placed as approved by the Engineer.
> 2¼ in [55 mm] above slump range	The Department will pay 25 percent of the relevant contract unit price for materials placed as approved by the Engineer

* If the Contractor places piling or footing concrete below the slump range, the Department will deduct $100 per cu. yd [$130 per cu. m] or the Contractor-provided invoice amount to the relevant contract unit price of the concrete represented by the slump test, whichever is less. The Department will not reduce contract unit price for low slump concrete placed with the slip-form method as approved by the Engineer.

Table 2461-24
Bridge Deck Concrete, Grade S

Outside of Slump Range	Adjusted Contract Unit Price
Below slump range	No deduction for materials placed as approved by the Engineer.
≤ 1½ in [40 mm] above slump range	The Department will pay 75 percent of the relevant contract unit price for materials placed as approved by the Engineer.
> 1½ in [40 mm] above slump range	The Department will pay 25 percent of the relevant contract unit price for materials placed as approved by the Engineer.

Table 2461-25
Low Slump Bridge Deck Concrete, 3U17A
From ½ in to 1 in [12 mm to 25 mm]

Outside of Slump Range	Adjusted Contract Unit Price
Below slump range	No deduction for materials placed as approved by the Engineer.
≤ ½ in [12 mm] above slump range	The Department will pay 50 percent of the relevant contract unit price for materials placed as approved by the Engineer.
> ½ in – ¾ in [12 mm – 20 mm] above slump range	The Department will not pay for concrete placed but will allow the concrete to remain in place as approved by the Engineer.
> ¾ in [20 mm] above slump range	The Department will not pay for concrete. Provide additional testing as directed by the Engineer to determine if the concrete can remain in place or is subject to removal and replacement.

Table 2461-26
Low Slump Concrete — Patching
From ½ in to 1 in [12 mm to 25 mm]

Outside of Slump Range	Adjusted Contract Unit Price
Below slump range	No deduction for materials placed as approved by the Engineer
≤ ½ in [12 mm] above slump range	The Department will pay 75 percent of the relevant contract unit price for materials placed as approved by the Engineer.
≥ ¾ in [20 mm] above slump range	The Department will pay 25 percent of the relevant contract unit price for materials placed as approved by the Engineer.

G.8 Air Content

Maintain the air content of Type 3 general concrete at the specified target of 6.5 percent (+2.0 percent and −1.5 percent) of the measured volume of the plastic concrete in accordance with 1503, "Conformity with Contract Documents."

Measure the air content at the point of placement but before consolidation.

Make any adjustments immediately to maintain the desired air content.

G.8.a Non-Conforming Material

Only place Type 3 concrete meeting the air content requirements in the work. If the Contractor places Type 3 concrete not meeting the air content requirements into the work, the Engineer will not accept non-conforming concrete at the contract unit price.

For concrete not meeting the required air content, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the contract unit price for the contract item of the concrete in accordance with Table 2461-27.

When there is not a separate contract unit price for *Structural Concrete* for an item of work or the concrete is a minor component of the contract unit price, the Department will reduce payment based on a concrete price of $100.00 per cu. yd [$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-27
General Concrete (Target Air Content 6.5%), Grades B, F, G, M, P, R, and S

Air Content, %	Adjusted Contract Unit Price
> 10.0	The Engineer, in conjunction with the Concrete Engineer will determine the concrete suitability for the intended use in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work,"
>8.5 – 10.0	The Department will pay 75 percent of the Contract unit price for the concrete represented for material placed as approved by the Engineer.
5.0 – 8.5	The Department will pay 100 percent of the contract unit price for the concrete represented, for material placed as approved by the Engineer.
>4.0 – <5.0	The Department will pay 75 percent of the contract unit price for the concrete represented for material placed as approved by the Engineer.
>3.5 – 4.0	The Engineer, in conjunction with the Concrete Engineer will determine the concrete suitability for the intended use in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."
≤ 3.5	Remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in place, the Engineer will not pay for the concrete and if the Engineer determines the surface is exposed to salt-brine freeze-thaw cycling, coat with an approved epoxy penetrant sealer from the Approved/Qualified Products List.

G.9 Allowable Testing Tolerances

Allowable tolerances are based on the results from two different testers and two different pieces of equipment from the same sample. Perform the test within the allowable tolerances in accordance with Table 2461-28.

Table 2461-28
Allowable Testing Tolerances

Test	Allowable Tolerance
Air content, % volume of concrete	1.0
Average slump:	
≤ 4 in [100 mm]	1.0 in [25 mm]
4 in – 6 in [100 mm – 150 mm]	1.5 in [38 mm]
≥ 6 in [150 mm]	2.0 in [50 mm]
Unit weight, per cu. ft [cu. m], calculated to an air-free basis	1.0 lb/cu. ft [16 kg/cu. m]
Compressive strength 3,000 psi – 8,000 psi [20.6 MPa – 55.2 MPa], average of 3 tests	500 psi [3.4 MPa]

2461.4 METHOD OF MEASUREMENT

The Engineer will measure fresh concrete produced as required by the contract by the theoretical volume.

The Engineer will deduct accountable waste from the concrete measurement.

The Engineer will measure concrete mixtures on the basis of the dimensions of the structure shown on the plans. If the plans do not include a contract item for concrete used in miscellaneous items, include the cost of the concrete with the relevant contract items.

2461.5 BASIS OF PAYMENT

The Department will include the cost of the Certified Ready-Mix Plant Program with other relevant contract items.

The contract cubic yard [cubic meter] price for *Concrete Mix No.* ___ includes the cost of production, placement, finishing, curing, and protection of concrete.

The Department will pay for structural concrete on the basis of the following schedule:

Item No.:	Item:	Unit:
2461.501	Concrete Mix No.___	cubic yard [cubic meter]

2462 PRECAST CONCRETE

2462.1 DESCRIPTION

This work consists of producing, providing, placing, curing, and protecting precast portland cement concrete in structures, pavements and incidental construction. The State Materials Engineer is the Engineer for the purposes of this specification.

2462.2 MATERIALS

A Cementitious Materials

Provide cementitious materials from certified sources listed on the Approved/Qualified Products list.

Use Type I, I/II, IS, IL, IP, or Type III cement to produce Type 1 non-air-entrained concrete.

Use Type I, I/II, IS, IL, IP, or Type III cement and an air-entraining admixture listed on the Approved/Qualified Products List to produce Type 3 air-entrained concrete.

A.1 Portland Cement.....3101

A.2 Slag Cement 3102

A.3 Blended Hydraulic Cement 3103

A.4 Fly Ash 3115

B Fine Aggregate 3126

C Coarse Aggregate 3137

D Water.....3906

E Concrete Admixtures.....3113

For all Concrete Grades shown in Table 2462-6, use any of the following admixtures on the MnDOT Approved/Qualified Products list:

(1) Type A, Water Reducing Admixture
(2) Type B, Retarding Admixture
(3) Type D, Water Reducing and Retarding Admixture
(4) Type F, High Range Water Reducing Admixture
(5) Type G, High Range Water Reducing and Retarding Admixture
(6) Type S, Specific Performance Based Admixture

Use of any of the following MnDOT Approved/Qualified admixtures required approval of the Concrete Engineer, unless otherwise allowed in the Contract:

(1) Type C, Accelerating Admixture
(2) Type E, Water Reducing and Accelerating Admixture

Incorporate admixtures into the concrete at the Manufacturer recommended dosage rates.

F Precaster Concrete Mix Designs

F.1 Classification of Concrete

The Department will classify concrete by mix number to identify type, grade, consistency, aggregate size, coarse aggregate class and supplementary cementitious material, if any, in accordance with Table 2462-1.

Table 2462-1
Mix Number Identification

First Digit	Second Digit	Third Digit	Fourth Digit	Fifth Digit	Sixth Digit	Additional Digits
Type Designation	Grade Designation	Maximum Slump	Coarse Aggregate Designation	Class of Coarse Aggregate	Supplementary Cementitious Material Designation	Additional Digits Allowed

F.1.a Type Designation

Provide Type 1 or Type 3 concrete in accordance with Table 2462-2:

Table 2462-2
Concrete Type Designation

Concrete Type	Target Air Content*, %
1	2.0
3	6.5

* For concrete mix design purposes only.

F.1.b Grade Designation

The Department will designate concrete grade in accordance with Table 2462-6 using a letter to represent the following:

(1) Intended Use
(2) Maximum water/cement (w/c) ratio
(3) Cementitious Content Range
(4) Maximum Supplementary Cementitious Substitution (SCM)
(5) Slump range
(6) Minimum 28-day compressive strength, f'c
(7) Coarse Aggregate Quality in accordance with 3137

F.1.c Slump Designation

The Department will designate the upper limit of the slump range as defined by the Grade Designation in accordance with Table 2462-6.

F.1.d Coarse Aggregate (CA) Designation

Determine the coarse aggregate designation in accordance with Table 2462-3 based on the intended use and the gradation requirements in 3137, "Coarse Aggregate for Portland Cement Concrete."

Table 2462-3
Coarse Aggregate Designation for Concrete

Designation	Coarse Aggregate Gradation Table 3137-4
0	Job Mix Formula (JMF)*
1	#467
2	#67
3	#7
4	#89

*Job Mix Formula (JMF) is defined as the combined coarse and fine aggregate gradation.

F.1.e Class of Coarse Aggregate Designation

Identify class of coarse aggregate in accordance with Table 2462-4.

Table 2462-4 Class of Coarse Aggregate Designation for Concrete	
Designation	**Spec. 3137.2.B, "Coarse Aggregate Classification"**
A	Class A Aggregate
B	Class B Aggregate
C	Class C Aggregate

F.1.f Supplementary Cementitious Material (SCM) Substitution Designation
Identify the type of supplementary cementitious material in the concrete mix in accordance with Table 2462-5.

Table 2462-5 Supplementary Cementitious Material Designation for Concrete	
Designation	**Type**
F	Fly Ash
S	Slag
M	Microsilica
T	Ternary (Blend of two supplementary cementitious material)

F.1.g Additional Concrete Mix Designation Digits
The Precaster may add additional digits to the right of the required digits in the concrete mix number.

F.2 Concrete Mix Design Requirements
The Precaster assumes full responsibility for the mix design and performance of the concrete.

F.2.a General Concrete Mix Design Requirements
The Department defines the concrete mix design requirements for Precaster Designed Mixes in accordance with Table 2462-6. When specified, precast bridge deck and precast pavement panel requirements are included in the Special Provisions of the Contract.

Table 2462-6
Precast Concrete Mix Design Requirements

Concrete Grade	Mix Number *	Intended Use ‖	Maximum w/c ratio	Cementitious Content (lbs/cy)	Maximum %SCM (Fly Ash/ Slag/ Ternary)	Slump Range ‡	Minimum Compressive Strength, f'c (28-day) #	3137 Spec.
W	1W82	Bridge Girders	0.42	660 – 850	30/35/40	1 – 8″	Design Strength Per Plan	2D1
	3W82	Noisewall posts, box culverts, bridge girders†	0.42	660 - 850	30/35/40	1 – 8″	Design Strength Per Plan	2D1
Y	3Y82	Jumbo retaining wall blocks, noisewall panels	0.45	605 – 850	30/35/40	1 – 8″	4300 psi	2D1
	3Y82	Thin Panel Retaining Walls	0.45	605 – 850	30/35/40	1 – 8″	4300 psi	2D2
M	3M82	Precast Concrete Barrier	0.45	530 – 750	30/35/40	1 – 8″	4500 psi	2D1

* The Contractor may choose to use the Coarse Aggregate Designation "1" for the 4th digit in accordance with Table 2462-3, if allowed by the structure.
‖ If the intended use is not included elsewhere in the Specification or Special Provisions, design concrete mix 3W82.
† Review the Plans to determine if the bridge girders require air entrainment.
‡ Slumps exceeding the maximum allowed require approval of the MnDOT State Materials Engineer.
\# Requires control cylinders for determining shipping strength.

F.3 Precaster Submittal Requirements

At least 21 calendar days before initial placement of the concrete, submit a Precaster Mix Design Submittal package to the Concrete Engineer for approval. The Precaster Mix Design Submittal package is available from the MnDOT Concrete Engineering Website.

Design the concrete mix to an absolute volume of 27.00 cu. ft [1.0 cu. m]

The Concrete Engineer will:

(1) Provide specific gravity and absorption data using saturated surface dry (SSD) weights for mix design calculations.

(2) Review the mix design submittal and approve the materials and mix design for compliance with the Specifications.

F.4 Precaster Mix Design Adjustments

The Department will allow mix design adjustments based upon the criteria as defined in Table 2462-7:

Table 2462-7
Mix Design Adjustments Requirements

Type of Change or Adjustment	Mix Design Approval Resubmittal Requirements
• Admixture Dosage Rate • Cement or SCM sources	No resubmittal required
• Admixture Source • Aggregate Source • Any cementitious or SCM proportion • Aggregate Proportions	Resubmittal of Mix Design

2462.3 CONSTRUCTION REQUIREMENTS

A Batching Equipment

A.1 Mixer Requirements

Provide stationary mixers or truck mixers.

A.2 General Condition

Maintain mixers as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examine to detect wear of blades.

Replace or recondition pickup and throwover blades in mixers with a rated capacity less than 14 cu. ft [0.40 cu. m] showing a blade wear loss of greater than ½ in [13 mm], and pickup and throwover blades in mixers of greater capacity, showing a blade wear loss of no greater than ¾ in [19 mm] from the original factory dimensions.

A.3 Manufacturer's Rating Plate

Provide mixers that include the manufacturer's rating plate, showing the following information:

(1) Serial number of the unit,

(2) Mixing speed of the drum or paddles, and

(3) Maximum capacity in terms of volume of mixed concrete.

A.4 Drum Speed for Stationary Mixers

Operate the drum speed in the mixer as specified by the manufacturer or as directed by the Engineer.

A.5 Auxiliary Equipment Requirements

Provide mixers equipped with the following:

(1) Timing device,

(2) Discharge locking device,

(3) Water measuring device that operates mechanically and automatically during each batching cycle, and

(4) A graduated adjustable indicator device to represent the volume of discharge in increments no greater than ¼ gal [1 L] in full view.

A.6 Mixer Capacity

Do not exceed the manufacturer's rated capacity of the mixer when mixing a single batch of concrete.

Batch concrete in volumes the mixer can accommodate without spilling, leaking, or segregating during the charging, mixing, or discharging operations. Provide mixers with a capacity of at least 1 sack [0.25 cu. m].

A.7 Mixing Time

The Department defines the mixing time as the time period beginning when the cement and aggregates enter the mixer drum and ending when the discharge begins.

Refer to the manufacturer's recommended minimum mixing time for single drum and dual drum mixers. In the absence of manufacturer's recommendation, the Engineer will designate the minimum mixing time. The minimum mixing time for any concrete batch is 60 s. The Precaster may reduce the manufacturer's recommended minimum mixing time or the Engineer designated mixing time if the Precaster obtains uniform mixing in accordance with 2462.3.E, "Mixing Requirements," and as approved by the Engineer, in conjunction with the Concrete Engineer.

If there is evidence of inadequately mixed concrete (unmixed or partially mixed materials) during concrete placement, the Engineer may direct an increase in the mixing time.

A.8 Turbine Type Mixers

Provide turbine type mixers meeting the applicable requirements for conventional type mixers (2462.3.A.1 through 2462.3.A.7) and in accordance with this subsection (2462.3.A.8). Maintain the mixer drum in a cylindrical shape within ¾ in [19 mm] from the original factory dimensions at any point. Maintain the mixer discharge gate in a mortar tight condition in the closed position. Replace or recondition mixer paddles showing a wear loss greater than ½ in [13 mm] from the original factory dimensions.

Add the mixing water to the batch materials in a manner that distributes the water to the inner or central areas of the drum. Start the flow of water before introducing the solid batch materials into the mixer drum.

During mixing, operate the paddles at a speed between 20 revolutions and 30 revolutions per minute. After adding the batch materials to the drum, mix the concrete for an additional 60 s.

A.9 Horizontal Axial-Revolving Blade Type Mixers

Provide horizontal axial-revolving blade type mixers in accordance with the applicable requirements for conventional type mixers (2462.3.A.1 through 2462.3.A.7) and in accordance with this subsection (2462.3.A.9).

Test the concrete uniformity as directed by the Engineer. The Engineer will use concrete uniformity tests to determine the minimum mixing time.

A.10 Counter-Current Pan Type Mixers

Provide counter-current pan type mixers in accordance with industry standards and the applicable requirements for conventional type mixers (2462.3.A.6 through 2462.3.A.7). The counter-current pan type mixer must have stationary side wall scrapers, a primary mixing motor and a secondary mixing plow. Completely clean the pan of concrete prior to proceeding with the next batch. Maintain the pan and all working parts of the counter-current manufacturer's recommended tolerances.

Test the concrete uniformity as directed by the Engineer. The Engineer will use concrete uniformity tests to determine the minimum mixing time.

B Transportation Units

B.1 General Requirements

Equip transportation units intended for both mixing and agitating with watertight revolving drums mounted and powered and fitted with properly designed mixing blades in accordance with 2462.3.A.1 through 2462.3.A.7. Provide units capable of combining all the ingredients into a homogeneous mixture and designed to provide two drum speeds, one for mixing and the other for agitating. Provide units capable of delivering the concrete without segregation or loss of any of the batch materials.

Equip the mixer drum with a working counting device to record the number of revolutions.

Equip dump trucks and agitator trucks with vibrators to aid in discharge, are mortar tight, capable of complete discharge of the concrete.

B.2 Capacity of Transportation Units

Refer to the truck mixer manufacturer's certification plate attached to the unit for the maximum capacity of the unit. If the unit will not satisfactorily mix the maximum volume shown, reduce the batch volume to allow proper mixing or discontinue use of the mixing unit as directed by the Engineer until the problem is corrected.

C Handling and Storing Materials

C.1 Batch Material Requirements

Do not change the source, kind or gradation of batch materials after the start of concrete production for the work unless otherwise approved by the Engineer. If the Engineer approves use of different material, completely exhaust the supply on hand before changing to the different material.

If delivering freshly washed aggregates to the batching plant, drain the aggregates before using in the batching operation. If draining freshly washed aggregates at the site of the batching plant, completely separate the drained material from the undrained materials, and provide for the disposal of water that accumulates from the drainage of materials. Drain any excess water from the aggregate hoppers prior to batching concrete.

Provide smooth, firm, and well-drained stockpile sites cleared of vegetable and extraneous matter. Where the natural foundation is unsatisfactory, as determined by the Engineer, construct the stockpiles on suitable platforms. Construct suitable bulkheads or partitions to separate different kinds of aggregate, gradation, or water content.

Construct stockpiles by methods that hold segregation and degradation to a minimum. If the Engineer sees segregation or degradation, the Engineer may designate that pile as unacceptable for use.

Do not use aggregates used to construct runways for loading or hauling equipment in concrete batches.

Use of aggregates from the bottom 1 ft [0.3 m] of a stockpile placed on an unprepared surface in concrete batches is allowed only under the Engineer's direct supervision and if the material meets all requirements of 3126, "Fine Aggregate for Portland Cement Concrete," and 3137, "Coarse Aggregate for Portland Cement Concrete."

Provide aggregates in accordance with the specified gradation requirements.

The Engineer will consider aggregates unacceptable if the variation in moisture content carried by any of the aggregates causes a marked variation in the consistency of successive batches of the mixed concrete, and will suspend operations until corrected.

C.2 Concrete Temperature Control

Produce concrete at temperatures from 50 °F to 90 °F [10 °C to 30 °C] and maintain temperatures until deposited in the work.

If necessary to maintain placement temperature, uniformly heat or cool the water, aggregates, or both, before introduction into the mixer. Control the temperature of the mixing water during heating or cooling.

Use aggregate at temperatures from 32 °F to 130 °F [0 °C to 55 °C]. Do not allow cementitious material to contact other batch material when the aggregate temperature exceeds 130 °F [55 °C].

Do not heat the cement, add salt, or add chemical admixtures to the concrete mix to prevent freezing.

Use a heating system to heat batch materials as approved by the Engineer. Do not use steam jets to spot heat the material as the work progresses.

Do not place mixer heaters intended for heating the batch materials in the mixer drum.

D Batching Requirements

Calibrate weighing equipment in accordance with 1901, "Measurement of Quantities." Inspect and calibrate the scales in accordance with section 5-694.400 of the Concrete Manual.

D.1 Batching by Weight

D.1.a Proportioning Methods

Proportion concrete batch materials by weight in a central plant or by volume as directed by the Engineer, in conjunction with the Concrete Engineer.

D.1.b Weighing Equipment and Tolerances

Weigh or measure concrete mixture ingredients to within the targeted batch weight in accordance with the following:

(1) Water – 1 percent,
(2) Cement – 1 percent,
(3) Other cementitious materials – 3 percent,
(4) Aggregates – 2 percent, and
(5) Admixtures – 3 percent.

D.1.c Batching of Mixing Water

Measure the mixing water on scales or water metering devices containing the following:

(1) A discharge indicator capable of being set to within 1 gal [5 L] of a predetermined quantity,
(2) A positive automatic shutoff valve, and
(3) An approved inspection seal on the scale or water metering device dating the time of the previous calibration and adjustment

An authorized service agency will calibrate the water meter in accordance with the following:
(1) Before startup of the production season,
(2) Every 6 months during production, and
(3) When requested by the engineer.

Make adjustments as necessary before use meeting the requirements of the weighing procedure in section 5-694.400 of the Concrete Manual.

Check the water meter for accuracy at least once each month as the work progresses.

D.1.d Batching of Cementitious Materials

Weigh the cementitious material independently of the aggregates in separate compartments or on separate scales.

If the Precaster weighs the cement first and then separately records the weights of each individual cementitious material, the Precaster may weigh the cementitious materials cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.e Batching of Aggregates

If the Precaster records each individual fraction weight of aggregates separately, the Precaster may weigh aggregates cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.f Admixture Proportioning

If using two or more admixtures in a single concrete batch, add each admixture separately to prevent interaction of the different admixtures before mixing with other batch materials. Agitate admixtures to ensure homogeneous concentrations in accordance with the manufacturers recommendations.

Incorporate admixtures to the batch mix in liquid form. Maintain admixture solutions at a uniform concentration at all times. Use the solution concentration and proportions designated by the manufacturer.

If using a mechanical dispenser for proportioning Class I or Class II admixtures, provide a site gauge or meter. Have the admixture manufacturer check admixture dispensers yearly to determine accuracy and ensure unobstructed flow.

D.2 Batching by Volume

Proportion concrete for precast products by volume or as required by the contract.

The Engineer will approve all methods and equipment used in volumetric proportioning.

Determine all material proportions and calibration settings on the basis of 100 lb [100 kg] of cementitious material.

Provide and use only sacked cement in the original mill containers unless the Precaster calibrates the mixer for the specific materials in use. Do not use fractional sacks.

Increase the cementitious content by 10 percent in the computation of volume proportions unless the Precaster calibrates the mixer for the specific materials in use.

E Mixing Requirements

The Engineer may check the water measuring equipment for accuracy before mixing operations begin and at any other time, the Engineer considers necessary.

Mix concrete by one of the following methods:

(1) A central plant (stationary plant),
(2) Entirely or in part in truck mixers, or
(3) At the construction site.

Do not allow the mixing batch to merge or intermix with the subsequent dry batch during mixing.

Discharge water remaining in the drums before batching.

Mix concrete to provide a mixture that is homogeneous and uniform in color. The Engineer will reject concrete batches that show a marked variation in consistency or evidence of improper mixing as unacceptable work in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

After completely mixing the concrete, either in a central plant mixer or truck mixer, continuously agitate while in transit to the point of placement until the concrete is discharged from the unit, unless otherwise allowed by the Engineer, in conjunction with the Concrete Engineer. Transport in non-agitating equipment is exempt from this requirement.

If the mixing does not appear uniform, perform slump tests at the 15 percentage point and the 85 percentage points during unloading. If the results show a slump variation greater than 1½ in [38 mm], stop work and correct the mixing unit.

Produce concrete in such quantity and at such a rate as proper placement and finishing will permit. Do not re-temper partially set concrete.

Do not hand mix concrete.

E.1 Mixing In Truck Mixer

Charge the materials into the truck mixer drum by introducing sufficient water before adding solid materials. Perform charging operations without losing materials.

Leave the truck mixer at the plant site for a minimum of 5 min or 50 revolutions during the mixing period. Transport the concrete at agitating speed to the point of placement.

F Batch Ticket

Provide a computerized or handwritten batch ticket for each batch of concrete. The Department defines computerized to mean a document that records mix design quantities from load cells and meters.

Provide a batch ticket for each item of information, including the following:

(1) Date,
(2) Time concrete was batched,
(3) Quantity of concrete in this load,
(4) Mix number,
(5) Labels identifying each material that correlates with the Precaster mix design,
(6) Target weight of materials, and
(7) Actual batched weights of materials.

Review and sign the first batch ticket for each mixer, each mix type, each day, for accuracy.

G Concrete Placement

Assume full responsibility for the acceptable production, placement, finishing, and curing of all concrete under the conditions prevailing, regardless of the restrictions imposed. Provide any artificial lighting, rain or cold weather protection necessary, including that directed by the Engineer, at no additional cost to the Department.

Place concrete after the Engineer inspects and approves forms and falsework erection, placement of reinforcement steel, materials, equipment condition, and cold weather protection.

Do not place concrete if portions of the form are frozen. Maintain the surface temperature above freezing for forms, steel, strands, inserts, brackets and adjacent concrete that will come in contact with the poured concrete.

Protect the concrete from freezing.

Protect the concrete against damage from construction operations or traffic.

The Engineer will evaluate any defects in concrete or concrete surfaces resulting from weather conditions, inadequate lighting, or other causes in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.1 Placement Temperatures

Discontinue concrete placement if the air temperature falls below 36 °F [2 °C]. Do not place concrete when the air temperature at the point of placement is below 36 °F [2 °C] or is predicted by the national weather service forecast to fall below 36 °F [2 °C] within the next 24 h unless approved cold weather provisions are in-place.

Maintain concrete at a temperature from 50 °F to 90 °F [10 °C to 30 °C] until placement.

G.2 Delivery Requirements

Place concrete into the forms in accordance with the following:

(1) Type 1 Concrete—within 90 min of batching, and
(2) Type 3 Concrete—within 90 minutes of batching when all admixtures are added at the plant at the manufacturer's recommended dosage rates listed on the Approved Products list.

The Precaster may transport Type 1 or Type 3 concrete in non-agitating equipment if the concrete is discharged within 45 min of batching.

Batch time starts when the batch plant or the transit mix truck adds the cement to the other batch materials.

G.3 Field Adjustments

Do not add additional mixing water once the concrete is 60 min old.

Mix the load a minimum of 5 minutes or 50 revolutions at mixing speed after addition of any admixture.

For concrete with slumps of greater than 1 inch [25 mm] do not make water adjustments after approximately 1 cubic yard [**1 m^3**] is discharged.

For concrete with slumps of 1 inch [25 mm] or less, the Engineer will allow water adjustments as necessary to facilitate placement.

Test the concrete for compliance with 2462.3.G.5, "Consistency," and 2462.3.G.6, "Air Content," in accordance with the following:

(1) If the first test taken passes, continue verification testing in accordance with the Schedule of Materials Control.
(2) If the test taken fails, make adjustments and perform any quality control testing before the final test. Acceptance or rejection of the truck is based on the final test result.
(3) Test up to two additional trucks in accordance with items (1) and (2) above, and
(4) If the concrete does not meet the specification after those three trucks, increase verification testing rate to once per truck for acceptance for the remainder of the pour.

G.4 Test Methods and Specimens

Perform sampling and testing in accordance with section 5-694.500 of the Concrete Manual and test according to the requirements of the Schedule of Materials Control.

The Department requires that anyone who tests concrete cylinders hold a current ACI Strength Testing Technician Certification.

Furnish molds based on the maximum size aggregate for the test specimens in accordance with the following:
(1) 4 in × 8 in [100 mm × 200 mm] cylinder molds,
(2) 6 in × 12 in [150 in × 300 mm] cylinder molds for maximum aggregate sizes greater than 1¼ in [31.5 mm]

G.5 Consistency

Test the concrete for consistency using the slump test during the progress of the work.

If any test shows the slump outside of the slump range requirements, reject the concrete represented by that test. In order to bring the mixture back into the slump range requirements, the Engineer will allow adjustments to the concrete in accordance with 2462.3.G.2, "Delivery Requirements" and 2462.3.G.3, "Field Adjustments.

Adjust the slump not to exceed the slump range allowed to optimize both placement and finishing. Contact the Materials Engineer if encountering unusual placement conditions that render the maximum slump unsuitable.

G.5.a Non-Conforming Material

Only place concrete meeting the slump requirements in the work. If the Precaster places concrete not meeting the slump requirements into the work, the Engineer will determine acceptance in accordance with 1512, "Unacceptable and Unauthorized Work".

G.6 Air Content

Maintain the air content of Type 3 general concrete at the specified target of 6.5 percent (+2.0 percent and -1.5 percent) of the measured volume of the plastic concrete in accordance with 1503, "Conformity with Contract Documents."

Measure the air content at the point of placement but before consolidation.

Make any adjustments immediately to maintain the desired air content.

The Engineer will reject concrete with a measured air content greater than 8.5% or less than 5.0%.

G.6.a Non-Conforming Material

Only place Type 3 concrete meeting the air content requirements in the work. If the Precaster places Type 3 concrete not meeting the air content requirements into the work, the Engineer will determine acceptance in accordance with 1512, "Unacceptable and Unauthorized Work".

2471 STRUCTURAL METALS

2471.1 DESCRIPTION

This work consists of shop and field work for manufacturing, fabricating, and coating structural metals.

2471.2 MATERIALS

If the contract states that the project is a Federal aid project, provide domestic material. Provide Mill Test Reports (MTRs) for Federal aid projects to document that the material was melted and manufactured in the U.S.A. If the Contractor supplies foreign material, the provisions of 1601, "Source of Supply and Quality," shall apply.

Provide new materials in accordance with the following sections. Unless otherwise required by the contract, use structural steel in bridges in accordance with 3309, "High-Strength Low-Alloy Structural Steel," and use structural steel for all other structures in accordance with 3306, "Low-Carbon Structural Steel."

Provide materials from mills, warehouses, or processors with supporting certified MTRs meeting the requirements of applicable ASTM specifications. If the MTR does not contain sufficient information, provide copies of the test results to the Engineer for review and approval before fabrication.

A Low-Carbon Structural Steel 3306

B General Requirements for Structural Steel 3308

C Structural Alloy Steel

C.1 High-Strength Low-Alloy Structural Steel 3309

C.2 High-Strength Low-Alloy Columbium-Vanadium Structural Steel 3310

C.3 Stainless Steel 3312

D Pin and Roller Steel

D.1 Hot-Rolled Bar Steel 3313

D.2 Cold Finished Bar Steel 3314

E Steel Forgings 3315

F High Performance Steel (Y.S. 345 MPa [50 ksi]) 3316

G High Performance Steel (Y.S. 485 MPa [70 ksi]) 3317

H Gray Iron Castings 3321

I Carbon Steel Castings 3322

J Alloy Steel Castings 3323

K (Blank)

L Malleable Iron Castings 3324

M Bronze

M.1 Wrought Plates 3325

M.2 Castings, Type 1 3327

M.3 Castings, Type 2 3328

M.4 Lubricated Bearing Plates and Bushings 3329

N Sheet Brass 3331

O Sheet Copper 3332

P (Blank)

Q (Blank)

R Sheet Lead 3335

S Sheet Metal Products 3351

T Aluminum-Wrought and Extruded 3336

U Pipe

U.1 Cast Iron Soil Pipe 3252

U.2 Structural Steel Tubing 3361

U.3 Structural Steel Pipe 3362

U.4 Aluminum Tube for Pipe Railing 3363

U.5 Wrought Steel 3364

U.6 Cast Iron Water Pipe 3365

U.7 Copper Water Tube and Fittings 3366

U.8 Rigid Steel Conduit 3801

V Anchor Rods 3385

W Fasteners 3391

X Galvanized Hardware 3392

Y Galvanized Structural Shapes 3394

2471.3 CONSTRUCTION REQUIREMENTS

A General

For the purpose of the work specified in this section these terms have the following meaning:

(1) "Engineer" means the Bridge Engineer, unless otherwise indicated.
(2) "Fabricator" means the manufacturer or supplier of fabricated structural metals. In the event that the Contractor performs this work, the term will mean the Contractor or the Contractor's agent.
(3) "Supplier" means fabricator, galvanizer, and paint shop.

Provide the Engineer with a list of fabricators, galvanizers, and painters, including addresses, and a list of products they will provide.

Do not order materials or direct the fabricator to perform shop work until the Engineer approves of the shop drawings.

If installing fabricated components on an existing structure, measure field dimensions in accordance with 2433, "Structure Renovation."

A.1 Definitions

A.1.a Minor Structural Components

The Department defines minor structural components as materials used in the following applications:

(1) Bridges: Bearing assemblies, sole plates, expansion joint devices, shear connectors, ballast plates, diaphragms for bridges (except curved steel bridges), pile and appurtenances, drainage systems, guardrail connections, railings, fencing, conduit systems, and protection angles;
(2) Electric lighting, traffic signs, and signal systems;
(3) Pedestrian bridges; and
(4) Other system or component designated by the Engineer.

A.1.b Major Structural Components

The Department defines major structural components as all components other than minor structural components as defined in 2471.3.A.1.a.

A.2 Certification Requirements

Provide a certification from a fabricator certified in accordance with AISC Quality Certification Program Category, Simple Steel Bridge Structures (Sbr) for the following types of structures and structure components:

(1) Rolled beam bridges with a pay quantity for structural steel no greater than 300,000 lb [136,000 kg],
(2) Pedestrian bridges,
(3) Steel diaphragms with a linear quantity greater than 5,000 ft [1,500 m],
(4) Diaphragms designated major structural components (curved steel bridges), and
(5) Other items as directed by the Engineer.

Provide a certification from a fabricator certified in accordance with AISC Quality Certification Program Category, Major Steel Bridges (Cbr) for the following types of structures and structure components:

(1) Rolled beam bridges with a pay quantity for structural steel of at least 300,000 lb [136,000 kg],
(2) Welded bridge girders,
(3) Tubs,
(4) Boxes,
(5) Trusses, and
(6) Other items designated by the Engineer.

Provide fracture critical items from a fabricator certified in accordance with AISC Quality Certification Program Category, Major Steel Bridges (Cbr) with Fracture Critical Member endorsement (F).

The Contractor/Fabricator performing coating application must demonstrate qualification by obtaining the AISC Sophisticated Paint Endorsement (SPE) or the SSPC QP Certification, and a Quality Control Plan (QCP) that is acceptable to the Engineer.

B Shop Detail Drawings

B.1 General Requirements

Submit to the Engineer shop detail drawings from the fabricator that include the following:
(1) Detailed plans showing the dimensions and sizes of materials,
(2) Details and information necessary for fabrication,
(3) Fastener lists for shop and field erection,
(4) Blocking and camber diagrams,
(5) Match marking diagram,
(6) Radiographic diagram showing weld locations and identification in accordance with this section (2471),
(7) Complete field erection plan showing piece marks, and
(8) All dimensions as measured in the field.

Ensure shop detail drawings include welding symbols meeting the requirements of ANSI/AWS A2.4, "Standard Symbols for Welding, Brazing, and Nondestructive Examination." Verify that the fabricator placed Welding Procedure Specification (WPS) numbers in the tail of the arrow(s).

Submit shop detail drawings from the fabricator for the complete fabrication of structural metals as required by the contract. If the Department provides standard detail drawings as required by the contract, submit finished detail drawings from the fabricator with additions and revisions.

If the contract requires a "Standard Plate," the Department will not require re-detailed plates except to indicate fit at connections to other structural members for changes shown on the plans or to complete detailed information to the shop or the material supplier. Provide these detail changes from the fabricator.

B.2 Format

Submit shop detail drawings from the fabricator meeting the following characteristics and requirements:

(1) Prepared in a neat and legible form on media from which clear, sharply defined prints can be made for the Engineer's review and inspection purposes,
(2) 22 in × 34 in [559 mm × 864 mm],
(3) ½ in [13 mm] border on all edges except a 2 in [50 mm] border on the 22 in [559 mm] left edge,
(4) Containing title box in the lower right hand corner with the following information:
  (4.1) Departments structure number,
  (4.2) Project number,
  (4.3) Federal Project number (if applicable),
  (4.4) Fabricator's name,
  (4.5) Fabricator's contract number,
  (4.6) Detailer's and checker's initials,
  (4.7) Date of preparation, and
  (4.8) Brief description of the details shown on each sheet.
(5) Height of letters and numerals on each drawing at least 0.14 in [3.5 mm],
(6) Text, details, lines, and dimensions capable of reducing in size to 11 in × 17 in [280 mm × 432 mm] without affecting readability,
(7) Containing a complete bill of materials listing the individual pieces with piece marks and quantities, including dimensions,
(8) Consecutively numbered sheets, and
(9) First drawing of the shop details containing a schedule of sheet numbers, including a brief description for reference.

The Contractor may also provide standard sheets from the fabricator with fastener lists.

B.3 Submittal for Engineer's Review and Approval

Submit two sets of prints of required shop detail drawings from the fabricator to the Engineer for review and release for fabrication. Notify the Engineer of detail variances shown on the plans in writing. The Engineer will return one set of prints of the shop detail drawings to the Contractor with comments.

Submit only checked drawings, in complete collated sets, from the fabricator for review. The Contractor may submit details such as ice-breakers, anchorages, bearing plates, and castings, separately to facilitate the work.

Submit a schedule showing the submission dates of shop drawings and anticipated dates for shop fabrication from the fabricator, as directed by the Engineer. Arrange the schedule to avoid delay in completing the work. If constructing a structure composed of several units, consider submitting shop detail drawings of the separate units in proper order to expedite the review and release for fabrication of the details.

If the Engineer requests changes to the submitted drawings or if the fabricator makes additional changes not required by the Engineer, provide revised prints from the fabricator with circles, underscores, or other marks to distinguish the changes from unchanged details or dimensions.

The Engineer will release shop detail drawings for fabrication after corrections are completed. Provide six sets of prints of the corrected drawings and additional prints as required by the contract or requested by the Engineer from the fabricator at no additional cost to the Department.

The shop drawings approved by the Engineer will become part of the Contract. Do not make changes on approved drawings unless otherwise approved by the Engineer in writing.

The Engineer's approval of shop drawings will not relieve the Contractor of full responsibility for submission of complete and accurate drawings and for the accurate assembly and fitting of all structural members.

B.4 Submittal for Completed Work

After the fabricator completes the shop work, provide detailed shop drawings to the Engineer in two formats:

(1) One set of drawings on 11 in × 17 in bond paper, and
(2) An electronic file in PDF format containing all sheets.

Ensure that the drawings submitted accurately reflect the actual configuration of all structural members and components, including modifications made during fabrication and after delivery to the project, under the fabricator's direction. If making the electronic files by scanning, use a minimum scan resolution of 400 dpi.

C General Fabrication Practices

Provide structural material fabricated and assembled meeting the requirements of AASHTO/NSBA Steel Bridge Collaboration "Steel Bridge Fabrication Guide Specification" and AWS welding codes, except as modified in this chapter. Provide material structurally welded meeting the requirements of ANSI/AASHTO/AWS D1.5, "Bridge Welding Code," for major structural components and ANSI/AWS D1.1, "Structural Welding Code Steel," for minor structural components. Ensure the Certified Welding

Inspector (CWI), or an equivalent, witnesses the welder and welding operator qualification tests unless otherwise specified in this section.

Before the start of work, the fabricator is to supply a Quality Control Plan (QCP) to the Engineer for approval. Ensure the QCP describes the methods, equipment, Non Destructive Testing (NDT), and frequency of testing used. The Engineer will use the AASHTO/NSBA, "Steel Bridge Fabrication QC/QA Guide Specification," as the basis for approving the QCP. The Engineer will audit suppliers with approved QCPs on a biannual or annual basis or as otherwise directed by the Engineer to ensure the implementation of the QCP. The Department will invoke its Corrective Action Process if the audit indicates non-conformance. The Department will require corrective action, including hiring a third party Quality Control Inspector at no additional cost to the Department. The Contractor may obtain a copy of the Department's Corrective Action Process from the Engineer.

If the Engineer determines that fabrication work does not comply with the QCP or that fabrication does not follow approved fabrication procedures, the Engineer will deem the materials as non-conforming in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the Engineer finds non-conforming work, direct the Supplier to immediately correct the procedure and conduct additional tests and submit a written non-conformance report, containing data required by the Engineer to ensure compliance with the QCP. Perform additional testing in conjunction with the supplier as required by the Engineer at no additional cost to the Department.

C.1 Prefabrication Conference

Before fabrication, the Engineer may schedule a Prefabrication Conference with the Contractor and the fabricator to discuss pertinent specifications, procedures, and requirements of the job. The Engineer will consult the Contractor and the fabricator to decide the location, date, and agenda items for the conference.

C.2 Notification

Notify the Engineer at least 5 business days before the fabricator begins work so that the Engineer may perform inspections. Do not allow the fabricator to begin work before notifying the Engineer.

C.3 Identification of Materials

Before fabrication begins, the Fabricator will provide a copy of purchase orders, Mill Test Report (MTR), or other documentation required by the Engineer, indicating that the materials meet the physical, chemical, and source (mill) requirements of this section for each heat of steel used in the work. The Fabricator will provide copies of purchase orders when placing the orders. When the materials are received, the fabricator will indicate in writing or by ink stamp that the MTRs have been checked for compliance. Include the name of the individual who checked the MTR and the date of inspection with the purchase order. If the Engineer determines that the documentation is incomplete, direct the fabricator to sample and test materials as directed by the Engineer at no additional cost to the Department. Provide scale weights of individual members or sections as required by the Engineer.

Except for the following, the Fabricator of minor structural components may provide Certificates of Compliance and shipping documents for each contract item to the Engineer instead of submitting purchase orders and MTRs:

(1) Pedestrian bridges,
(2) Post and truss chord materials for traffic signs,
(3) High mast light poles,
(4) Modular expansion devices,
(5) Pot bearings, and
(6) Other items designated by the Engineer.

In conjunction with the fabricator, keep appropriate documentation on file for at least seven years.

During each stage of fabrication of major structural components, ensure the fabricator provides and maintains identification to establish the heat of the material from which the component is fabricated. Provide the Engineer with a list showing heat numbers referenced to the material incorporated into each component. The Engineer will reject material that loses its identity unless the identity can be re-established to the satisfaction of the Engineer.

Provide wide flange beams, flanges, webs, splice plates, welded cover plates, and fracture critical members with identification numbers placed on each individual piece of material that referenced to the corresponding heat number.

Ensure the fabricator uses non-oil-based markers or low stress die stamps for the identification coding of material.

C.4 Weld Identification System

Before implementation, ensure the fabricator uses the MnDOT standard weld identification system as described in 2471.3.C.4.a, "Standard Weld Identification System," or an alternate system approved by the Engineer to identify welds subject to radiographic testing, ultrasonic testing, or both. Use a traceability system with a unique identification assigned to all welds being examined. Do not repeat identification numbers. Use identification numbers traceable back to the original member examined and document the identification number on the shop detail drawings.

C.4.a Standard Weld Identification System

C.4.a(1) Piece Mark
Provide material marked with the fabricator's piece identification as shown on the approved shop detail drawings.

C.4.a(2) Splice Plane Number
The Department defines a splice plane as a 3 ft [1 m] wide vertical section of a piece that contains a full penetration welded splice in any component of the piece. The Department considers any other full penetration welded splice in any component of the piece within the 3 ft [1 m] vertical splice plane in the same splice plane.

Provide the number of the splice plane on the piece starting from the left end of the piece as shown on the radiographic diagram.

C.4.a(3) Piece Components Code
Verify that the fabricator placed film identification numbers or location marks, only on film, meeting the requirements of AWS D 1.5. Begin marking from NS edge for flanges and the bottom edge for webs.

(1) Bottom flange
(2) Web – single web or near side (NS) web for two webs
(3) Top Flange – single top flange or NS flange for two top flanges
(4) Web – far side (FS) web for two webs
(5) Top Flange – FS flange for two top flanges

C.4.a(4) General Notes
Ensure the fabricator performs the following:

(1) Performs radiographic and ultrasonic testing of welds meeting the requirements of AWS D1.5, except as modified by this section.
(2) Establishes the center line of the weld on the components of the piece before welding by placing punch marks 1 ft [300 mm] back from the center line of the weld and 1 in [25 mm] from the edge of the plate.
(3) Provides Image Quality Indicators (wire penetrameters) as directed by the Engineer.
(4) For joints radiographically inspected less than100 percent, include the untested areas in the Film Identification Number scheme.

C.5 Storage of Materials
Store material above ground on platforms, skids, or other supports. Protect material from dirt, oil, and other foreign matter. Drain material so that water is never in constant contact with the surface. Replace damaged material with new material or repair using a procedure approved by the Engineer.

C.6 Nonconformances
Provide an established Quality System outlined in the QCP for controlling nonconforming material from the fabricator, including procedures for identification, isolation, and disposition.

Submit Non-conformance Report forms from the supplier to the Engineer documenting deviation from the QCP, approved shop drawings, the plans, or specifications. Include the following in the Non-conformance Report form:

(1) Company name and address,
(2) Report title,
(3) Non-conformance Report number,
(4) Date,
(5) Company job number,
(6) Piece mark,
(7) Owner of bridge/structure,
(8) Contractor,
(9) Owner's project number,
(10) Location,
(11) Detailed description of the non-conformance,
(12) Photo, sketch, or drawing,
(13) Proposed repair/disposition of the non-conformance, and
(14) Quality Control Manager's signature and date.

The Engineer will advise the supplier of the resolution to non-conformance in writing.

D Structural Components

D.1 Welded Shear Stud Connectors

In accordance with OSHA Subpart R 1926.754, attach shear stud connectors and other similar devices to the top flange of beams or other steel components after the installation of decking falsework or other walking surfaces.

D.2 End Connection Angles

The Engineer will only require finishing of end connection angles to correct a non-conforming assembly. Produce a finished angle at least ⅜ in [10 mm] thick. Do not reduce the original thickness of the angle by greater than ⅛ in [3 mm]. Grind flush portions of members extending beyond the face of the connection angles. Do not recess the web of a connecting member by greater than ⅜ in [10 mm] from the face of the connection angles.

D.3 Bolts

Provide high strength structural steel bolts in accordance with 3391, "Fasteners," except the Contractor may use common structural steel bolts for connections in expansion and deflection devices and in hand railings. Place structural bolts with a projection from ⅛ in to ⅜ in [3 mm to 10 mm] through the nut.

Provide extra bolts in the amount of 5 bolts plus 5 percent of the actual number of field bolts necessary, at no additional cost to the Department. The Department will not include this number of additional bolts in the plan quantity and will include the cost of these additional bolts in the contract unit prices for the bolts in the contract item.

D.4 Pins and Rollers

Provide pins and rollers with a 75 µin [1.6 µm] finish.

Provide pin threads meeting the requirements of American Standard Coarse Thread Series Class 2 and free fit meeting the requirements of ANSI B1.1. Thread pin ends and nuts with diameters of at least 1⅜ in [35 mm] with 6 threads per 1 in [25 mm]. Provide nuts meeting the following requirements and characteristics:

(1) Made of structural steel in accordance with 3306, "Low-Carbon Structural Steel," 3309, "High-Strength Low-Alloy Structural Steel," and 3310, "High-Strength Low-Alloy Columbium-Vanadium Steel;"
(2) Recessed;
(3) Hexagonal; and
(4) Galvanized in accordance with 3392, "Galvanized Hardware."

Machine the grip face of the nut square to the axis of the pin. Ensure the recessed face of the nuts will bear uniformly against the end face of the pin when turning the nut tight. Place pins with a projection of at least ¼ in [6 mm] through the nut after assembly. If making a recessed cut between the threads and the shoulder of the pin, do not make cuts wider than ¼ in [6 mm] or deeper than the base of the thread.

D.5 Shims

The Department defines shims as metal plates not shown on the plans that bring metal surfaces of members into contact or bring the structure to the grade or alignment shown on the plans.

Make shims ⅛ in [3 mm] or thicker of structural steel. Make shims ⅛ in [3 mm] or thinner from sheet steel or sheet brass.

Provide shims at no additional cost to the Department.

E Structural Fabrication

Ensure the fabricator performs the following:

E.1 Cutting

Cut steel and fabricate steel plates and splice plates for major structural components so the primary direction of rolling is parallel to the direction of the main tensile or compressive stresses.

Cut metals to the size shown on the plans with allowance for necessary or required finishing operations. Cut metals within $^{1}/_{16}$ in [2 mm] from true lines. The Department defines true lines as theoretical lines exactly corresponding to and used to transfer dimensions as shown on the plans to materials for cutting, drilling, and fitting.

Cut flange plates or other members to a true curve. Do not use a series of straight cuts to create the curve.

E.1.a Re-Entrants

Form interior and re-entrant corners with a radius of at least 1 in [25 mm]. Form filleted corners with radii no greater than 1 in [25 mm] by drilling.

E.1.b Shearing

Do not shear nonferrous metals with a thickness greater than ½ in [13 mm].

E.2 Machining

E.2.a General

Perform heat treatment before final machining. The Department defines heat treatment as intentionally and systematically applying heat at a temperature below the melting point of any ferrous castings, weldment, or other components.

E.2.b Machining Tolerances

For members requiring machine finishing, the standard tolerance is ±0.03 in [760 µm]. Apply this tolerance to the following:

(1) Spacing between bearing assembly pintles and pintle holes,
(2) Depth of pintle holes and height of pintles after welding, and
(3) Thickness of each individual plate that makes up a bearing assembly.

E.2.c Machine Lubricant

Use machining lubricant on structural material requiring machine work or drilling capable of being completely removed.

E.2.d Edge and Corner Finishing

Bevel corners of painted bridge member edges to at least $^{1}/_{16}$ in [2 mm]. If thermal cutting material to final size, grind or mill edges to remove thermal cutting marks sufficient to achieve and measure the required painting surface profile.

E.2.e Finishing

Machine finish, or straighten by a method approved by the Engineer, warped or deformed plates to provide the proper fit. Machine finish surfaces intended for contact bearing with other structural parts to a flatness no greater than 0.005 × nominal dimension of the part to achieve full contact for all parts.

E.3 Bending

Before bending, round the corners of the plates to a radius of $^{1}/_{16}$ in [2 mm] throughout the portion of the plate at which the bending is to occur as shown on the plans. Bend metals before coating or heat treatment. Bend without causing fractures, kinks, reduced section below minimum, or other defects in the material.

E.4 Cambering and Curving

The Engineer will verify measurements of vertical camber and horizontal curvature for final acceptance after the completion of welding and heating operations and after the flanges cool to uniform ambient temperature. The Engineer will check horizontal curvature with the girder in the vertical position.

The Engineer may reject materials showing over hardening, fractures, or other defects due to improper heating.

E.5 Straightening Material

Straighten material without shearing, fracturing, stressing, or damaging the bolts, welds, or base metal. Use heat straightening methods approved by the Engineer. Replace material damaged during straightening operations with new material at no additional cost to the Department.

If the Engineer determines it is not possible to straighten a member as part of an assembly, remove the bent material from the assembly, straighten, and re-assemble.

E.6 Dimensional Tolerances

Provide fascia beam webs with a flatness tolerance no greater than half the limit in ANSI/AASHTO/AWS D1.5, "Bridge Welding Code."

F Structural Welding

Ensure the fabricator performs the following:

F.1 General

Obtain written approval from the Engineer before performing welding, including weld repair, or deviating from the approved shop drawings or project plan.

Submit Weld Procedure Specifications (WPS) with shop detail drawings. Do not begin fabrication until the Engineer has approved the WPS(s). The Engineer may require testing for particular weld details described in the WPS to assure the Engineer that proper welds can be made. Test welds as required by the Engineer.

Provide information or Procedure Qualification Records (PQRs) demonstrating that the proposed WPSs meet the requirements of the ANSI/AASHTO/AWS D1.5, "Bridge Welding Code" (BWC) as approved by the Engineer. PQRs, once approved, will remain valid indefinitely.

Provide a minimum weld size per BWC and 2471, "Structural Metal," when a weld symbol is void of a weld size.

For the purpose of this specification, a weld repair is defined as any area of the welded product not in compliance with the WPS, approved Quality Manual or current edition of BWC.

Notify the Engineer to witness welding and testing. If the Engineer cannot witness qualification or certification welding or testing, arrange the witness of an approved third party, at no additional cost to the Department.

Conduct testing of qualification welds in a laboratory accredited by the American Association for Laboratory Accreditation (A2LA) or an approved equal at no additional cost to the Department

F.1.a Welded Flange Splices

Place welded flange splices at least 12 in [300 mm] from web splices. For welded girders with radii no greater than 1,900 ft [580 m], the Department will allow additional splices only on individual flanges that are uniform in thickness and greater than 39 ft [12 m] in length. The Department will allow these splices in addition to the splices shown on the plans. Provide flanges with no more than two additional splices.

Locate additional splices in accordance with the following:

(1) Near the third points of individual flange plates,
(2) Midway between adjacent diaphragm connections,
(3) At least 12 in [300 mm] from transverse stiffeners and welded connection plates,
(4) At least 10 ft [3 m] from field splices, bearing points at piers, and flange groove welds as shown on the plans, and
(5) At locations approved by the Engineer.

F.1.b Web-to-Flange Welds

The Department defines a repair as any area of the welded product not meeting the requirements of BWC. Limit each individual web-to-flange weld repairs to 2 percent of the weld length and grinding web-to-flange weld repairs to 5 percent of the weld length. If the Contractor exceeds the repair limits, the Engineer will revoke the WPS used to perform the initial production welding.

F.2 Preparation of Base Metal

For coated metals, remove coatings on either side of the weld area to a distance of at least 2 in [50 mm].

F.3 Conditions for Welding

Preheat without producing visible moisture in the weld joint before welding.

F.4 Backing

Produce "Complete Joint Penetration" (CJP) groove welds using steel backing that is continuous for the full length of the weld. Make joints in the steel backing CJP joints, also.

G Fracture Critical Members

Ensure the fabricator performs the following:

(1) Provide fracture critical members meeting the requirements of BWC, Fracture Control Plan (FCP) for Fracture Critical Bridge Members" and as modified by this section.
(2) Provide fracture critical members as shown on the plans. The Engineer may provide written exemption from these requirements for welds in designated members not subject to tension forces.
(3) Do no weld or drill holes for temporary attachments to rolled beams or girders.

G.1 Fracture Critical Welder Qualifications

Provide fracture critical members welded by welders meeting the certification requirements in accordance with BWC. Annual requalification is to be based on acceptable radiographic test results of either a production groove weld or test plate. If employing a welder requalified by test, use a WPS written in accordance with the requirements of BWC and show the test plate in accordance with Figure 5.24. Include the WPS in the QCP.

H Hole Forming Operations

H.1 Bolt Holes

Hole forming operations other than drilling will require a written procedure in the suppliers Quality Control Plan and a verification test for each hole forming process. Produce holes after any required bending, cambering, curving, or heat-treating of member. Sub-punching or sub-drilling of holes is permitted only where specifically allowed by this specification.

Except for field connections and field splices, the Contractor may punch material forming parts of a member composed of no greater than five thicknesses of metal $^{1}/_{16}$ in [2 mm] larger than the nominal diameter of the bolts for the following:

(1) Structural steel no thicker than ¾ in [19 mm],

(2) High strength steel no thicker than ⅝ in [16 mm], or
(3) Quenched and tempered alloy steel and non-ferrous metals no thicker than ½ in [13 mm].

In addition to drilling and punching, the fabricator may produce holes for minor structural components by plasma, water jet, or laser cutting methods.

Produce holes and slots that meet the following criteria:

1. Free of sharp, torn, or jagged edges;
2. Walls square to the surface;
3. Surface roughness not exceeding 1000 micro inches; and
4. Size tolerance of -0/+1/32" when compared to as detailed.

Produce holes and slots free of sharp, torn, or jagged edges with walls square to the surface. Surface roughness of holes shall not exceed 1000 micro inches. As built holes shall have a size tolerance of -0/+1/32" when compared to as detailed.

H.1.a Line Assembly

Ensure the fabricator performs the following:

(1) If the contract requires line assembly, drill the connection holes in flange and web splices full size in the assembled position,
(2) Drill connection holes in secondary members, including diaphragms, diaphragm stiffeners, lateral bracing, and lateral bracing connection plates $+^{3}/_{16}$ in [5 mm] greater than the bolt diameter to facilitate alignment,
(3) Use predrilled splice plates as a template only one time, and
(4) For oversized holes, place hardened washers meeting the requirements of ASTM F 436 under the bolt head and nut.

H.1.b Full Assembly

If the contract requires full assembly, ensure the fabricator drills bolt holes for field connections, in all members and all components of each structural unit, from the solid to the specified size while assembled with the following exceptions:

1) Two sub-sized holes may be used to attach each diaphragm to stiffeners and field splice plates to webs and flanges to facilitate assembly.
2) The fabricator has the option to drill one ply of a field connection with full size holes providing it is used as a template only once.

H.1.c Punched Bolt Holes

Ensure the diameter of the die does not exceed the diameter of the punch by greater than $^{1}/_{16}$ in [2 mm]. If the fabricator enlarges holes to admit the bolts, provides a written repair procedure from the fabricator to the Engineer for approval.

H.1.d Field Connection Bolt Holes

Ensure the fabricator drills holes full size to a steel template while assembled for the following:

(1) Floor beams,
(2) Stringer end field connections, and
(3) Holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames.

The Contractor may drill holes for the following full size and unassembled to a steel template if approved by the Engineer in writing:

(1) Field splices of rolled beam stringers continuous over floor beams or cross frames, and
(2) Holes for floor beams, cross frames, or bent plate diaphragms.

If using a steel template for drilling field connection holes to full size, ensure the fabricator locates the template to the correct position and angle, and bolt the template in place before drilling, and uses duplicate templates to drill matching members and the opposite faces of a single member.

H.2 Boring Pin Holes

Ensure the fabricator produces the final surface of pin holes by a finishing cut, and provides pin holes in diameters in accordance with the following:

(1) No greater than $^{1}/_{64}$ in [0.5 mm] for pins no greater than 5 in [127 mm] in diameter, and
(2) No greater than $^{1}/_{32}$ in [0.8 in] for pins greater than 5 in [127 mm] in diameter.

Ensure the distance outside-to-outside of end holes in tension members and inside-to-inside of end holes in compression members does not vary from that specified by greater than $^{1}/_{32}$ in [0.8 m]. Ensure the fabricator bores pin holes in built-up members after the completion of assembly.

I (Blank)

J Shop Assembly

Ensure the fabricator performs the following:

Complete fabrication, weld inspection, nondestructive testing, and any repairs, before placing any component in the assembly.

Adjust each assembly unit to the true field position with respect to alignment, camber, grade and skew, as shown on the plans, prior to drilling field connection. The fabricator may angularly rotate the assembly from true field position, with respect to grade, providing the fabricator supplies shop drawings showing elevations at all points of bearing and the relative position of webs of main members, with respect to true field position. Provide calculations to support the information shown in the drawings. Rotation is not allowed on hold over members.

For multiple span continuous structures, both straight and curved, progressive assembly is allowed providing a length no shorter than the length supported by three adjacent points of bearing is used as a minimum length of each structural sub-assembly. For these progressive assemblies, hold over pieces between adjoining assemblies shall be held to the following tolerances in relation to their documented position prior to removal:

(1) At point of support: Vertical +1/16", -0, Horizontal and Tilt +/-1/32"

(2) At member ends: Vertical, Horizontal and Tilt +/-1/32"

Clean metal surfaces in contact with each other before assembling. Assemble, pin, and draw together the parts of a member before drilling or bolting.

Assemble all structures that contain secondary connections utilizing full size holes in accordance with 2471.J.2, "Full Assembly."

In the assembly plan, identify maximum deviations of differential camber and sweep between girder lines.

Provide a written record of each shop assembly set-up. The inspection of the assembly and the written report shall be completed by a competent individual with experience in structural assemblies. If a total station or similar device is used to check the assemblies the operator shall be certified to a National Standard or the equipment manufacture. If a progressive assembly is used the written report shall contain all the required information for each assembly and a final written report for the full length and width of the structure. Include the following assembly dimensions, theoretical (as shown on a blocking diagram) and actual measurements with the written record:

(1) X, Y, and Z dimensions (horizontal offset, elevations, and tilt) at bearing points, ¼ span points, field splice locations, Plan ordinates closest to mid span and any other connection points, and

(2) Span lengths.

Temporary bolts shall be drawn sufficiently tight to bring the required parts into bearing and to preclude loosening of the nut. The permanent bolt assembly shall be in accordance with 2402.3.G.2, "Connections Using High Strength Bolts".

Take apart assembled pieces, if necessary, to remove burrs, shavings, or other irregularities produced by the operation. Adjust the members if they have any twists, bends, and other deformations.

J.1 Line Assembly

Assemble, major structural components, pedestrian truss bridges, overhead sign trusses, and modular and finger expansion joint devices at the fabrication shop, unless otherwise required by the contract. Line assemble principal members [such as but not limited to beams, girders, arches, trusses, etc.] full length with all components completely assembled.

J.2 Full Assembly

Performs full assembly as required by the Contract in accordance with the following:

(1) Assemble, in totality, the main members for the complete length as required by the Contract and assemble to the full width of the structural unit,

(2) Block all members in the "no load" or "zero gravity" position unless other requirements are specified in the Contract. This shall include at a minimum, five points of support for each individual main member: ends, ¼ points and midpoint, and

(3) Include components such as diaphragms, brackets, laterals, wind frames, links, and transverse floor systems. The Department will not require components such as expansion and deflection devices and bearings to be assembled.

J.3 Match Marking

Match-mark connecting parts assembled in the shop to assure proper fit in the field using low stress die stamps before disassembly.

Use a match marking system that uses a series of letters and numbers to indicate the exact location in the structure without continual reference to detail drawings. Do not use shop piece marks as a match-marking scheme. Mark all pieces or parts planned for assembly at a point with the same mark to avoid rotation of pieces.

Use material used for match marking capable of removal without damage to the appearance of painted or unpainted surface visible in the completed structure.

K Uncoated Weathering Steel Surfaces

Ensure the fabricator performs the following:

(1) Removes foreign matter including oil, grease, dirt, and concrete spatter from uncoated 3309, "High-Strength Low-Alloy Structural Steel," or other types of weathered steel material in accordance with SSPC-SP 1, "Surface Preparation Specifications – Solvent Cleaning;" and
(2) Blasts clean uncoated weathering steel, including contact areas of bolted structural connections, in the shop or field in accordance with SSPC-SP6/NACE No. 3, "Commercial Blast Cleaning."

L Coating

The Department defines coating as any protective barrier including paint, galvanizing, or metalizing.

Ensure the fabricator performs the following:

(1) Before performing work, supply a Quality Control Plan (QCP) as approved by the Engineer and meeting the requirements of the AASHTO/NSBA *Steel Bridge Fabrication QC/QA Guide Specification* and the AASHTO/NSBA *Guide Specification for Coating Systems with Inorganic Zinc-Rich Primer*, and
(2) Do not apply the coating material to a part until the Engineer inspects and approves the work.

The Engineer may reject material coated before approval in accordance with 1512, "Unacceptable and Unauthorized Work." Remove rejected material as directed by the Engineer.

L.1 Galvanizing

Galvanize in accordance with 3392, "Galvanized Hardware," or 3394, "Galvanized Structural Shapes," this section (2471), and as shown on the special provisions.

Completely seal weld contacting or welded overlapping surfaces. Degrease material for rolled or folded joints before forming.

Clean material of paint, lacquer, and crayon markings before galvanizing. Do not galvanize closed or blind sections of pipe.

Prior to pickling and galvanizing, abrasive blast clean surfaces to be galvanized to SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning". The following products are exempt from this requirement:

(1) Bearings,
(2) Channel, Bent Plate, or Bolt assembled Diaphragms,
(3) Sole Plates,
(4) Expansion Devices,
(5) Shear Connectors,
(6) Ballast Plates,
(7) Piling,
(8) Drainage Systems,
(9) Conduit,
(10) Protection Angles, and
(11) Other systems or components designated by the Engineer.

Submit an NCR to the Engineer before performing any repairs.

L.2 Metallizing

Before metalizing steel surfaces, blast and clean meeting the requirements of AWS C2.18, "Guide for Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites."

Use zinc metalizing wire or powder of a purity equal to Federal Specification MIL-W-6712 (99.9 percent zinc). Metalize to an average coating total thickness of 0.010 in [254 µm]. Coat to a thickness of at least 0.0075 in [190 µm].

Preheat the substrate to 250 °F [120 °C] to eliminate surface condensation and reduce shrinkage and differentials between the coating and the substrate. Do not metalize unless approved by the Engineer in writing.

L.3 Painting

Prepare the surface and paint in accordance with 2479, "Inorganic Zinc-Rich Paint System," unless otherwise required by the contract.

M Fabricator Inspection

Ensure the fabricator provides QC personnel as required by the approved Quality Control Plan (QCP) and the following:

M.1 Nondestructive Testing (NDT)

Ensure the fabricator performs nondestructive testing in accordance with the appropriate ASTM specifications and applicable welding code specifications and the following:

(1) Use trained personnel, who have at least two years of experience as an American Society for Nondestructive Testing (ASNT) NDT Level II operator and qualified in accordance with ASNT-TC-1A,
(2) Submit a copy of the NDT operators training and certification records to the Engineer before performing any NDT inspections,
(3) Provide the Engineer a copy of the written practices and procedures for each NDT method used, and
(4) Submit a final written report of NDT to the Engineer, with interim test reports submitted as performed.

For the NDT of bridge components, the Department defines tension areas in accordance with the following:

(1) Any location in a rolled beam or welded girder where:
  a. the superstructure curvature is greater than 4 degrees, and/or
  b. members are designed as an interactive 2-D structure where members are sharing or distributing load to one another, and/or
  c. Contract requires full assembly in fabrication.
(2) Any other tension area as shown in the Project Plan.

Perform NDT at locations and frequencies in accordance with the Contract and/or the applicable Welding Code with the following modifications:

(1) 100% Radiograph Testing (RT) is required of any CJP horizontal web splices,
(2) 100% RT or UT is required for backing bars, when used and left in place,
(3) Radiograph Testing (RT) is required for any CJP web or flange welds in compression or shear areas, and
(4) In addition to testing one-sixth of the web depth beginning at the point(s) of maximum tension 50% of the remaining area will be tested.

If the Contract or welding Code does not otherwise specify NDT, 100% Ultrasonic Testing (UT) of any CJP is required.

Ensure the fabricator performs the following:

(1) Do not weld groove-welded parts to other members until the Engineer approves NDT of groove welds,
(2) Perform NDT of repair welding in accordance with the repair procedure as described in 2471.3.C.6, "Nonconformances," at no additional cost to the Department, and
(3) Perform NDT of areas required by the Engineer.

The Department may require NDT of areas not designated in the contract for such inspection. If the inspection shows the area to be defective, the fabricator shall perform the NDT at no additional cost to the Department. If the inspection is satisfactory, the Department will pay for the inspection as Extra Work in accordance with 1402, "Contract Revisions." In addition, when NDT of an area designated in the contract for inspection shows defects, the Engineer may direct the fabricator to perform NDT of adjacent areas to determine the extent of the defective area, at no additional cost to the Department.

M.1.a Visual Testing (VT)

Ensure the fabricator performs visual inspections during the entire welding process and again after the weld is complete, cool, and clean of slag and residue.

M.1.b Dye Penetrant Testing (PT)

Ensure the fabricator checks edges of complete penetration groove welds on major structural components for 3 in [75 mm] on each side of the centerline of the weld or 1 in [25 mm] beyond either side of the weld area, whichever is greater, using Dye Penetrant Testing (PT). The fabricator may substitute Magnetic Particle Testing (MT) with approval from the Engineer.

M.1.c Magnetic Particle Testing (MT)

Ensure the fabricator performs MT on the following:

(1) At least 12 in [300 mm] of every 10 ft [3 m] of length for fillet welds in major structural components and pedestrian bridges,
(2) 100 percent of bearing stiffener welds,
(3) At least 20 percent of all weld terminations, and
(4) 100 percent of the base plate and gusset plate welds for overhead signs and high mast light poles.

Ensure the fabricator locates the tests at random areas of the weld. Do not use the prod method unless approved by the Engineer.

M.1.d Radiographic Testing (RT)

Ensure the fabricator provides developed radiographic film with a film density from 2.5 to 3.5. The Department will retain ownership of radiographic film provided by the Contractor.

Computed Radiography (CR) may be used in lieu of conventional radiography providing the CR procedure is approved by the Engineer.

M.1.e Overhead Signs

The Department considers sign posts and trusses for free standing cantilevered and non-cantilevered overhead signs as cyclically loaded structures. Bridge mounted signs are considered statically loaded structures. Provide overhead sign structures welded in accordance with the requirements of AWS D1.1, as outlined in the "AASHTO Structural Supports for Highway Signs, Luminaires, and Traffic Signals." Perform RT, UT, and MT, as outlined in the current overhead sign standards sheets. The Engineer will base acceptance for overhead signs in accordance with AWS D1.1

N Department Inspection

N.1 General

The Engineer will inspect major and minor structural steel components before use in the work. The Engineer may perform inspections at the mill, foundry, fabrication shop, or in the field.

The purpose of Department inspection(s) is to establish compliance with those test requirements and process controls outlined in the contract as required by federal and state laws. The Department inspection does not supplement or replace the supplier's own Quality Control and does not relieve the supplier of its responsibility for the correction of errors and faulty workmanship, of for the replacement of nonconforming materials.

The Department may reject work not performed in accordance with the supplier's approved QCP in accordance with 1512, "Unacceptable and Unauthorized Work."

The Department will not charge the Contractor for plant inspections by Department personnel.

Provide the Department Inspectors with suitable hard hats, face and hand shields, safety glasses, respirators, and other safety equipment necessary to ensure the Inspector's safety while performing structural metals inspections.

Notify the Engineer at least 5 business days before the fabricator begins work to allow the Engineer to perform inspections. Do not allow the fabricator to perform work or manufacture material until after notifying the Engineer. The Engineer may reject work performed without notice in accordance with 1512, "Unacceptable and Unauthorized Work," or may subject the work performed to additional NDT, at no additional cost to the Department.

The Department may reject material or work not meeting the requirements of the contract. The Contractor, in conjunction with the fabricator, may appeal to the Engineer. The Engineer will make final decisions on disputes.

The Engineer may reject material shipped to the project site without a Department inspection tag as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

N.2 Facilities for Inspection

Ensure the fabricator provides an office, access to a computer and a copy machine, and any needed tools and assistance to the Inspector for at least 30 business days before work is scheduled to start to 30 business days after the shipment of material.

Ensure the fabricator provides an inspector's office meeting the following requirements and characteristics:

(1) Floor space of at least 100 ft^2 [9.3 m^2],
(2) Containing at least two desks, or a desk and table, two chairs, a file case, and other necessary furniture,
(3) Clean, modern, and having adequate lighting, heating, and ventilation,
(4) Located in a completely partitioned area and provided with a separate locking door, and
(5) Contains telephone service and a separate dedicated computer data line.

The relevant contract unit price for steel bridge construction includes the cost of providing, maintaining, and repairing, or replacing inspection facilities as included in the cost of steel bridge construction.

O Marking and Shipping

Ensure the fabricator performs the following:

(1) Before shipping, legibly mark material according to the field erection plan, and as approved by the Engineer,
(2) Place markings on the "inside" of fascia beams on a bridge,
(3) Mark duplicate pieces unless otherwise approved by the Engineer,
(4) Bolt connection plates for members in position for shipment,
(5) Ship pins, bolts, nuts, and washers in weatherproof containers no greater than 500 lb [230 kg]. Ship pins with nuts in place,
(6) Package bolts of the same length and diameter, nuts, and washers meeting the requirements of ASTM A 325, "Packaging and Package Instructions",
(7) Pad coated material to keep the material clean and undamaged during loading, transporting, unloading, handling, and storage,
(8) Ship beams and girders in an upright position, unless otherwise approved by the Engineer. Block material to prevent buckling, warping, or twisting during transportation, and
(9) Block cambered members to prevent loss of camber.

2471.4 METHOD OF MEASUREMENT 2402

2471.5 BASIS OF PAYMENT 2402

2472 METAL REINFORCEMENT

2472.1 DESCRIPTION

This work consists of providing and placing metal reinforcement of the types, shapes, and sizes as required by the contract.

2472.2 MATERIALS

A Reinforcement Bars 3301

B Steel Fabric 3303

C Spiral Reinforcement 3305

2472.3 CONSTRUCTION REQUIREMENTS

A Bending

Bend bars to the shapes as shown on the plans. The Contractor may bend the bars cold. If hot bending a non-coated bar, do not heat bars to temperatures greater than 1,200 °F [650 °C] and do not quench the bars.

Bar bending details shall conform to the American Concrete Institute 315, "Details & Detailing of Concrete Reinforcement," unless otherwise shown or noted in the plans. Ensure that the bar bend diameters are as shown "Recommended" in the American Concrete Institute 315.

Repair bond loss or coating damage after bending epoxy coated reinforcement bars in accordance with 3301, "Reinforcement Bars." Clean damaged areas to remove loose or deleterious material before patching. Remove rust by blast cleaning. The Engineer, in conjunction with the Materials Engineer, will not require the repair of hairline cracks with no bond loss or other damage. Perform repairs before oxidation appears.

B Storage and Protection

Do not store metal reinforcement in a manner that will cause, induce, or accelerate corrosion or contamination of the metal. Locate timbers (dunnage) on the ground to support the bundles and keep them free of contamination. Store materials at the project site to allow the Engineer to visually inspect and check the various types of reinforcement for conformance to the dimensions as shown on the plans. Store bars of the same type together. Identify reinforcement bars with tags bearing the identification symbols as shown on the plans.

Protect coated reinforcement bars before handling or shipping to prevent damage to the coating. Pad bundling bands and lift bundles using an OSHA-approved spreader bar, multiple supports, or platform bridge to prevent bar-to-bar abrasion from sags in the bar bundle. Do not drag or drop bars or bundles. Support bars or bundles in transit to prevent damage to the coating.

If the epoxy-coated reinforcing steel is incorporated into the Project and is exposed to the weather or stored exposed to the weather for more than 60 calendar days, cover the steel to protect the material from sunlight, salt-spray and weather exposure. Provide for air circulation around the covered steel to minimize condensation under the protective covering.

C Placing, Supporting, and Tying Bar Reinforcement

C.1 General Requirements

Before placing concrete in a unit, ensure the reinforcement bars meet the condition defined in the current CRSI manual titled *Placing Reinforcing Bars,* Chapter VII, "Unloading, Storing, and Handling Bars on the Job." Place the bars as specified in "Tolerances in Placement" section in Chapter X, "General Principles for Bar Placing, Splicing and Tying Reinforcing Bars."

Carefully place the beam seat/pedestal reinforcement to avoid interference with drilling holes for fixed bearing anchor rods. Provide a template demonstrating that the anchor rods have a 2 in [50 mm] clear distance to all reinforcement for the entire embedment at all bearing anchor rod locations. Confirm the proper clearance to the reinforcement with the Engineer prior to placing the affected substructure concrete. Place the beam or girder in its final position prior to drilling or coring holes for the anchor rods. If reinforcement steel is encountered during the drilling or coring process, contact the Engineer, and the Engineer will determine how to proceed. Verify the depth of the holes in the presence of the Engineer prior to inserting the anchor rods.

Firmly support and securely tie reinforcement bars in their proper position. Tie all outermost intersections, and enough of the intermediate intersections, to ensure that no shifting or displacement of the bars will occur during subsequent operations. Bar supports are intended to support the steel reinforcement and normal construction loads; and are not intended to, and should not be used to, support runways for concrete buggies or similar loads. Use black, soft iron wire of at least 16 gauge [1.5 mm] for tying the reinforcement bars. Do not use welded ties. Do not place concrete before the Engineer inspects and approves the placement, support system, and ties for the reinforcement bars.

Provide supports with the following characteristics for reinforcement bars bearing on the falsework sheathing for exposed concrete surfaces:

(1) Stainless steel;
(2) Hot-dip galvanized, epoxy, vinyl, or plastic coated tips extending at least ½ in [12.5 mm] above the sheathing; or
(3) Plastic.

The wire coating shall not chip, peel, crack, or distort under any job conditions and temperatures.

C.2 Special Requirements for Bridge Slabs

Support and tie reinforcement bars for bridge slabs in accordance with the General Requirements and the maximum spacing requirements specified in Table 2472-1. These spacing requirements define only the maximum permissible distances between ties or lines of support. Table 2472-1 does not relieve the Contractor of responsibility for providing additional supports or ties for holding and supporting bars firmly in their correct position.

For bridge slabs, use slab bolsters as the primary support for the bottom transverse reinforcement bars meeting the requirements of "Bar Support Specifications and Standard Nomenclature" in the *CRSI Manual of Standard Practice*. Place the bolsters on the falsework sheathing in continuous lines, parallel to the beams, girders, or centerline of the roadway at locations that will permit placement of supports for the top transverse reinforcement bars directly over the bolsters on the bottom transverse bars.

Use continuous lines of upper continuous high chairs with wire runners as the support system for the top transverse reinforcement bars. Place the high chairs to transfer load to the bottom bolsters without causing deflection in the bottom transverse bars. Use individual type high chairs only as supplemental support or for sections where the use of continuous type high chairs is not practical and the Engineer approves, in writing, the use of the individual type high chairs.

For all interior bays on beam span bridges, place slab bolsters and upper continuous high chairs within 6 in [150 mm] of the edge of beam flanges.

Use tie wires to tie down the top mat of bridge slab reinforcing to the in-place beam stirrups or shear connectors at spacing no greater than 5 ft [1,500 mm], as measured longitudinally along each beam.

If the support system specified in this section is not practical, the Contractor may propose an alternative support system for slab span bridges or other special designs. Provide working drawings showing the proposed support system to the Engineer. If approved by the Engineer in writing, the Contractor may use the proposed support system.

Table 2472-1 Maximum Spacing of Supports and Ties for Bridge Slabs	
Bar Size Number ***English [metric]***	**Maximum Spacing for Slab Bolsters and Continuous Type High Chairs, *ft [mm]***
3 [10] and 4 [13]	3.00 [900]
5 [16], 6 [19], and 7 [22]	4.00 [1,200]

Support the bottom layer of longitudinal reinforcement bars for slab span bridges, cast-in-place concrete girders, beams, struts, and similar sections on beam bolsters or heavy beam bolsters commensurate with the mass to be supported. Do not use precast concrete block or brick supports on formed surfaces.

Use the upper beam bolsters or the upper heavy beam bolsters to support subsequent layers of longitudinal bottom reinforcement, except for bars that can be tied to vertical bars, unless otherwise approved by the Engineer.

After the completion of the placement and tying of the reinforcement bars for a section of bridge slab, and before ordering concrete delivery for that section, set the strike-off rails or guides to the correct elevation. Notify the Engineer when the section is ready for a final check. Operate the strike-off device over the entire section in the presence of the Engineer. Attach a filler strip, ¼ in [6 mm] less in thickness than the minimum concrete cover requirement, to the bottom of the strike-off during this check to detect areas where the top reinforcement may encroach on the required clearance. Do not place concrete for a bridge slab before the Engineer inspects and approves the deck grades.

Tie the top mat of epoxy-coated reinforcement bars at every transverse bar intersection along each continuous row of longitudinal bars. Tie the bottom mat of reinforcement bars and non-continuous rows of top mat bars at least at every second transverse bar intersection. Stagger the ties for the bottom mat along adjacent rows of longitudinal bars. Use plastic or nylon-coated tie wires.

Use plastic bar supports or epoxy-coated wire bar supports with coating resistant to abrasion. Provide epoxy coating for bar supports at least 0.005 in [127 µm] thick and in accordance with 3301, "Reinforcement Bars." Provide plastic coated tips or additional epoxy coating on the legs of the supports for wire bar supports that bear on falsework sheathing for exposed concrete surfaces. Ensure the additional material extends at least ½ in [13 mm] above the sheathing, not including portions of the supports other than the legs. Use a grey-colored coating with a total coating thickness on the ½ in [13 mm] portion, including the initial 0.005 in [127 µm] of epoxy coating, of at least $^{3}/_{32}$ in [2.5 mm]. Use incompressible and abrasion resistant plastic or epoxy material.

C.3 Special Requirements for Coated Bars

The Engineer will not require the Contractor to repair damage caused during shipment of coated bars or by the installation procedures if the damaged area is no greater than ¼ in × ¼ in [6 mm × 6 mm] and the sum of damaged areas in each 1 ft [300 mm] length of bar is no greater than 2 percent of the bar surface area. Repair damage greater than ¼ in × ¼ in [6 mm × 6 mm] as recommended by the manufacturer. The Engineer will reject bars with total damage greater than 2 percent of bar surface area. Remove rejected bars. Ensure the total bar surface area covered by patching material is no greater than 5 percent.

Do not flame cut coated reinforcing bar in any application.

If using an abrasive blade to cut epoxy-coated reinforcing bar and the cut ends are properly coated with a two-part epoxy patching material as recommended by the manufacturer of the epoxy coating, the Department will allow cutting of epoxy-coated bars.

Use a non-metallic vibrator head to consolidate the concrete around coated reinforcement bars and other components.

D Splicing Metal Reinforcement

Provide reinforcement in the lengths shown on the plans. Do not place splices unless otherwise shown on the plans or approved in writing by the Engineer. Place field splices at locations and with details as approved by the Engineer.

D.1 Lap Splices

Provide lap splices as shown on the plans. If not shown on the plans, provide bar reinforcement lap lengths equal to at least 36 diameters for No. 7 [22] bar and smaller and at least 40 diameters for No. 8 [25] bar through No. 11 [36] bar. Lap bar reinforcement for No. 14 [43] bar through No. 18 [57] bar as approved by the Engineer in writing.

Lap wire mesh reinforcement at least the width of one full mesh plus 2 in [50 mm] for transverse laps or one full mesh plus 2 in [50 mm] plus two end overhangs for longitudinal laps.

D.2 Couplers for Reinforcement Bars

Provide reinforcement bar couplers at construction joints in the locations as shown on the plans and with the following characteristics:

(1) Epoxy-coated in accordance with 3301, "Reinforcement Bars,"

(2) Developing at least 125 percent of the yield strength of the reinforcement bar, and
(3) Having a fatigue design limit of at least 12 ksi [83 mPa] when tested in accordance NCHRP Project 10-35.

Submit written coupler details, yield strength and fatigue test results, and the name of the manufacturer to the Engineer for written approval before installation. If assembling threaded couplers, insert the bar into the coupler to the full depth of the thread and torque the assembly as recommended by the manufacturer.

E Spiral Reinforcement

The Contractor may provide rigid or collapsible cages of spiral reinforcement for circular columns. Finish the ends of each column spiral with one and one-half turns of the reinforcement.

The Contractor may make the spiral cages rigid by tying the vertical column bars to the spiral wires at their intersections or by using epoxy-coated metal spacer strips. Provide enough tied intersections or use enough spacer strips to ensure a rigid noncollapsible cage with properly spaced loops when the cage is in its final position. Do not tack weld the reinforcement.

Provide full-length spiral reinforcement cages. If approved by the Engineer, provide spiral reinforcement cages in two pieces with added stock to provide for lapping the two adjoining ends at least one and one-half turns.

2472.4 METHOD OF MEASUREMENT

A Reinforcement Bars

The Engineer will measure *Reinforcement Bars*, including reinforcement in bar mats, by the weight incorporated into the structure in accordance with Table 2472-2. The Engineer will only include quantities for splices shown on the plans.

Reinforcement bars may be marked in either U.S. Customary or metric sizes. The conversion shall be made per the following table:

Table 2472-2
Reinforcement Bars
Theoretical Weights

U.S. Customary Bar Size	Metric Bar Size*	Nominal Dimensions		
		Diameter, *in* *[mm]*	Area *in² [mm²]*	Weight, *lb/ft* *[kg/m]*
3	10	0.375 [9.5]	0.11 [71]	0.376 [0.560]
4	13	0.500 [12.7]	0.20 [129]	0.668 [0.994]
5	16	0.625 [15.9]	0.31 [199]	1.043 [1.552]
6	19	0.750 [19.1]	0.44 [284]	1.502 [2.235]
7	22	0.875 [22.2]	0.60 [387]	2.044 [3.042]
8	25	1.000 [25.4]	0.79 [510]	2.670 [3.973]
9	29	1.128 [28.7]	1.00 [645]	3.400 [5.060]
10	32	1.270 [32.3]	1.27 [819]	4.303 [6.404]
11	36	1.410 [35.8]	1.56 [1006]	5.313 [7.907]
14	43	1.693 [43.0]	2.25 [1452]	7.650 [11.380]
18	57	2.257 [57.3]	4.00 [2581]	13.600 [20.240]

* Bar designation numbers approximate the nominal diameter of the bar in millimeters

B Steel Fabric

The Engineer will measure *Steel Fabric* by the weight incorporated into the structure, based on the quantity shown on the plans. The Engineer will only include quantities for splices shown on the plans.

C Spiral Reinforcement

The Engineer will measure *Spiral Reinforcement* by the weight incorporated into the structure, based on the weight shown in the table in chapter 250 of the Bridge Construction Manual. The Engineer will only include quantities for splices shown on the plans.

D Couplers

The Engineer will measure *Reinforcement Bar Couplers* by the number of couplers installed as required by the contract and as directed by the Engineer.

2472.5 BASIS OF PAYMENT

The Department will pay for metal reinforcement at the contract unit prices for the contract items listed in the detailed specifications for the type of structure where the metal reinforcement is used. For structure type, with no detailed specifications, the Department will pay for metal reinforcement on the basis of the following schedule. The contract unit price for the relevant

metal reinforcement contract item includes the cost of providing, fabricating, delivering, placing the metal reinforcement as specified in this section (2471), bar supports, bar chairs, spacers, and tie wire.

The contract unit price for *Spiral Reinforcement* includes the cost of metal spacer strips, bar supports, and tie wires.

Item No.:	Item:	Unit:
2472.501	Reinforcement Bars	pound [kilogram]
2472.511	Steel Fabric	pound [kilogram]
2472.521	Spiral Reinforcement	pound [kilogram]
2472.525	Couplers (Reinforcement Bars) T-___	each

2478 ORGANIC ZINC-RICH PAINT SYSTEM

2478.1 DESCRIPTION

This work consists of the following for shop or field full-system applications of organic zinc-rich paint systems for new construction and recoating of existing structures:

(1) Surface preparations;
(2) Providing and applying the coating;
(3) Protecting and curing the coating;
(4) Protecting pedestrians, vehicular traffic, and property against damage; and
(5) All work incidental to these operations.

A Definitions

Whenever the following terms are used in this section (2478), the terms shall have the following meaning:

(1) Engineer: Shall be defined as in 1103, "Definitions," except for shop applied paint coats, where Engineer shall mean the State Bridge Engineer.
(2) Contractor: Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and applies the coatings.
(3) Shop (in shop coating): The indoor facility where structural metals are prepared and coated.
(4) Field Coating: The outdoor on-site coating of new or previously coated steel structures before or after erection.
(5) Quality Assurance (QA): The process and person(s) responsible for verification of the conformance of materials and methods of application to the governing specification, in order to achieve a desired result.
(6) Quality Control (QC): The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality. The job foreman or production painter cannot be this person.
(7) Quality Control Plan (QCP): The formal written document prepared by the contractor that describes the policies and procedures that ensure and verify that the coated structural steel component will satisfy the contract requirements.
(8) Quality Assurance Inspector (QAI): The Department's representative responsible for duties specified in the Quality Assurance Plan, with the authority to accept work that meets Contract requirements.
(9) Contact surfaces: Those surfaces in the completed structure that touch other surfaces.
(10) Corner: The intersection of two surfaces.
(11) Edge: An exposed, through-thickness surface of a plate or rolled shape. This may be the as-rolled side face of a beam flange, channel flange or angle leg, or may result from thermal cutting, sawing, or shearing. Edges may be planar or rounded, and either perpendicular or skewed to adjacent faces.
(12) Non-contact surfaces: Surfaces that are not in direct contact with other surfaces.
(13) Prime Coat: Application of a zinc-rich coating to a bare metal substrate.
(14) Coating thickness: The Dry-Film Paint Thickness (DFT) above the peaks of the blast profile.
(15) Mist Coat (Fog Coat or Tack Coat): (a) thin, mist-spray application of a coating to improve adhesion and uniformity of the subsequent full application of the same coating. (b) A light coat of unspecified DFT used to prevent rust staining of steel substrates or temporarily inhibit corrosion.
(16) Stripe Coat: A coating, of sufficient thickness to completely hide the surface being coated, on all edges, corners, seams, crevices, interior angles, junctions of joining members, bolt heads, nuts and threads, weld lines, and similar surface irregularities. This coating shall be followed, as soon as practicable, by the application of the full prime coat to its specified thickness.
(17) Qualified: Holding appropriate documentation and officially on record as competent and experienced to perform a specified function or practice of a specific skill.
(18) Coating System: The surface preparation and application of specific coating classifications (i.e., Inorganic Zinc-Rich, Organic Zinc-Rich, Polyurethane, Acrylic, Polyurea, Latex, etc.) of coating products to provide a film forming a unified whole for the purpose of corrosion protection and/or aesthetics.
(19) Paint System: A set of interacting film forming paint materials and products which combine to make up a complete coating system.

2478.2 MATERIALS

A Zinc-Rich Paint Systems.....3520

Provide paint systems listed on the Approved/Qualified Products List for bridge structural steel coating, three coat systems (organic).

Deliver the paint to the site in the original containers no greater than 5 gal [20 L]. Do not alter the contents unless approved by the Engineer in writing. Package multi-component coatings in separate containers or kits.

Provide the Engineer with the following for each paint shipment:

(1) The manufacturer's material safety data sheets (MSDS),
(2) Material certifications, and

(3) Written instructions for mixing, handling, and application of the coatings.

Ensure a manufacturer's technical representative with knowledge of this paint system is available to assist during coating application.

2478.3 CONSTRUCTION REQUIREMENTS

A Contractor Qualifications and Documentation

At least 30 calendar days before starting work submit a Quality Control Plan (QCP) meeting the requirements of this chapter and AASHTO/NSBA S8.1-*Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges* to the Engineer for approval or be pre-qualified on MnDOT's approved suppliers for fabricated structural metals products list as maintained by the Structural Metals Engineer at http://www.dot.state.mn.us/bridge/pdf/approvedsuppliers.pdf.

Perform the preparation and application of field applied coatings with staff meeting the requirements of The Society of Protective Coatings Certified Application Specialist (SSPS CAS) Level 2. One CAS Level 2 is required on sight overseeing the work in each work area up to a crew of 10 workers. Multiple work areas will require an additional CAS for each area.

At least 30 calendar days before starting work, submit to the Quality Assurance Inspector (QAI) or the Engineer documentation showing that the paint manufacturer's technical representative trained the painters, applicators, and Quality Control (QC) personnel to apply the coating system on the project. Make training materials available to the Engineer upon request.

The Bridge Engineer will audit Contractors with approved QCPs once or twice a year or as otherwise determined by the Bridge Engineer to verify if the Contractor is implementing its QCP. The Department will invoke its Corrective Action Process if the audit indicates non-conformance up to and including requiring the supplier hire a third party Quality Control as a disciplinary step, at no cost to the Department. The Contractor may obtain a copy of the Corrective Action Process from the Bridge Engineer.

B General

For new construction, preserve or transfer erection markings to ensure legibility when erecting members. Provide removable markings or place markings at locations not visible in the completed structure. Use marking material that will not damage the paint system.

If painting a structure erected under a previous contract, the Department will not require disassembly of portions of the structure or removal of appurtenances to expose contact surfaces or otherwise inaccessible metal surfaces unless otherwise shown on the plans or in the special provisions.

For new construction projects, paint contact surfaces with the zinc primer at the recommended DFT, except for surfaces completely sealed by:

(1) Welding,
(2) Bolt heads,
(3) Nuts and washers, and
(4) Embedment in concrete (ex. shear devices and anchorages).

Coat the top surfaces of beams and girders with a mist coat of primer.

Protect the environment and property as required by federal, state, and MnDOT regulations.

Protect non-painted surfaces (concrete bridge deck overhangs and vertical faces of abutments) that are adjacent to the painted surfaces from overspray, unless otherwise shown on the plans or in the special provisions. The Engineer will allow up to 2 inches [50 mm] of overspray and may require the excessive over sprayed paint be removed, covered with a special surface finish, or wire wheeled from the adjacent surface(s).

Provide a system for inspection that will allow the inspector to safely access the steel components. For safety systems that require temporary fastening to the steel to support the system, use fastening hardware that will not damage the paint. Repair damages as approved by the Engineer at no additional cost to the Department.

C Inspection

Perform QC inspections of the shop and field painting in accordance with approved QCP.

The Department will appoint a Quality Assurance Inspector (QAI) as a Department representative to accept work meeting the Contract requirements.

C.1 Quality Control Plan (QCP) Requirements

Provide the minimum requirements and frequencies in the QCP as shown in Table 2478-1:

Table 2478-1 Coating Inspection Requirements	
Requirement	**Frequency/Extent**
General:	
Ambient temperature	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Dew point and humidity	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Surface temperature	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Date and time	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Piece mark and bundle	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Compressed Air Test ASTM D4285	Daily – when abrasive blasting or blow down operations are occurring
DFT (each coat of paint)	SSPC PA 2
Visual inspection (each coat of paint)	100 percent
Surface Preparation:	
Pre-clean per SSPC-SP 1 – Solvent Cleaning	Each component to be prime coated. Visually inspect 100%
Abrasive blast clean per SSPC-SP 10 – Near-White Blast Cleaning	Each component to be prime coated
Visually inspect per VIS-1 – Standard for Blast Comparisons	100 percent
Soluble Salt Test	See Special Provisions
Blast profile inspection per ASTM D 4417	**Steel Girders** – minimum of three locations per each blasted. **Diaphragms** – three locations minimum per each blasted. **Sole Plates** – three locations minimum per each blasted. **Pedestrian Bridges** – minimum of three locations on each truss and a minimum of three locations on the floor beam. **Railing** – ten locations minimum for each 100 lineal ft [30 m] of rail. **Bridge Truss** – three locations minimum for each 1000 sq. ft. [93 sq. m] or the amount of truss blasted by each blasting nozzle in an eight hour shift (whichever is less). Items not covered by this list shall have three documented profile locations for every 1000 sq. ft. [93 sq. m] blasted.
Prime, Intermediate, and Finish Coat:	
Batch number	Every paint kit
Verification of surface cleanliness	Examine visually within 1 h before prime painting
Temperature of mixed product	Just before application
Proper mixing and straining	Every pot mix
Induction time	Every pot mix
Pot life	Every pot mix
Cure time	As recommended by the manufacturer
Proper use of stripe coats (prime coat only)	Visual, 100 percent of all applicable areas, as specified in 2478.3.F, "Paint Coats"
Coating evaluation and repair	Visual, 100 percent of each element
Recoat time	As recommended by the manufacturer
Adhesion (Final Coating system)	As required by the Engineer
Coating system final evaluation and repair	Visual, 100 percent of each element

Provide written records meeting the *QCP Coating Inspection Requirements* in Table 2478-1 to the Engineer upon request on an ongoing basis as the work is being performed. Provide written records meeting the *QCP Coating Inspection Requirements* in Table 2478-1, in its entirety, at the completion of the job, prior to receiving final payment. The QAI or the Engineer may reject the coating system or reduce payment per 1512 if the Contractor did not adhere to the approved QCP or provided inadequate

documentation of adherence to the QCP. Conduct subsequent testing with the QAI or the Engineer's approval, at no additional cost to the Department, to determine compliance.

D Surface Preparation

The QAI or Engineer will inspect the surface preparation as it is done, after its completion, review the QCP documentation, or any combination of the three. Notify the QAI or the Engineer at least 5 working days before beginning surface preparation.

D.1 Cleaning

D.1.a Solvent Cleaning

Clean areas containing organic and synthetic and other visible contaminants with solvent meeting the requirements of SSPC-SP 1, "Solvent Cleaning." Protect the adjacent environment and property while solvent cleaning.

D.1.b Abrasive Blasting

Abrasive blast clean surfaces to achieve a SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning" before applying prime coat. Use job site visual standards and SSPC-VIS 1, "Guide and Reference Photographs for Steel Surfaces Prepared by Abrasive Blast Cleaning." Perform blast cleaning operations meeting the requirements of Minnesota MPCA Rule 7025.0230 through 7025.0380.

Abrasive blast clean to achieve a profile range from 2.0 mils to 4.0 mils [50 µm to 100 µm]. Re-blast clean surfaces when the surface profile is less than 2.0 mils [50 µm]. Provide a Nonconformance Report (NCR) or use a preapproved "Request for Deviation" as stated in the approved QCP, to the Engineer if the profile exceeds 4.0 mils [100 µm]. Provide written documentation proving that the specified profile has been achieved.

D.1.c Post Blasting

After blast cleaning, remove blasting debris from steel surfaces using procedures that leave the surfaces free of moisture and contaminants. Remove the blasting residue from the containment area, specifically the floor area, to prevent dust from being airborne once painting process starts. Provide structural steel members free of surface defects, such as small seams, blisters, weld spatter, fins, laps, and tears. Perform grinding up to 1/32 inch or 5% of the material thickness, whichever is less. Perform grinding parallel to the direction of the stresses. Remove surface defects and repair gouges before applying prime coat.

E Application of Paint

E.1 General

Provide prime, intermediate, and finish coats of paint in accordance with 2478.2.A, "Zinc-Rich Paint Systems."

Do not start painting until the QAI or the Engineer approves the surface preparation and paint. Before applying paint, clean the surface of flash rust, dust, dirt, grease, oil, moisture, overspray, and other deleterious contaminants that will prevent the paint from adhering. Apply paint to produce a smooth and uniform film free of runs, drips, sags, pinholes, blisters, mudcracking, and other deleterious conditions. Apply paint in accordance with manufacturer's printed instructions except as stated in this document.

Do not apply paint to metal surfaces when weather conditions that the manufacturer's literature defines as unsatisfactory are present, and when:

(1) The air temperature falls below 40° F [4° C],
(2) Metal surface temperatures are less than 5° F [3° C] above the dew point,
(3) Water mist is in the air, and
(4) Metal surfaces are damp or frosted.

Do not apply paint if other work operations, wind, or traffic causes the air to carry dust, dirt, or sand onto the prepared or newly painted metal surfaces. Do not apply spray painted paint without protective shields that prevent scattering wet paint particles in areas where rebounding or blowing paint particles could cause harm to persons, adjacent environment, or property. The QAI or Engineer will suspend spray painting operations if the Contractor does not properly control paint application.

Do not thin paint more than as stated in the manufacturer's written instructions. After mixing, strain the primer through a 30 – 60 mesh screen or a double layer of cheesecloth. Do not allow un-dispersed clumps of zinc to remain in the paint after mixing.

Before applying a subsequent coat of paint, perform the following:

(1) Cure the previous coat to the "recoat" time as defined in the manufacturer's Product Data Sheet, and
(2) Screen or scrape smooth and repaint wrinkled, detached, distorted, scuffed, abraded areas.

Remove dust or chalk-like deposits. Repair or replace defective previously applied paint coats as required by the Engineer and at no additional cost to the Department. Apply the subsequent paint coat within the maximum time interval recommended by

the manufacturer. If the maximum time interval is exceeded, blast the areas to SSPC-SP 10/NACE NO. 2, "Near-White Blast Cleaning" and recoat at no additional cost to the Department.

Do not paint within 2 in [50 mm] of the zones requiring field welding as shown on the plans. Prepare and paint the heat affected areas after field welding, in accordance with this section.

When the Contract specifies shop painting and the Contractor does not provide the specified coating(s) in the shop, apply the paint coat(s) for the unpainted portion at the project site.

Submit paint repair procedures to the QAI or the Engineer for approval.

E.2 Spraying

Perform power spraying using a fine, even spray. The Contractor may brush out paint applied with spray equipment to obtain uniform coverage and to eliminate wrinkling, blistering, sags, runs, and air holes if the brushing is done immediately. When spraying, maintain a "spray tip-to-surface" distance to achieve an even, wet coat, free of runs, drips, sags, overspray and dry spray.

When using conventional air spray, equip the air lines with approved water and oil traps. Use ASTM D 4285 "Standard Test Method for Indicating Oil or Water in Compressed Air" to ensure the compressed air is oil and water free.

E.3 Brushes and Daubers

The Contractor may apply paint by brushing in areas unsuitable for spray painting, such as small surface areas where over-spray would be excessive, and small areas requiring paint repair.

If using brushes, manipulate the paint under the brush to provide a smooth, uniform coating over the entire surface, including corners and crevices. Perform final brush strokes horizontal and parallel to each other. Remove brush hairs on the paint surface.

The Contractor may use sheepskin or other approved daubers to paint surfaces inaccessible by spray or brush.

Equip the paint pot with an approved agitator during application of paint by brushing or daubers.

F Paint Coats

F.1 Measurement of Paint Thickness

The Department refers to "Dry Film Thickness" (DFT) when using the term "thickness" in this section. Use a properly calibrated thickness gage to measure the paint thickness and average thickness meeting, at a minimum, the requirements of SSPC-PA 2, "Measurement of Dry Coating Thickness with Magnetic Gages." Measure paint thickness from the top of the peaks of the blast profile.

Perform painting operations as recommended by the manufacturer's literature, unless otherwise specified in this section. If the manufacturer's recommended DFT differs from the DFT in accordance with this section, submit a request in writing to the Engineer before painting to determine the DFT deviation from the manufacturer's written recommendations.

Refer to 2478.3.J for deficient paint thickness.

F.2 Stripe Coats

Before applying prime coat, apply a stripe coat on the edges, corners, seams, crevices, interior angles, junctions of joining members, rivets or bolt heads, nuts and threads, weld lines, and similar irregularities. Ensure the stripe coat completely hides the surface to be covered. Apply the prime coat on top of the stripe coat before it is fully cured, to its specified thickness as defined in this section, and after the QAI or the Engineer accepts the stripe coat.

Apply the stripe coat per 2478.3.E.

F.3 Prime Coat

Apply the stripe coat and primer coat after preparing the surface in accordance with this section and as approved by the QAI or the Engineer and before the surface rusts.

Equip the paint pot with an agitator during spray, brush, or dauber painting work. Provide an agitator or stirring rod capable of reaching within 2 in [50 mm] of the bottom of the pot to keep the paint mixed during application. Apply prime coat to a DFT as stated in Table 2478-2, with no spot reading measuring less than the minimum primer DFT listed, unless the manufacturer requires otherwise. Remain within the maximum DFT limits as defined by the manufacturer.

Table 2478-2 Blast Profile / Paint Thickness Requirements for Primer		
Blast Profile	**Minimum Primer DFT**	**Average Primer DFT**
2.0 – 3.0 mils [50 - 75 µm]	3.0 mils [75 µm] minimum	4.0 mils [100 µm] average
3.0 – 4.0 mils [75 - 100 µm]	4.0 mils [100 µm] minimum	5.0 mils [125 µm] average
>4.0 mils [100 µm]	Write a Nonconformance Report (NCR) or use a preapproved "Request for Deviation" as stated in your QCP	Write a Nonconformance Report (NCR) or use a preapproved "Request for Deviation" as stated in your QCP

For contact surfaces of bolt splices, do not apply prime coat to a thickness greater than the manufacturer's certified thickness for Class B slip co-efficient.

Apply the prime paint coat per 2478.3.E.

F.4 Intermediate Coat

Apply the intermediate coat to a DFT of at least 3.0 mils [75 µm] after the prime coat cures to the "dry-to-topcoat," as defined in the manufacturer's Product Data Sheet. Remain within the maximum DFT limits as defined by the manufacturer.

Provide epoxy intermediate coat in a color that will contrast between the organic zinc-rich primer and the polyurethane topcoat.

Apply the intermediate paint coat to prime coated surfaces exposed in the completed structure.

Apply the intermediate paint coat per 2478.3.E.

F.5 Finish Coats

Fillet seal crevices and cavities along the edge of faying surfaces that are separated by $^{1}/_{16}$ in [1.5 mm] or more with an approved sealant that is listed on the Approved/ Qualified Products List for Bridge Structural Steel Coating Sealants and apply per the coating manufacturer installation instructions. Do not seal the bottom edge of faying surfaces allowing the juncture to release trapped moisture. Ensure the sealant color is a match to the finish paint color by submitting a sample to the MnDOT lab for color approval.

Apply the finish coat to a DFT of at least 2.0 mils [50 µm] (remain within the maximum DFT limits as defined by the manufacturer) after the intermediate cures to the "dry-to-topcoat," as defined in the manufacturer's Product Data Sheet. Ensure the finish coat color matches the color standard required by the contract.

Apply the finish paint coat to intermediate coated surfaces exposed in the completed structure. Ensure the finished surface is uniform in color and free of visible lap marks and other blemishes.

Apply the finish paint coat per 2478.3.E.

F.6 Total Paint Thickness

Ensure the total paint thickness of the entire paint system averages at least 10 mils [250 µm] but remains in the maximum thickness limits defined by the manufacturer of the paint system. If the Engineer finds total paint thickness deficient or excessive over any part of a structure and if the Engineer does not require additional paint applications or removal of paint, the Department will reduce payment for the appropriate item of work.

G Markings for Identification

Stencil the year of painting and the specification numbers of the prime, intermediate, and top coats in numerals 3 in [75 mm] high on the interior surface of fascia beams, at the same corner displaying the bridge name plate and at the corner diagonally opposite that corner (example: 2016 2478).

G.1 Stenciling after Primer

When the primer is applied in the shop, ensure the fabricator/painter stencils the name of the paint manufacturer and the primer product name applied in the shop on the inside web of both fascia girders in characters 3 in [75 mm] high and in a contrasting color compatible with the specified paint system.

H Fasteners

H.1 Requirements for Coating

Remove all organic or other material that would interfere with the adhesion of the coating. The Contractor may use industrial cleaning solutions to remove fastener lubricants if the solutions do not contaminate or interfere with adherence of subsequently applied coating materials as approved by the QAI or the Engineer. Adhesion tests may be required by the Engineer to prove that there is no interference, at no additional cost to the Department.

H.2 Paint Thickness Requirements

After installing fasteners and after removing lubricant and residuals from exposed parts of fasteners, apply additional primer to meet the required primer thickness as defined in this section. Provide the required thickness of the intermediate and finish coats to fasteners as defined in this section.

I Handling, Storage, and Shipping of Painted Steel

Do not apply paint to members loaded for shipment except to apply touch-up paint as approved by the QAI or the Engineer.

Do not damage the painted steel in the shop and field during shipping, erection, and construction of the bridge and components. Do not move or handle the painted steel items until the coating cures in accordance with the manufacturer's data sheet. Use nylon straps, padded hooks, slings, or other non-metallic lifting devices to protect coated components or products during handling and loading. Use softeners and edge protection devices to protect the steel from binding chains. Provide padded hooks and slings to hoist the painted components.

Store completed items in accordance with 1606, "Storage of Materials," and the following:

(1) Tag or permanently mark items before final storage. Include individual piece marks, bridge number, project number, manufacturer number, and the applicator job number in the identification markings.

(2) Locate the final storage area out of any traffic lanes and in an area capable of bearing the full weight of the members or items and stable enough to maintain bundles, members or items within the supporting substrate. Inspect and store bundles, members, or items in one general location before final acceptance unless otherwise approved by the QAI or the Engineer.

Support individual items or bundles of coated products in transit in a manner that will prevent damage to the coating. Do not drop or drag individual items or bundles of coated products. Pad when shipping, bundling, or banding materials to protect the components from direct contact with packaging materials that may damage the coated products finish. Use softeners and edge protection devices in conjunction with high-density foam or other acceptable packaging materials at all points of contact.

J Paint Repair

The Contractor may use a "Tooke Gauge" to perform a destructive test to measure the DFT, at no additional cost to the Department, if it is not possible to satisfactorily determine the coating thickness of any paint coat after application. Repair the destructively tested area as approved by the Engineer and at no additional cost to the Department. Do not perform mechanical grinding to reduce paint thickness. Completely remove and recoat the paint system with deficient or excessive paint thickness, as defined in this section, for prime, intermediate, or topcoat if directed by the Engineer.

Submit paint repair procedures to the Engineer in writing for acceptance.

2478.4 METHOD OF MEASUREMENT

The Engineer will make area calculations. The Engineer will not make allowance in area calculations for actual areas of rivets and bolt heads, curved surfaces of welds, radii, or corners.

A Shop Painting

The Engineer will measure shop painting required by the contract based on the area of acceptable paint coverage on non-contact areas, as computed from the dimensions shown on the plans. The Engineer will not include contact areas in the measurement for payment.

B Field Painting for New Construction

The Engineer will measure field painting in the bolted field splice areas of newly constructed shop painted steel based on the field splice area of acceptable paint coverage as shown on the plans. The Department will consider the cost of paint repairs to correct damage from field storage or erection with the relevant contract unit prices for structural steel.

C Field Painting of an Existing Bridge

The Engineer will measure field painting of structural steel on the basis of the area of acceptable paint coverage, as computed from the dimensions as shown on the plans for the structure.

2478.5 BASIS OF PAYMENT

A Shop Painting

The contract square foot [square meter] for *Organic Zinc-Rich Paint (Shop)* includes the costs providing and applying an acceptable shop applied paint system, including all necessary repairs to the paint coating that occur before unloading at the project storage site.

B Field Painting of Shop Painted Components

The contract square foot [square meter] price for *Organic Zinc-Rich Paint System (Field)* includes the costs of preparing and applying field applied paint systems to shop primed bolted splice areas.

C Painting of Existing (Old) Components or Structures

The contract square foot [square meter] price for *Organic Zinc-Rich Paint System (Old)* includes the costs of surface preparation, providing, and applying coating system to existing structural steel.

D Payment

The Department will pay for organic zinc-rich paint system on the basis of the following schedule:

Item No.:	Item:	Unit:
2478.502	Organic Zinc-Rich Paint System (Shop)	square foot [square meter]
2478.503	Organic Zinc-Rich Paint System (Field)	square foot [square meter]
2478.506	Organic Zinc-Rich Paint System (Old)	square foot [square meter]

2479 INORGANIC ZINC-RICH PAINT SYSTEM

2479.1 DESCRIPTION

This work consists of the following for new work where the application of inorganic zinc-rich primer is done in the shop and where field applied intermediate and top coating is desired:

(1) Surface preparations,
(2) Providing and applying the coating,
(3) Protecting and curing the coating,
(4) Protecting pedestrians, vehicular traffic, and property against damage, and
(5) All work incidental to these operations.

A Definitions

Whenever the following terms are used in this section (2479), the terms shall have the following meaning:

(1) Engineer: As defined in 1103, "Definitions," except for shop applied paint coats, where Engineer shall mean the State Bridge Engineer.
(2) Contractor: Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and applies the coatings.
(3) Shop (in shop coating): The indoor facility where structural metals are prepared and coated.
(4) Field Coating: The outdoor on-site coating of new or previously coated steel structures before or after erection.
(5) Quality Assurance (QA): The process and person(s) responsible for verification of the conformance of materials and methods of application to the governing specification, in order to achieve a desired result.
(6) Quality Control (QC): The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality. The job foreman or production painter cannot be this person.
(7) Quality Control Plan (QCP): The formal written document prepared by the contractor that describes the policies and procedures that ensure and verify that the coated structural steel component will satisfy the contract requirements.
(8) Quality Assurance Inspector (QAI): The Department's representative responsible for duties specified in the Quality Assurance Plan, with the authority to accept work that meets the contract requirements.
(9) Contact surfaces: Those surfaces in the completed structure that touch other surfaces.
(10) Corner: The intersection of two surfaces.
(11) Edge: An exposed, through-thickness surface of a plate or rolled shape. This may be the as-rolled side face of a beam flange, channel flange or angle leg, or may result from thermal cutting, sawing, or shearing. Edges may be planar or rounded, and either perpendicular or skewed to adjacent faces.
(12) Non-contact surfaces: Surfaces that are not in direct contact with other surfaces.
(13) Prime Coat: Application of a zinc-rich coating to a bare metal substrate.
(14) Coating thickness: The Dry Film Paint Thickness (DFT) above the peaks of the blast profile.
(15) Mist Coat (Fog Coat or Tack Coat): (a) thin, mist-spray application of a coating to improve adhesion and uniformity of the subsequent full application of the same coating. (b) A light coat of unspecified DFT used to prevent rust staining of steel substrates or temporarily inhibit corrosion.
(16) Stripe Coat: A coating, of sufficient thickness to completely hide the surface being coated, on all edges, corners, seams, crevices, interior angles, junctions of joining members, bolt heads, nuts and threads, weld lines, and similar surface irregularities. This coating shall be followed, as soon as practicable, by the application of the full prime coat to its specified thickness.
(17) Qualified: Holding appropriate documentation and officially on record as competent and experienced to perform a specified function or practice of a specific skill.
(18) Coating System: The surface preparation and application of specific coating classifications (i.e., Inorganic Zinc-Rich, Organic Zinc-Rich, Polyurethane, Acrylic, Polyurea, Latex, etc.) of coating products to provide a film forming a unified whole for the purpose of corrosion protection and/or aesthetics.
(19) Paint System: A set of interacting film forming paint materials and products which combine to make up a complete coating system.

2479.2 MATERIALS

A Zinc-Rich Paint Systems 3520

Provide paint systems listed on the Approved/Qualified Products List for bridge structural steel coating, three coat systems (inorganic).

Deliver the paint to the site in its original containers no greater than 5 gal [20 L]. Do not alter the contents unless approved by the Engineer in writing. Package multi-component coatings in separate containers or kits.

Provide the Engineer with the following for each paint shipment:

(1) The manufacturer's Material Safety Data Sheets (MSDS);

(2) Material certifications; and
(3) Written instructions for mixing, handling, and application of the coatings.

Ensure a manufacturer's technical representative with knowledge of the approved paint system is available to assist during coating preparation and application.

2479.3 CONSTRUCTION REQUIREMENTS

A Contractor Qualifications and Documentation

At least 30 calendar days before starting work submit a Quality Control Plan (QCP) meeting the requirements of this chapter and AASHTO/NSBA S8.1-*Guide Specification for Application of Coating Systems with Inorganic Zinc-Rich Primers to Steel Bridges* to the Engineer for approval or be pre-qualified on MnDOT's approved suppliers for fabricated structural metals products list as maintained by the Structural Metals Engineer at http://www.dot.state.mn.us/bridge/pdf/approvedsuppliers.pdf.

Perform the preparation and application of field applied coatings with staff meeting the requirements of The Society of Protective Coatings Certified Application Specialist (SSPS CAS) Level 2. One CAS Level 2 is required on sight overseeing the work in each work area up to a crew of 10 workers. Multiple work areas will require an additional CAS for each area.

At least 30 calendar days before starting work submit to the QAI or Engineer documentation showing that the paint manufacturer's technical representative trained the painters, applicators, and Quality Control (QC) personnel to apply the coating system on the project. Make training materials available upon request by the Engineer.

The Bridge Engineer will audit Contractors with approved QCPs once or twice a year or as otherwise determined by the Bridge Engineer to verify if the Contractor is implementing its QCP. The Department will invoke its Corrective Action Process if the audit indicates non-conformance up to and including requiring the Contractor hire a third party Quality Control as a disciplinary step, at no cost to the Department. The Contractor may obtain a copy of the Corrective Action Process from the Bridge Engineer.

B General

For new construction, preserve or transfer erection markings to ensure legibility when erecting members. Provide removable markings or place markings at locations not visible in the completed structure. Use marking material that will not damage the paint system.

If painting a structure erected under a previous contract, the Department will not require disassembly of portions of the structure or removal of appurtenances to expose contact surfaces or otherwise inaccessible metal surfaces unless otherwise shown on the plans or in the special provisions.

For new construction projects, paint contact surfaces with the zinc primer at the specified DFT, except for surfaces completely sealed by:

(1) Welding,
(2) Bolt heads,
(3) Nuts and washers, and
(4) Embedment in concrete (ex. shear devices and anchorages).

Coat the top surfaces of beams and girders with a mist coat of primer.

Protect the environment and property as required by federal, state, and MnDOT regulations.

Protect non-painted surfaces (concrete bridge overhangs, and vertical faces of abutments) that are adjacent to the painted surfaces from overspray unless otherwise shown on the plans or in the special provisions. The Engineer will allow up to 2 inches [50 mm] of overspray and may require the excessive over sprayed paint be removed, covered with a special surface finish, or wire wheeled from the adjacent surface(s).

Provide a system for inspection that will allow the inspector to safely access all the steel components. For safety systems that require temporary fastening to the steel to support the system, use fastening hardware that will not damage the paint. Repair damages as approved by the Engineer at no additional cost to the Department.

C Inspection

Perform QC inspections of the shop and field painting in accordance with approved QCP.

The Department will appoint a Quality Assurance Inspector (QAI) as a Department representative to accept work meeting the contract requirements.

C.1 Quality Control Plan (QCP) Requirements

Meet the minimum requirements and frequencies in the QCP as listed in Table 2479-1:

Table 2479-1 Coating Inspection Requirements	
Requirement	**Frequency/Extent**
General:	
Ambient temperature	Every 4 (field) h; 8 (shop) h or at the start of each shift
Dew point and humidity	Every 4 (field) h; 8 (shop) h or at the start of each shift
Surface temperature	Every 4 (field) h; 8 (shop) h or at the start of each shift
Date and time	Each lot of work (shop); Every 4 (field) h
Piece mark and bundle	Each lot of work (shop); Every 4 (field) h
Compressed Air Test ASTM D4285	Daily – when abrasive blasting or blow down operations are occurring
DFT (each coat of paint)	SSPC PA 2
Visual inspection (each coat of paint)	100 percent
Surface Preparation:	
Pre-clean per SSPC-SP 1 – Solvent Cleaning	Each component to be prime coated. Visually inspect 100%
Abrasive blast clean per SSPC-SP 10 – Near-White Blast Cleaning	Each component to be prime coated
Visually inspect per VIS-1 – Standard for Blast Comparisons	100 percent
Soluble Salt Test	See Special Provisions
Blast profile inspection per ASTM D 4417	**Steel Girders** – minimum of three readings per each blasted **Diaphragms** – three readings minimum per each lot blasted* **Sole Plates** – three readings minimum per each lot blasted* **Pedestrian Bridges** – minimum of three readings on each truss and a minimum of three readings on the floor beam **Railing** – three readings minimum for each 100 lineal feet [30 m] of rail **Bridge Truss** – three readings minimum for each 1000 sq. ft. [93 sq. m] or the amount of truss blasted in an eight hour shift (whichever is less) *The amount of diaphragms or sole plates going through an automated blast machine at one time or the amount being blasted in an eight hour shift. Items not covered by this list shall have three documented profile readings for every 1000 sq. ft. [93 sq. m] blasted.
Prime, Intermediate, and Finish Coat:	
Batch number	Every paint kit
Verification of surface cleanliness	Examine visually within 1 h before prime painting
Temperature of mixed product	Just before application
Proper mixing and straining	Every pot mix
Induction time	Every pot mix
Pot life	Every pot mix
Cure time	As recommended by the manufacturer
Proper use of stripe coats (prime coat only)	Visual, 100 percent of all applicable areas, as specified in 2479.3.F, "Paint Coats"
Coating evaluation and repair	Visual, 100 percent of each element
Recoat time	As recommended by the manufacturer
Adhesion (Final Coating system)	As required by the Engineer
Coating system final evaluation and repair	Visual, 100 percent of each element

Provide written documentation of the measurements to the QAI or to the Engineer during the work and in its entirety at the completion of the job. For field painting provide written records meeting the *QCP Coating Inspection Requirements* in Table

2479-1, in its entirety, at the completion of the job, prior to receiving final payment. The QAI or the Engineer may reject the coating system or reduce payment per 1512 if the Contractor did not adhere to the approved QCP or provided inadequate documentation of adherence to the QCP. Conduct subsequent testing with the QAI or the Engineer's approval, at no additional cost to the Department, to determine compliance.

D Surface Preparation

The QAI or Engineer will inspect the surface preparation as it is done, after its completion, or review the QCP documentation, or any combination of the three. Notify the QAI or the Engineer at least 5 working days before beginning surface preparation.

D.1 Cleaning

D.1.a Solvent Cleaning

Clean areas containing organic and synthetic and other visible contaminants with solvent meeting the requirements of SSPC-SP 1, "Solvent Cleaning." Protect the adjacent environment and property while solvent cleaning.

D.1.b Abrasive Blasting

Abrasive blast clean surfaces to achieve a SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning" before applying prime coat. Use job site visual standards and SSPC-VIS 1, "Guide and Reference Photographs for Steel Surfaces Prepared by Abrasive Blast Cleaning." Perform blast cleaning operations meeting the requirements of Minnesota MPCA Rules 7025.0230 through 7025.0380.

Abrasive blast clean to achieve a profile range from 2.0 mils to 3.5 mils [50 µm to 89 µm]. Re-blast clean surfaces when the surface profile is less than 2.0 mils [50 µm]. Provide a Nonconformance Report (NCR), as specified in the QCP, to the Engineer if the profile exceeds 3.5 mil [90 µm]. Provide written documentation proving that the specified profile has been achieved.

D.1.c Post Blasting

After blast cleaning, remove blasting debris from steel surfaces using procedures that leave the surfaces free of moisture and contaminants. Remove the blasting residue from the containment area, specifically the floor area, to prevent dust from being airborne once painting process starts. Provide structural steel members free of surface defects, such as small seams, blisters, weld spatter, fins, laps, and tears. Perform grinding up to 1/32 inch or 5% of the material thickness, whichever is less. Perform grinding parallel to the direction of the stresses. Remove surface defects and repair gouges before applying prime coat.

E Application of Paint

E.1 General

Provide prime, intermediate, and finish coats of paint in accordance with 2479.2.A, "Zinc-Rich Paint Systems."

Do not start painting until the QAI or the Engineer approves the surface preparation and paint. Before applying paint, clean the surface of flash rust, dust, dirt, grease, oil, moisture, overspray, and all other deleterious contaminants that will prevent the paint from adhering. Apply paint to produce a smooth and uniform film free of runs, drips, sags, pinholes, blisters, mudcracking, and any other deleterious condition. Apply paint in accordance with manufacturer's printed instructions except as stated in this document.

Do not apply paint to metal surfaces when weather conditions that the manufacturer's literature defines as unsatisfactory are present, and when:

(1) The air temperature falls below 40° F [4° C],
(2) Metal surface temperatures are less than 5° F [3° C] above the dew point,
(3) Water mist is in the air, and
(4) Metal surfaces are damp or frosted.

Do not apply paint if other work operations, wind, or traffic causes the air to carry dust, dirt, or sand onto the prepared or newly painted metal surfaces. Do not apply spray painted paint without protective shields that prevent scattering wet paint particles in areas where rebounding or blowing paint particles cause harm to persons, adjacent environment, or property. The QAI or Engineer will suspend spray painting operations if the Contractor does not properly control paint application.

Do not thin paint more than what is stated in the manufacturer's written instructions. After mixing, strain the primer through a 30–60 mesh screen or a double layer of cheesecloth. Do not allow un-dispersed clumps of zinc to remain in the paint after mixing.

Before applying a subsequent coat of paint, perform the following:

(1) Cure the previous coat to the "recoat" time defined in the manufacturer's Product Data Sheet, and
(2) Screen or scrape smooth and repaint wrinkled, detached, distorted, scuffed, or abraded areas.

Remove dust or chalk-like deposits. Repair or replace defective previously applied paint coats as required by the Engineer and at no additional cost to the Department. Apply the subsequent paint coat within the maximum time interval recommended by the manufacturer. If the maximum time interval is exceeded blast the areas to SSPC-SP 10/NACE NO. 2, "Near-White Blast Cleaning," and recoat at no additional cost to the Department.

Do not paint within 2 in [50 mm] of the zones requiring field welding as shown on the plans. Prepare and paint the heat affected areas after field welding in accordance with this section.

When the contract specifies shop painting and the Contractor does not provide the specified coating(s) in the shop, apply the paint coat(s) for unpainted portion at the project site.

Submit paint repair procedures to the QAI or the Engineer for approval.

E.2 Spraying

Perform power spraying using a fine, even spray. The Contractor may brush out paint applied with spray equipment to obtain uniform coverage and to eliminate wrinkling, blistering, sags, runs, and air holes if the brushing is done immediately.

E.3 Brushes and Daubers

The Contractor may apply paint by brushing in areas unsuitable for spray painting, such as small surface areas where over-spray would be excessive, and small areas requiring paint repair.

If using brushes, manipulate the paint under the brush to provide a smooth, uniform coating over the entire surface, including corners and crevices. Perform final brush strokes horizontal and parallel to each other. Remove brush hairs on the paint surface.

The Contractor may use sheepskin or other approved daubers to paint surfaces inaccessible by spray or brush.

Equip the paint pot with an approved agitator during application of zinc-rich paint by brushing or daubers.

F Paint Coats

F.1 Measurement of Paint Thickness

The Department refers to "Dry Film Thickness" (DFT) when using the term "thickness" in this section. Use a properly calibrated thickness gage to measure the paint thickness and average thickness meeting the requirements of SSPC-PA 2, "Measurement of Dry Coating Thickness with Magnetic Gages." Measure paint thickness from the top of the peaks of the blast profile.

Perform painting operations as recommended by the manufacturer's literature, unless otherwise specified in this section. If the manufacturer's recommended DFT differs from the DFT in accordance with this section, submit a request in writing to the Engineer before painting to approve the DFT deviation to the manufacturer's written recommendations.

Refer to 2479.3.J for deficient paint thickness.

F.2 Stripe Coats

Before applying prime coat, apply a stripe coat on the edges, corners, seams, crevices, interior angles, junctions of joining members, rivets or bolt heads, nuts and threads, weld lines, and similar irregularities. Ensure the stripe coat completely hides the surface to be covered. Apply the prime, on top of the stripe coat before it is fully cured, and to its specified thickness, as defined in this section, and after the QAI or the Engineer accepts the stripe coat.

Apply the stripe coats per 2479.3.E.

F.3 Prime Coat

Apply the stripe coat and primer coat after preparing the surface in accordance with this section and as approved by the QAI or the Engineer and before the surface rusts.

Equip the paint pot with an agitator during spray, brush, or dauber painting work. Provide an agitator or stirring rod capable of reaching within 2 in [50 mm] of the bottom of the pot to keep the paint mixed during application.

Apply prime coat to a DFT average of at least 4.0 mils [100 µm] with no spot reading measuring less than 3 mils [76 µm], unless otherwise required by the contract.

For contact surfaces of bolt splices, do not apply prime coat to a thickness greater than the manufacturer's certified thickness for Class B slip co-efficient.

Apply the prime coat per 2479.3.E.

F.4 Intermediate Coat

Apply the intermediate coat to a DFT of at least 3.0 mils [75 µm] after the prime coat cures to the "dry-to-topcoat," as defined in the manufacturer's Product Data Sheet. Remain within the maximum DFT limits as defined by the manufacturer.

Provide epoxy intermediate coat in a color that will contrast between the inorganic zinc-rich primer and the polyurethane topcoat.

Apply the intermediate paint coat to prime coated surfaces exposed in the completed structure.

Apply the intermediate paint coat per 2479.3.E.

F.5 Finish Coats

Fillet seal crevices and cavities along the edge of faying surfaces that are separated by $^{1}/_{16}$ in [1.5 mm] or more with an approved sealant that is listed on the Approved/ Qualified Products List for Bridge Structural Steel Coating Sealants and apply per the coating manufacturer installation instructions. Do not seal the bottom edge of faying surfaces allowing the juncture to release trapped moisture. Ensure the sealant color is a match to the finish paint color by submitting a sample to the MnDOT lab for color approval.

Apply the finish coat to a DFT of at least 2.0 mils [50 µm] (remain within the maximum DFT limits as defined by the manufacturer) after the intermediate cures to the "dry-to-topcoat," as defined in the manufacturer's Product Data Sheet. Ensure the finish coat color matches the color standard required by the contract.

Apply the finish paint coat to intermediate coated surfaces exposed in the completed structure. Ensure the finished surface is uniform in color and free of visible lap marks and other blemishes.

Apply the finish paint coat per 2479.3.E.

F.6 Total Paint Thickness

Ensure the total paint thickness of the entire paint system averages at least 9 mils [225 µm] but remains in the maximum thickness limits defined by the manufacturer of the paint system. If the Engineer finds total paint thickness deficient or excessive over any part of a structure and if the Engineer does not require additional paint applications or removal of paint, the Department will reduce payment for the appropriate item of work.

G Markings for Identification

Stencil the year of painting and the specification numbers of the prime, intermediate, and top coats in numerals 3 in [75 mm] high on the interior surface of fascia beams, at the same corner displaying the bridge name plate and at the corner diagonally opposite that corner (example: 2016 2479).

G.1 Stenciling after Primer

When the primer is applied in the shop, ensure the fabricator/painter stencils the name of the paint manufacturer and the primer product name applied in the shop on the inside web of both fascia girders in characters 3 in [75 mm] high and in a contrasting color compatible with the specified paint system.

H Fasteners

H.1 Requirements for Coating

Remove all organic or other material that would interfere with the adhesion of the coating. The Contractor may use industrial cleaning solutions to remove fastener lubricants if the solutions do not contaminate or interfere with adherence of subsequently applied coating materials as approved by the QAI or the Engineer. Adhesion tests may be required by the Engineer to prove that there is no interference, at no additional cost to the Department.

H.2 Paint Thickness Requirements

After installing fasteners and after removing lubricant and residuals from exposed parts of fasteners, apply additional primer to meet the required primer thickness as defined in this section. Provide the required thickness of the intermediate and finish coats to fasteners as defined in this section.

I Handling, Storage, and Shipping of Painted Steel

Do not apply paint to members loaded for shipment except to apply touch-up paint as approved by the QAI or the Engineer.

Do not damage the painted steel in the shop and field during shipping, erection, and construction of the bridge and components. Do not move or handle the painted steel items until the coating cures in accordance with the manufacturer's data sheet. Use nylon straps, padded hooks, slings, or other non-metallic lifting devices to protect coated components or products during handling and loading. Use softeners and edge protection devices to protect the steel from binding chains. Provide padded hooks and slings to hoist the painted components.

Store completed items in accordance with 1606, "Storage of Materials," and the following:

(1) Tag or permanently mark items before final storage. Include individual piece marks, bridge number, project number, manufacturer number, and the applicator job number in the identification markings, and

(2) Locate the final storage area out of any traffic lanes and in an area capable of bearing the full weight of the members or items and stable enough to maintain bundles, members or items within the supporting substrate. Inspect and store bundles, members, or items in one general location before final acceptance unless otherwise approved by the QAI or the Engineer.

Support individual items or bundles of coated products in transit in a manner that will prevent damage to the coating. Do not drop or drag individual items or bundles of coated products. Pad when shipping, bundling, or banding materials to protect the components from direct contact with packaging materials that may damage the coated products finish. Use softeners and edge protection devices in conjunction with high-density foam or other acceptable packaging materials at all points of contact.

J Paint Repair

The Contractor may use a "Tooke Gauge" to perform a destructive test to measure the DFT, at no additional cost to the Department, if it is not possible to satisfactorily determine the coating thickness of any paint coat after application. Repair the destructively tested area as approved by the Engineer and at no additional cost to the Department. Do not perform mechanical grinding to reduce paint thickness. Completely remove and recoat the paint system with deficient or excessive paint thickness, as defined in this section, for prime, intermediate, or topcoat if directed by the Engineer.

Submit paint repair procedures to the Engineer in writing for acceptance.

2479.4 METHOD OF MEASUREMENT

The Engineer will make area calculations. The Engineer will not make allowance in area calculations for actual areas of rivets and bolt heads, curved surfaces of welds, radii, or corners.

The Engineer will measure painting of the structural steel by the square foot [square meter] based on the area of acceptable paint coverage on non-contact areas as computed from the dimensions as shown on the plans. The Engineer will not include contact areas in the measurement for payment.

2479.5 BASIS OF PAYMENT

A Shop Painting

The contract square foot [square meter] price for *Inorganic Zinc-Rich Paint System (Shop)* includes the cost of providing paint product for the primer and applying the primer in accordance with this section and 2402, "Steel Bridge Construction."

B Field Painting

The contract square foot [square meter] price for *Inorganic Zinc-Rich Paint System (Field)* includes the cost of providing and applying the paint product for the intermediate and finish coats of the approved paint system. The Department will include the cost of paint repairs to correct damage from field storage or erection with the relevant contract unit price for structural steel.

C Shop and Field Painting

The contract square foot [square meter] price for *Inorganic Rich Paint Systems (Shop and Field)* includes the costs of surface preparation, providing, and applying shop and field coatings. The Department will include the cost of paint repairs to correct damage from field storage or erection in the relevant contract unit price for structural steel.

D Payment

The Department will pay for inorganic zinc-rich paint system on the basis of the following schedule:

Item No.:	Item:	Unit:
2479.502	Inorganic Zinc-Rich Paint System (Shop)	square foot [square meter]
2479.503	Inorganic Zinc-Rich Paint System (Field)	square foot [square meter]
2479.504	Inorganic Zinc-Rich Paint System (Shop and Field)	square foot [square meter]

2481 WATERPROOFING

2481.1 DESCRIPTION

This work consists of waterproofing joints.

2481.2 MATERIALS

A Three-Ply System Materials

A.1 Asphalt Primer for Waterproofing Concrete 3165

A.2 Saturated Fabric for Waterproofing 3201

A.3 Asphalt for Mopping Coat 3166

B Membrane Waterproofing System.....3757

2481.3 CONSTRUCTION REQUIREMENTS

A General

Remove form ties, fill cavities with mortar, and remove all sharp protrusions before waterproofing. Before applying the primer, ensure the concrete has cured for 72 hours and is clean, dry, smooth, and free of voids. Clear the concrete of dust and other loose material immediately before applying the primer.

Apply the waterproofing system in dry, fair weather when the air temperature is above 40 °F [4 °C].

Protect waterproofing against damage during succeeding construction operations. Repair damaged waterproofing as approved by the Engineer, at no additional cost to the Department.

B Membrane Waterproofing System

Provide a self-adhering strip of waterproofing membrane at least 12 in [300 mm] wide listed on the Approved/Qualified Products List for the membrane waterproofing system. Prime the surface on the joint as recommended by the manufacturer. Center the membrane on the joint. Provide polyethylene sheeting with a thickness of 4 mils [102 µm] and provide rubberized asphalt with a nominal thickness of 0.06 in [1.5 mm], for a total nominal thickness of 0.06 in [1.6 mm]. Ensure the face of the rubberized asphalt opposite the face bonded to the sheeting includes a removable covering. Allow the removable covering to remain on the membrane until placement of the membrane.

The Contractor may make splices in the joint waterproofing membrane using an overlap of at least 6 in [150 mm] at the splice. For splices on vertical face joints, ensure the upper strip overlays the lower strip.

C Three-Ply Joint Waterproofing

Heat and place asphalt used for waterproofing at a temperature from 300 °F to 350 °F [149 °C to 177 °C]. Frequently stir the asphalt while heating to prevent local overheating.

Apply the primers cold.

Center the waterproofing over the joint for its entire length. After preparing the surface, coat the surface with a uniform and continuous application of primer at least 2 in [50 mm] wider than the widest piece of fabric. Allow the primer coat to dry before mopping the surface with an additional uniform coat of asphalt. Place a layer of bituminized fabric 12 in [300 mm] wide with the selvedge removed from the fabric on the surface and immediately roll. Coat the surface with a second layer of asphalt, and place and roll a layer of bituminized fabric 18 in [450 mm] wide. Coat the surface with a third layer of asphalt, and place and roll a layer of bituminized fabric 24 in [600 mm] wide. Mop asphalt over the last layer of fabric at a rate of at least 1 gal per yd [4 L per m] of joint.

If splicing fabric, ensure the end splices lap at least 12 in [300 mm]. Coat the lap with asphalt immediately before making the splice. Do not make splices in the separate layers of fabric at the same location. For splices in fabric covering vertical joints, ensure the upper strip overlays the lower strip.

Perform joint waterproofing before applying surface protection courses as shown on the plans or special provisions.

2481.4 METHOD OF MEASUREMENT

The Engineer will measure joint waterproofing by the length of the joints waterproofed.

2481.5 BASIS OF PAYMENT

The Department will pay for joint waterproofing only if the contract contains a specific pay item for waterproofing. If the contract does not specify a pay item for waterproofing, the Department will include the cost of joint waterproofing with other relevant contract unit prices.

The Department will pay for waterproofing on the basis of the following schedule:

Item No.:	Item:	Unit:
2481.501	Joint Waterproofing	linear foot [meter]

Miscellaneous Construction

2501 PIPE CULVERTS

2501.1 DESCRIPTION

This work consists of the construction of pipe culverts using plant-fabricated pipe and appurtenant materials or using preformed structural plates fabricated for field assembly, installed primarily for passage of surface water through embankments.

2501.2 MATERIALS

A Pipe

Provide one of the following types of culvert pipe meeting the lowest strength class specified in the referenced specification, unless otherwise shown on the plans or specified in the special provisions. Provide special fabrication or jointing details as shown on the plans. Provide culvert pipe with the coating type shown on the plans or specified in the special provisions.

A.1 Corrugated Aluminum (CA) 3225

A.2 Corrugated Steel (CS) 3226

A.3 Corrugated Polyethylene (CP) 3247

A.4 (Blank)

A.5 (Blank)

A.6 Reinforced Concrete (RC) 3236

A.7 Polymeric Coated-Corrugated Steel (PC-CS) 3229

A.8 Corrugated Aluminized Steel (CAS) 3222

A.9 Polyvinyl Chloride (PVC) 3248

B Structural Plate

B.1 Corrugated Aluminum (CA) 3233

B.2 Corrugated Steel (CS) 3231

C Aprons

Provide aprons of the type required by the contract. The Contractor may provide and attach galvanized steel aprons to corrugated steel, corrugated polyethylene, and polymeric coated-corrugated steel pipe, unless otherwise specified on the plans. The Contractor may provide and attach galvanized steel aprons to corrugated aluminum and corrugated aluminized steel pipe, if the Contractor applies geotextile Type II or other insulation material approved by the Engineer between the contact surfaces of the different materials.

C.1 Reinforced Concrete (RC) 3236

C.2 Galvanized Steel (GS) 3226

C.3 Aluminum Alloy (AA) 3225

C.4 (Blank)

C.5 (Blank)

C.6 (Blank)

C.7 (Blank)

C.8 Corrugated Aluminized Steel (CAS) 3222

D Flap Gates 3399

E Anti-seepage Diaphragms 3351

F Pipe Joint Sealer Materials

F.1 Preformed Rubber, Type A 3726

F.2 Preformed Plastic, Type B 3726

F.3 Bituminous Mastic 3728

G Granular Materials 3149

H Geotextile, Type II 3733

I (Blank)

J Reinforced Concrete Dissipator Ring 3236

2501.3 CONSTRUCTION REQUIREMENTS

Install pipe culverts using new or old material in accordance with the following requirements:

A General

For prefabricated structures, excavate, construct foundations, and backfill the culvert in accordance with 2451, "Structure Excavations and Backfills," and the following:

B Foundations

The Contractor may install entrance culverts without special foundation shaping, unless otherwise specified in 2451.3.C.2, "Prefabricated Structures," if installing the culvert in a trench or if special bedding is shown on the plans.

C Laying Pipe

C.1 General

Terminate pipes that connect with inlet structures flush with the inside of the structure wall.

Jack culverts through the existing earth structure into position as shown on the plans or as approved by the Engineer. Ensure the flow line elevation at the starting point for jacking is within 0.1 ft [30 mm] of the staked grade. Do not reverse the flow line grade at any point. Ensure the line and grade at any point within the pipe does not vary by greater than ½ ft [150 mm] from the line and grade designated on the plans.

C.2 Metal Culvert

Lay corrugated metal pipes having circumferential joints with the outside laps pointing upgrade and with the longitudinal joints at the springlines.

Use metal connecting bands, centered over the joint, to join metal pipe sections. Place the pipe sections so that the pipe ends are abutting. Tighten the band to ensure a tight joint where the soil does not infiltrate into the pipe and the sections do not pull apart.

Use approved fasteners, as defined in the applicable materials specifications, to assemble structural plate culverts as required by the manufacturer. Tighten bolts after assembly to a torque of 100 lbf•ft to 300 lbf•ft [135 N•m to 400 N•m]. Provide a calibrated torque wrench to demonstrate the adequacy of the bolt tightening, as approved by the Engineer.

Where beveled ends on metal pipe are shown on the plans or standard plates, cut the bevels at right angles to a vertical plane through the longitudinal axis of the pipe.

C.3 Concrete Culvert

Lay concrete pipe with the female end of each section upgrade. Tightly join the pipe sections so that the interior of the pipe sections abut each other. Protect each joint against infiltration of backfill soil by filling the joint space with an approved sealer material as defined by the materials specification or by providing a full circumferential wrap of geotextile material extending at least 1 ft [300 mm] on each side of the joint. Secure the circumferential wrap against the outside of the pipe by metal or plastic strapping or by other methods approved by the Engineer. The Contractor may use a combination of sealer and geotextile materials.

Use preformed rubber, preformed plastic, or bituminous mastic elastic joint sealer material to provide flexible water-tight joint seals for concrete pipe at the locations required by the contract. Where the specified pipe is designed to accommodate preformed gasket type seals, seal the joints with the gasket type designed for that type of joint as shown on the plans and meeting the performance requirements of AASHTO M 198.

Apply mastic joint sealer materials as recommended by the manufacturer. Wipe joints clean on the inside after sealing. Plug lifting holes with a precast concrete plug, sealed, and covered with mastic or mortar.

Use approved fasteners shown on Standard Plate 3145 to tie together concrete culvert sections unless otherwise shown on the plans or specified in the special provisions.

C.4 Plastic Culvert

Make connections with bell and spigot joints using an elastomeric rubber seal (gasket) meeting the requirements of ASTM F 477 capable of passing a laboratory pressure test of at least 2 psi [14 kPa]. . Provide water-tight joints that do not allow soil, silt or water to migrate through the joint and meet the requirements of ASTM D 3212 as modified by the following:

(1) Perform the internal pressure test at a minimum of 10 psi [68 kPa] with the pipe in straight alignment, and
(2) The Department will not require the vacuum test.

Submit to the Engineer a laboratory certification provided by the pipe manufacturer that the pipe coupler for each size pipe meets or exceeds the requirements in this section. Submit the shop drawings of each pipe coupler provided by the pipe manufacturer and any additional mechanical connections as required by the contract.

Follow minimum cover, maximum cover and trench width requirements shown in detail "PLASTIC PIPE INSTALLATION REQUIREMENTS".

Place pipes and backfill in dry conditions by controlling the water conditions. Dewater groundwater and surface runoff to keep the water level below the pipe foundation.

Place pipes on the bedding starting at the downstream end with the female end of each section upgrade.

Install joints so connected pipe sections form a continuous surface free of irregularities in the flow line. Tightly join the pipe sections so that the interior of the pipe sections abut each other. Keep gaskets and joint surfaces clean and free from soil during installation.

Provide bedding and embedment as shown in the plan. The Department defines the embedment envelope as the zone of structural backfill around the pipe. Provide embedment material in accordance with 3149.2.D.1, "Granular Backfill," modified to 100 percent passing the 1 in [25 mm] sieve. Use the embedment material to provide 1 ft [300 mm] of fill over the pipe and fill for a trench width as specified by the contract. Use compaction equipment in the pipe zone that is capable of compacting the embedment material to the required density. Compact embedment material to the requirements of the Penetration Index Method per 2105, "Excavation and Embankment."

Before allowing vehicles or heavy construction equipment to travel over the pipe trench, maintain a minimum cover depth of material above the pipe of at least 2 ft [600 mm] and meeting the requirements of AASHTO LRFD *Bridge Construction Specifications*, Section 30, Table 30.6-1.

Perform deflection testing at least 30 days after installation. Evaluate the pipe to determine if the specific internal diameter of the barrel has deflected more than 5 percent. Use the following methods to perform the deflection test unless specified in the plan:

(1) Use a nine-point mandrel approved by the Engineer to perform deflection testing for pipes with an inside diameter 2 ft [600 mm] or smaller. Mandrel testing can be used for larger pipe diameters. Pull the mandrel through the pipe using non-mechanical means.

(2) Direct measurements can be used to perform deflection testing of pipes with an inside diameter of 30 inches [750 mm] or greater when approved by the Engineer. If the Department allows direct measurements, the Engineer will randomly select locations, but take measurements at least every 10 ft [3 m] throughout the pipe length and at the pipe ends. Visually inspect the pipe and take additional measurements at any location of observed anomaly or deflection. Ensure personnel making direct measurements meet confined space entry requirements in accordance with 1706, "Employee Health and Welfare."

(3) Visual inspection alone will not be allowed for deflection testing.

The Engineer will not accept pipe if the mandrel does not pass through it or if direct measurements indicate a deflection of more than 5 percent. Remove unacceptable pipe and reinstall new pipe or undamaged deformed pipe. Re-test the re-laid pipe for deflection after at least 5 calendar days.

C.5 Extending In-Place Culverts

Clear in-place culverts of obstructions to water flow before placing the extension pipe. The Engineer will only require the removal of sediment to the extent that improved flow is likely to be maintained.

If the pipe ends differ because of changed design, make the connection to the in-place culvert as shown on the plans or as approved by the Engineer.

Extend cast-in-place concrete box culverts with plant-fabricated pipe using the detailed connections as shown on the plans.

Use a transition section as shown on the plans if extending a box-type concrete cattle pass with precast concrete sections. Expose the ends of the in-place structure and remove concrete as shown on the plans. Construct the cast-in-place portion of the transition in accordance with 2411, "Minor Concrete Structures."

D Culvert Appurtenances

Provide and install appurtenant items such as aprons, safety aprons and grates, diaphragms, dissipator rings, flap gates, and safety grates, including special grates for concrete pipe and large size pipe, trash racks and other similar devices requiring a special design, as shown on the plans or the special provisions.

E Induced Trench Installation

Construct backfill over the culvert if shown on the plans and in accordance with the following:

Construct the embankment in accordance with 2105, "Excavation and Embankment," for a width on each side of the installed culvert at least equal to three pipe widths and to an elevation over the top of the culvert equal to the pipe height plus 1 ft [300 mm]. When using the Specific Density Method, compact the embankment to a density not less than 100 percent of maximum density.

Excavate a trench to a level 1 ft [300 mm] above the top of the culvert, for the width and length of the pipe, and with vertical sides. Loosely fill the trench with highly-compressible soil before constructing the remaining embankment in accordance with 2105, "Excavation and Embankment."

F Culvert Cleaning

Clean sediment and debris from culvert(s) before final acceptance.

2501.4 METHOD OF MEASUREMENT

A Culvert Excavation

If the contract contains separate items for culvert excavation as specified in 2501.5, "Pipe Culverts, Basis of Payment," the Engineer will classify and measure excavations for culverts in accordance with 2451, "Structure Excavations and Backfills."

B Culvert Pipe

The Engineer will measure culvert pipe by length, as determined by summation of the nominal laying lengths of the individual pipe sections incorporated in each structure. The Engineer will separate measurements by size, type, kind, and strength class in accordance with the item name.

The Engineer will measure elbow, tee, and wye sections as pipe along the centerline of the culvert barrel. The Engineer will not measure the length of branch legs, except as included in the measurements for a connecting structure. The Engineer will measure transition sections as pipe of the larger or more costly size, except for special sections designated by the contact for measurement as a unit.

The Engineer will measure the length of metal pipe installations requiring special fabrication, such as skewed or sloped ends, to the extreme ends to include waste material, unless otherwise shown on the plans.

C Culvert Appurtenances

The Engineer will separately measure appurtenant items such as aprons, safety aprons and grates, diaphragms, dissipator rings, flap gates, grates and other specially designed and identified units designated for payment on a per each basis by the number of units of each type and size incorporated in the culvert structures. The Department considers a safety apron and grate as one unit.

The contract unit prices for pipe culverts will include the cost of cast-in-place concrete work.

D Granular Materials

The Engineer will measure granular materials for special backfill or bedding in accordance with 2451.4.B, "Granular Materials."

2501.5 BASIS OF PAYMENT

The contract unit price for culvert pipe of each size, type, kind, and strength class includes the costs of providing and installing the pipe complete in place as required in the contract, except as otherwise specified in this section.

The contract unit prices for plastic pipe culverts will include the cost of deflection testing and buoyancy protection as required by the contract.

The Department will separately pay for aprons, safety aprons and grates, safety grates, flap gates, dissipator rings, diaphragms, and other specially designed and identified appurtenant items by type, size, and number of units incorporated in the structures as shown on the plans. The contract unit price for these items includes the cost of providing and installing the items complete in place.

The Department will separately pay for granular materials for special backfill or bedding in accordance 2451.5, "Structure Excavations and Backfills, Basis of Payment."

The Department will separately pay for culvert excavation at the contract unit prices included in the contract in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment." If not included in the contract, the Department will include excavating costs in the contract unit prices for culvert pipe and appurtenant items.

Surplus excavated materials not used for backfill shall become the property of the Contractor. Dispose of surplus material in accordance with the disposal form submitted to and approved by the Engineer. The contract unit price for the relevant culvert contract item includes the costs associated with the disposal of surplus material.

The Department will provide additional compensation for culvert elbows, tee or wye sections, and additional connectors directed by the Engineer, but not shown on the plans, in the amount of the actual invoice cost of the materials involved.

The Department will pay for installing culvert materials provided by the Department under the applicable installation items shown in the contract. The contract unit prices for installing culvert materials provided by the Department include the cost of work and additional materials required for the installation complete in place, except for extra work or work designated under other items.

If the Engineer allows installation by the jacking method and the contract does not contain a relevant contract item, the Department will pay for a jacking installation on the basis of contract unit prices relevant for the trenching method.

The contract unit price for the relevant pipe contract item includes the cost of culvert cleaning except when specifically designated under other items..

The Department will identify alternatives in the plans. The Department will include the costs associated with using an alternative, such as differences in installation requirements including deflection testing, trench width or embedment material specifications and quantities in the contract unit prices of the relevant pipe pay items.

The Department will pay for pipe culverts on the basis of the following schedule:

Item No.:	Item:	Unit:
2501.501	Culvert Excavation, Class *	cubic yard [cubic meter]
2501.511	___ in [mm] ‖ Pipe Culvert †	linear foot [meter]
2501.515	___ in [mm] ‖ Pipe Apron	each
2501.517	Anti-seepage Diaphragm for ‡ Pipe	each
2501.519	Flap Gate for ‡ Pipe	each
2501.521	___ in [mm] Span ‖ Pipe-Arch Culvert †	linear foot [meter]
2501.525	___ in [mm] Span ‖ Pipe-Arch Apron	each
2501.527	Anti-seepage Diaphragm for ‡ Pipe-Arch	each
2501.531	___ in [mm] ‖ Elliptical Pipe Culvert #	linear foot [meter]
2501.535	___ in [mm] ‖ Elliptical Apron	each
2501.541	___ in [mm] High ‖ Cattle Pass Culvert †	linear foot [meter]
2501.543	___ in [mm] High ‖ Cattle Pass Transition Section †	each
2501.545	___ in [mm] High ‖ Cattle Pass Apron Culvert †	each
2501.551	___ in [mm] ‖ Structural Plate Pipe Culvert †	linear foot [meter]
2501.555	___ in [mm] Span ‖ Structural Plate Pipe-Arch Culvert †	linear foot [meter[
2501.561	___ in [mm] ‖ Pipe Culvert, Design § †	linear foot [meter]
2501.565	___ in [mm] Span ‖ Pipe-Arch Culvert, Design § †	linear foot [meter]
2501.567	___ in [mm] ‖ Safety Apron and Grate Design §	each
2501.569	___ in [mm] ‖ **	each
2504.571	Install **	linear foot [meter]
2501.573	Install **	each
2501.575	___ in [mm] RC Dissipator Ring	each

* Specify Class U, E, or R only – Se 2451.3B2
‖ Specify Kind – See 2501.2, if alternatives are allowed do not specify kind
† Specify Strength Class, if other than minimum requirement.
‡ Specify size and kind
\# Specify HE or VE, and Strength Class, if other than minimum requirement.
§ Give Standard Plate Number for special pipe or joint designs
** Specify item name

2502 SUBSURFACE DRAINS

2502.1 DESCRIPTION

This work consists of constructing subsurface drains and installing plant-fabricated pipe and appurtenant materials to perform the following:

(1) Collect and discharge water infiltrating the pavement system (pavement edge drain),
(2) Collect and discharge water accumulated in the bottom of a granular-backfilled subcut, cut off, or intercept ground water flowing toward the roadway (subcut drain), and
(3) Collect and discharge water coming from a permeable aggregate base system (permeable aggregate base drain).

Subsurface drains include materials used to collect ground water and conduct it to a discharge point at a structure or on a side slope. The typical system includes a drain pipe, radial connecting pipe, discharge pipe, and drain outlet.

2502.2 MATERIALS

Provide one of the following types of drain pipe as shown or allowed as an option on the plans. Provide fittings connecting multiple lengths of drain pipe made of the same material as the pipe. Provide nonperforated pipe except where the perforated type is shown on the plans. The Contractor may use pipe meeting the lowest strength class listed in the referenced materials specification, unless higher strength pipe is shown on the plans or specified in the special provisions. Provide nonperforated Thermoplastic (TP) pipe for discharge pipe, radial connecting pipe, and associated fittings. Provide special fabrication or jointing details if shown on the plans or as approved by the Engineer. Provide appurtenances, geotextiles, metal oversleeves with rodent screens, and precast concrete headwalls with all subsurface drains for high bridge abutments, to intercept and carry off underground water in accordance with this section, 3245, "Thermoplastic Pipe," 3733, "Geotextiles," and as shown on the plans.

A Drain and Discharge Pipe

A1 Thermoplastic (TP) 3245

A2 Corrugated Polyethylene (PE) Drainage Tubing 3278

B Precast Concrete Headwall (Drain Outlet) ..... Standard Plate 3131

C Granular Materials 3149

D Geotextile, Type I 3733

E Erosion Blanket, Category 3A 3885

F Seed 3876

G Marking Tape 3354

H Corrugated Polyethylene Pipe (PE Pipe Drain Smooth) 3247

2502.3 CONSTRUCTION REQUIREMENTS

A Excavation

Excavate the trench to the lines and grades as shown on the plans. Provide a trench with a width, as measured at the bottom of the excavation, at least the nominal pipe width plus two times the pipe diameter. The Contractor may use corrugated PE drainage tubing when placed in a narrow, controlled-width trench constructed by a chain-type or wheel-type trenching machine designed and used for this application and as approved by the Engineer. Use other types of rigid pipe for other uses in narrow trenches where compaction is not controlled. Do not install PE tubing by plowing.

Remove rock encountered within the excavation to a width of at least the nominal pipe width plus two times the pipe diameter and to a depth of at least one pipe diameter below the pipe. Except for locations shown on the plans or specified in this specification that require granular material, the Contractor may backfill to the bottom of the pipe with suitable material, compacted uniformly to provide a proper foundation as approved by the Engineer.

B Laying Drains

Bed perforated pipe drains on fine filter aggregate. Provide aggregate in accordance with 3149.2.J.2, "Fine Filter Aggregate," with a thickness of at least one pipe diameter below the bottom of the pipe, and extending upwards under the haunches for the full width and length of the trench, to the elevation shown on the plans or specified in this specification for the specified foundation preparations.

The Engineer will not require granular bedding on nonperforated pipe installations unless otherwise shown on the plans, however do not place stones greater than 1 in [25 mm] in diameter in the trench.

Shape the foundation for drains in the required bedding material to fit at least the lower 30 percent of the outside circumference of the pipe. Lay drains to line and grade shown on the plans, with uniform bearing along the drain and with the perforations down, unless otherwise directed.

Wrap perforated pipe with factory-seamed or factory-produced continuous knit weave geotextile. Place the fabric seam at the top of the pipe, opposite the perforations. For seams at fittings or connectors, mechanically fasten or overlap the adjoining geotextiles at least 6 in [150 mm].

Join pipe sections with the coupling bands or fittings. Cement solvent type joints unless otherwise shown on the plans or specified in the specification. Close upgrade ends of subdrain pipe with caps. Use wyes or bends at junctions and turns suitable for cleaning and inspection.

Where a drain connects with a structure or catch basin, make a connection through the wall of the structure that does not leak. Unless otherwise shown on the plans or specified in the specifications, terminate drainage outfalls at a standard precast concrete headwall.

C Backfill

Backfill drains while making the pipe installations. On perforated pipe installations, place fine filter aggregate adjacent to and to a height of at least 6 in [150 mm] above the top of the pipe and as shown on the plans. The Contractor may backfill with the disturbed in-place soils above the elevation shown on the plans and on nonperforated pipe installations. Do not use stones greater than 1 in [25 mm] adjacent to and for 6 in [150 mm] above the pipe.

Compact fine filter aggregate if shown on the plans. Compact other backfill material to a density equivalent to that of the adjacent soils or in accordance with 2105.3.F, "Compacting Embankments."

D Drain Outlets

D.1 Precast Concrete Headwall

Place precast concrete headwall outlet inverts at least 6 in [150 mm], 12 in [300 mm] (preferred), above ditch grades. Place the uppermost point of the headwall flush with the in-slope at a downward grade of at least 2 percent to provide for drainage. Shape the earthen side slopes adjacent to the headwall to conform to the sides and toe of the headwall. Compact the soils around and under the concrete headwall outlet per 2105.3.F.2, Quality Compaction."

If headwalls are not placed during installation of discharge pipes, mark discharge points to locate in the future. Screen the drain opening, and allow the drain to remain open and operational after installation. Unless otherwise approved by the Engineer, place concrete headwalls on discharge pipes before the end of the construction season. For pipes without headwalls, leave screened pipe ends open and free-flowing.

D.2 Discharge Pipe

Provide nonperforated rigid TP pipe in accordance with 3245, "Thermoplastic Pipe," for discharge pipe and connections. Use a 4 in [100 mm] diameter TP discharge pipe for 3 in [75 mm] and 4 in [100 mm] PE subsurface drains. Use a 6 in [150 mm] diameter TP discharge pipe for 6 in [150 mm] PE subsurface drains. Use a 3 in × 4 in [75 mm × 100mm] TP adapter to make the connection between the 3 in [75 mm] PE subsurface drain and the 4 in [100 mm] diameter × 12 in [300 mm] straight length of TP pipe. Connect the 4 in [100 mm] PE subsurface drain to the 4 in [100 mm] diameter × 12 in [300 mm] straight length of TP pipe with a TP connector. Use a 90 degree, solvent-weld, bell and spigot elbow with a radius of at least 3 ft [915 mm] to make the connection between the 12 in [300 mm] length TP pipe and the variable length straight TP discharge pipe. The Contractor may use different configurations for similar size, radius and pipe quality as approved by the Engineer.

Construct the discharge pipe to the drain outlet while constructing the drains. Place the discharge pipe and the drains at right angles to the roadway centerline. Fully couple the discharge pipe to the headwall as approved by the Engineer. Make connections with one of the following:

(1) 3A Grout,
(2) Rubber gasket on the pipe,
(3) Rubber or plastic gasket cast into the headwall, or
(4) Solvent or gasket joint into a TP coupling cast into the headwall.

Ensure the coupling will secure the pipe and prevent separation caused by small movements of the headwall.

Provide a 12 in [300 mm] straight length of TP connecting pipe to connect the PE subsurface drain to the TP discharge pipe. Attach this connector pipe to the PE edge drain with a radius of at least 3 ft [900 mm] to provide entry for probes, cleaners, or video cameras. Secure connections and solvent joints to prevent soil intrusion and decoupling during backfilling. At joints with the possibility for soil intrusion, wrap connections with geotextile as directed by the Engineer. Tape joints to prevent separation as directed by the Engineer. Orient increasers with the "smooth flow" portion at the pipe invert. Use connection and coupling methods as approved by the Engineer.

Connect two drain runs that come together at a low point with a TP "Y" connection. Use a TP discharge pipe to outlet the "Y" connection to a single headwall.

Construct the discharge trench similar to the drains and backfill the discharge trench with the disturbed in-place soil.

Place discharge pipes at grades no less than the drain pipes and with at least 2 percent fall. The Engineer may approve trench widths greater than 10 in [250 mm] for the discharge pipes, if the Contractor meets the following requirements:

(1) Cradle the pipe invert,
(2) Compact soil adjacent to and above the pipe to prevent crushing the pipe, and
(3) Compact the backfill soil in accordance with 2105.3.F, "Compacting Embankments."

Use compaction equipment capable of compacting the material in the drain trench without compacting the adjacent soils. Use backfill layer uncompacted thicknesses no greater than 6 in [150 mm]. Correct shoulder settlement above the discharge pipe as directed by the Engineer and at no additional cost to the Department. Replace crushed or deformed discharge pipes or connections at no additional cost to the Department.

If drains discharge to storm sewers rather than through headwalls, place the drain invert from 6 in [150 mm] to 12 in [300 mm] above the sewer invert using a connection method approved by the Engineer at no additional cost to the Department.

D.3 Turf Establishment

Use seed and an erosion control blankets at the drain outlets, except at locations designated for sod as required by the contract.

Place a Category 3A erosion control blanket in accordance with 3885, "Rolled Erosion Control Products," to a width of at least 6½ ft [2 m]. Center the headwall along the width of the blanket. Extend the blanket 3 ft [1 m] above the headwall, and 6½ ft [2 m] below the headwall or to the bottom of the ditch, whichever is the shorter distance. Place anchor staples at intervals no greater than 1½ ft [½ m] apart. If placing a headwall at a location that will be sodded as required by the contract, delete the seed and mulch. Water and maintain turf installations in accordance with 2575.3.L, "Turf Establishment." Place a seed mixture under the erosion control blanket at the same mixture and rate as shown on the plans for the adjacent area. If the plans do not show a seed mixture, place seed mixture 25-141 at the rate of 2 lb per sq. yd [1 kg per sq. m] before anchoring the blanket.

D.4 Marking Outlet Locations

Permanently mark the locations of outlets with a 6 in × 18 in [150 mm × 450 mm] strip of white marking tape in accordance with 3354, "Preformed Pavement Marking Tape for Permanent Traffic Lane Delineation and Legends." Place the tape at the outside edge of the bituminous shoulder, at right angles to the roadway, and roll the tape into the shoulder while the bituminous pavement surface temperature is from 120 °F to 150 °F [48.9 °C to 65.6 °C]. If two runs of drain pipe come together at a low point and discharge via a "Y" to a single outlet, place two markings side-by-side with a 6 in [150 mm] spacing. For locations with no bituminous shoulder, place the tape on the bituminous pavement or spray a white paint strip on concrete pavements. The Engineer may approve alternate methods to mark the edge drain outlets.

D.5 Inspection and Cleanout

Once installed, maintain the discharge pipe and headwalls to prevent trapping water in the pipe. Inspect the discharge pipe and headwalls for proper grade, cleanliness, proper landscaping, proper erosion control installation and maintenance, and satisfactory operating condition. Maintain the discharge pipe and headwalls until final inspection with the Engineer.

The Engineer will perform inspections using a probe mounted on the end of a flexible fiberglass rod 4 in [100 mm] long and with a diameter of one nominal pipe size smaller than the drain pipe being inspected. The Engineer will conduct the inspection through the discharge pipe, radius connection, and at least 3 ft [1 m] into the main drainage line. Clean or repair inoperative discharge pipe and connections as approved by the Engineer at no additional cost to the Department.

E Permeable Aggregate Base Type

Construct subsurface drains to collect and discharge water coming from the following permeable aggregate base systems:

(1) Permeable Asphalt Stabilized Base (PASB),
(2) Open Graded Aggregate Base (OGAB), or
(3) Permeable Asphalt Stabilized Stress Relief Course (PASSRC)

Provide geotextile for trench lining in accordance with 3733, "Geotextiles," Type I. Provide perforated corrugated PE drainage tubing in accordance with 3278, "Corrugated Polyethylene Drainage Tubing." Provide aggregate in accordance with 3149.2.J.1, "Medium Filter Aggregate."

E.1 Trenching

Use a machine trencher capable of cutting the trench and placing the pipe in a continuous operation to place the drains. Do not plow. If the off-set between the tracks or tires of the trencher is greater than 6 in [150 mm], use a self-leveling trenching machine. Provide trenching equipment designed and operated to prevent the excavated material from falling back into the trench.

Construct a trench from 7 in [180 mm] to 10 in [250 mm] wide. Shape the bottom of the trench to cradle the lower one-third of the pipe. Place pipes in grades following pavement grades at the design depth shown on the plans. The Contractor may place the geotextile, pipe and medium filter aggregate while trenching or in a separate operation immediately after trenching. When using separate operations to place the pipe and medium filter aggregate, properly align the pipe in the cradle before placing the medium filter aggregate.

If the trench sides are sloughing or caving in, use a shield to place the medium filter aggregate.

The Contractor may trench drains constructed in conjunction with stabilized PASB immediately adjacent to the placed pavement. Place drains constructed in conjunction with unstabilized OGAB 6 in [150 mm] away from the pavement edge to minimize undercutting. The edge drain must intersect the PASB or OGAB.

Place drains constructed in conjunction with PCC pavement after pavement placement. Place drains constructed in conjunction with bituminous pavement after placement of the wear/non-wear courses and before placement of the final wearing course to avoid damage to the finished pavement. Construct drains before placing the additional aggregate base in the shoulder area.

Dispose of materials removed by the trenching operation off the right-of-way unless otherwise approved by the Engineer. Do not contaminate the permeable aggregate base, the medium filter aggregate, or the aggregate base. Sweep trenching spoils off the bituminous pavement before placing the wearing course, as approved by the Engineer.

E.2 Geotextile Trench Lining

Line the bottom of the drainage trench with geotextile. Do not wrap the PE pipe with geotextile. On the pavement side of the trench, terminate the geotextile within the aggregate base located below the permeable aggregate base. Do not extend the geotextile up onto the permeable aggregate base or allow it to fall below the bottom of the aggregate base. Do not allow the geotextile to lap up onto the permeable aggregate base. On the side of the trench farthest from the pavement, the Contractor may terminate the geotextile within or above the aggregate base, but not below it.

E.3 Compaction

Moisten the medium filter aggregate to allow easy placement and vibratory compaction as approved by the Engineer. Do not use the tire-rolling method to compact medium filter aggregate. After placement and compaction, ensure the top of the medium filter aggregate is at least as high as the top of the permeable aggregate base.

E.4 Maintenance

After placing the drain and discharge pipe, do not allow construction equipment to travel over the drain or discharge pipe until the system is protected as approved by the Engineer.

Place aggregate base in the shoulder area over the compacted drain and backfilled trench, to avoid contamination. Remove and replace contaminated materials at no additional cost to the Department. Allow the drain to remain open and operative after installation to prevent water from collecting in the pipe.

F Subcut Drain Type

Construct subcut drains in accordance with this section and the option details shown on the plan. Use subcut drains to collect and discharge infiltration water that may accumulate in the bottom of granular-backfilled subcuts. The Contractor may also use subcut drains to control high groundwater conditions.

Unless otherwise shown on the plans or specified in the special provisions, the Contractor may construct the drains using one of the following design options:

(1) Place 4 in [100 mm] perforated TP pipe in accordance with 3245, "Thermoplastic Pipe," in the bottom corner of the subcut and then backfill the subcut or
(2) Backfill the subcut and then use a machine trencher to place 4 in [100 mm] perforated corrugated PE pipe in accordance with 3278, "Corrugated Polyethylene Drainage Tubing."

For both design options, wrap the pipe with geotextile in accordance with 3733, "Geotextiles," Type I. Provide Fine Filter Aggregate in accordance with 3149.2.J.2, "Fine Filter Aggregate."

The Contractor may directly connect subcut drains to permanent drainage structures or outlet the drains to the ditch using a discharge pipe and headwall. If shown on the plans, make connections to drainage structures as approved by the Engineer. The Department will include the cost of connections with other relevant contract pay items.

Place pipe as shown on the plans or as approved by the Engineer. Provide drain grades of at least 0.2 percent and place ditch outlets at low points and spaced no greater than 500 ft [152.4 m] apart. The Contractor may place structure outlets spaced no greater than 800 ft [243.8 m] apart if both ends of the pipe are tied to structures. If pipe grades do not follow the roadway profile at a constant depth, provide and use laser grade control equipment to place TP pipe and PE pipe.

F.1 Design Option One

Place 4 in [100 mm] perforated TP pipe in the bottom of the subcut in accordance with the design typical in the plans. Place at least 12 in [300 mm] of subcut backfill above the pipe before compacting.

The Contractor may provide pipe with either bell and spigot or sleeve couplings and either gasket or solvent joints. Leave solvent joints uncemented unless otherwise directed by the Engineer. Mark the depth on the ends of the bell or sleeve. Place the perforations down. Provide connections to drainage structures made of angle fittings no greater than 22½ degrees.

F.2 Design Option Two

Place 4 in [100 mm] perforated corrugated PE tubing after partially or totally backfilling the subcut.

Use a machine trencher capable of performing the following functions to place the drains:

(1) Cutting the trench,
(2) Shaping the trench bottom to cradle the lower one-third of the pipe,
(3) Laying the pipe, and
(4) Backfilling with filter aggregate in one simultaneous and continuous operation.

Do not plow. Equip the trenching head with a shield to prevent adjacent material from caving. Trench to a width from 8 in [200 mm] to 10 in [250 mm] and center the pipe in the trench.

Backfill the trench with fine filter aggregate. Provide free flowing filter aggregate and vibratory compaction as approved by the Engineer. In addition to the required trench compaction, make at least one pass of the roller as directed by the Engineer over the trench before placing the overlying pavement structure as shown on the plans.

Perform the trenching operation after placing and compacting at least 24 in [600 mm] of subcut backfill. If trenching after completely backfilling the subcut, only backfill the lowermost 24 in [600 mm] of the trench with Fine Filter Aggregate. Backfill the remaining trench with the same material used for the subcut and compact to the compaction requirements in 2105.3.F, "Compacting Embankments."

G Pavement Edge Drain Type

Construct 3 in [75 mm] diameter edge drains. Use pavement edge drains to collect and discharge water infiltrating into the pavement system from rain or snow melt, and spring-thaw seepage.

Provide perforated corrugated PE tubing for edge drain pipe in accordance with 3278, "Corrugated Polyethylene Drainage Tubing." Wrap the pipe with geotextile in accordance with 3733, "Geotextiles," Type I to prevent infiltration of fine filter aggregate into the perforated pipe. Trench backfill with fine filter aggregate in accordance with 3149.2.J.2, "Fine Filter Aggregate."

Place drains adjacent to new pavements after constructing the pavement to prevent damage to the drain or discharge pipe. Use a machine trencher capable of cutting the trench and laying the pipe in a continuous operation to place the drains. Do not plow. Provide trenching equipment designed and operated to prevent excavated material from falling back into the trench. Use a self-leveling trenching machine if the off-set between tracks or tires of the trencher is greater than 6 in [150 mm]. Trench to a width from 6 in to 10 in [150 mm to 250 mm]. Shape the bottom of the trench to cradle the lower one-third of the pipe. If pipe grades do not follow pavement grades at a constant depth, provide and use laser grade control equipment to place pipe.

Install the edge drains before pavement cracking when cracking in-place PCC pavement before overlay.

If placing drains in conjunction with pavement widening, place the drains before excavating the widening-trench. Use an approved device on the trenching machine to ensure that the pipe is located at the design distance from the edge of the in-place pavement. After compaction, ensure the filter aggregate in the drain extends at least 4 in [100 mm] above the bottom of the pavement widening trench.

For drains placed next to a PCC pavement, run the trenching head tight against the pavement to completely excavate all adjacent soil.

If placing the drain next to a new bituminous pavement, construct the drain after placing the pavement base and leveling courses, but before placing the wearing course, to avoid damage to the finished pavement. For new and retrofit construction, ensure the trenching head continuously intercepts and cuts-off the roll-over portion of at least the lower bituminous pavement course. Ensure the trenching spoils always show evidence of bituminous materials. Clean spoils from the pavement before placing the wearing course for new pavements or the first bituminous lift for overlays as approved by the Engineer.

For bituminous shoulders remaining in place after drain placement, use a coulter, saw, milling mandrel, or other method by the Engineer on the bituminous shoulder to leave a smooth edge and to prevent disturbance to the bituminous pavement.

For new construction, place the aggregate base before trenching, except for bituminous pavements, place the aggregate base to the height of the adjacent layer at the time of trenching.

Provide drains on grades at least 0.2 percent and place outlets to the ditch at a spacing no greater than 500 ft [152.4 m] and at low points as shown on the plans.

The Contractor may place the filter aggregate backfill simultaneously with the pipe or in a separate operation immediately following the trenching activity. If placing the pipe and filter aggregate in separate operations, align the pipe in the shaped cradle before placing the filter aggregate. If soil type or Contractor operations cause sloughing or caving from either side of the trench, use a shield on the trenching head and place filter aggregate within the shield as directed by the Engineer.

Surplus excavated materials not used for backfill shall become the property of the Contractor. Dispose of surplus material in accordance with the disposal form submitted to and approved by the Engineer.

Compact the filter aggregate with equipment capable of achieving a minimum of 95 percent of maximum density for the full depth of the trench.

Before beginning routine trenching and backfilling, construct a test trench at least 50 ft [15.2 m] long that has the same requirements as the production work. The Engineer will measure adequacy of compaction in the test trench with a Department-supplied Dynamic Cone Penetrometer (DCP).

The Department defines successful compaction as penetration resistances no greater than 3 in [75 mm] per DCP hammer blow. The Engineer will base successful compaction on the average of three DCP readings for similar depths in three tests taken 10 ft [3 m] apart. Unless otherwise directed by the Engineer, begin penetration readings from the point where the DCP equipment stabilizes after setup in the trench.

Do not compact greater than 24 in [600 mm] of filter aggregate in any one layer. The Contractor may use smaller lifts or make more than one pass of the compactor to achieve a minimum of 95 percent of maximum density throughout the compacted depth, unless otherwise directed by the Engineer. Do not run the compactor at a rate greater than 60 ft per min [18.3 m per min] unless otherwise approved by the Engineer based on DCP test results. Stop the trenching operation if the compaction method or source of trench backfill changes, or compaction effort yields insufficient density, until the Engineer performs additional DCP testing and approves corrections. After compaction and leveling, extend the filter aggregate up onto the adjacent pavement as shown on the plans.

If capping filter aggregate trench with another type of granular material or bituminous mixture as shown on the plans, place and compact the materials separately from the filter aggregate and do not compact with future placement of similar material. Heap bituminous caps at least 1 in [25 mm] and roll. Place granular caps at least 1 in [25 mm] high and roll. Place caps to provide support for overlying material and to incorporate a second compaction effort in the trench.

Do not contaminate the filter aggregate. Do not deposit or mix aggregates or other soils on the adjoining concrete or bituminous pavement. Remove material spilled on the pavement surface by sweeping.

After placing the drain and discharge pipe, do not allow construction equipment to travel over the drain or discharge pipe until the system is covered as approved by the Engineer. Allow the drain to remain open and operational after installation to prevent water from collecting in the pipe.

2502.4 METHOD OF MEASUREMENT

A Subsurface Drains

The Engineer will measure subsurface drains by the length of the provided and installed subsurface drain and discharge pipe approved by the Engineer. The Engineer will measure drain and discharge pipes by installed length along the centerline of the pipe. The Engineer will begin and end measurement at the pipe end at free outlets, at the point of junction with in-place pipe, or at the center of structures, catch basins, or multiple junction points.

Where the contract requires subsurface drains, the Engineer will separately measure the lengths of each size and type of pipe.

B Blank

C Precast Concrete Headwalls

The Engineer will measure the number of provided precast concrete headwalls.

D CS Oversleeve with Rodent Guard

The Engineer will measure CS oversleeves with rodent guard by the number of CS oversleeves with rodent guard provided, installed, capped, and marked.

2502.5 BASIS OF PAYMENT

The contract unit prices for subsurface drains and outlets of each size, type, kind, and strength class include the cost of providing and installing the item as shown on the plans, except as otherwise specified in this subsection.

The Department will pay for subdrain elbow or wye sections and additional connectors directed by the Engineer but not shown on the plans at the invoice cost of the materials provided.

Unless otherwise shown on the plans, the Department will separately pay for special bedding or backfill in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment."

The contract unit price for contract item No. 2502.502 includes the cost of connecting pipe footage and couplings.

The contract unit price for drain outlet consisting of precast concrete headwall and discharge pipe includes the cost of providing and placing the unit, erosion control blanket and seed, marking, inspecting, and all other associated work. For required sodding, the Engineer will include the cost of the sod with relevant contract pay items.

The contract unit prices for the relevant subsurface drain contract items include the cost of geotextiles and other joint wrapping or sealing materials.

The contract unit price for contract item No. 2502.501 includes the cost of providing and placing tape or paint for marking outlet locations.

The contract unit price for the relevant subsurface drain contract item includes the costs associated with the disposal of surplus material.

The Department will pay for trench excavation required below an elevation greater than 12 in [300 mm] below the bottom of the pipe or tile as shown on the plans as extra work in accordance with 1402, "Contract Revisions."

Unless otherwise shown on the plans, the Department will pay for the removal of ledge rock or rocks larger than ½ cu. yd [0.4 cu. m] from the excavation as extra work in accordance with 1402, "Contract Revisions."

Granular Materials are incidental to the cost of the Subsurface Drains.

The Department will pay for subsurface drains based on the following schedule:

Item No.:	Item:	Unit:
2502.501	___in [mm] Precast Concrete Headwall	each
2502.502	Drainage System Type ___	lump sum
2502.521	___in [mm] * Pipe Drain ‖	linear foot [meter]
2502.541	___in [mm] Perforated * Pipe Drain ‖	linear foot [meter]
2502.571	Install ___in [mm] †	linear foot [meter]
2502.573	Install †	each

* Specify kind in accordance with 2502.2.A, "Drain and Discharge Pipe."
‖ Specify strength class if other than the minimum requirement.
† Specify item name.

2503 PIPE SEWERS

2503.1 DESCRIPTION

This work consists of constructing pipe sewers using plant-fabricated pipe and other appurtenant materials installed for conveyance of sewage, industrial wastes, or storm water.

Construct manholes and catch basins in accordance with 2506, "Manholes and Catch Basins." Provide aprons as shown on the plans and in accordance with 2501, "Pipe Culverts."

2503.2 MATERIALS

A Pipe

Provide one of the following types of sewer pipe as specified or allowed as an option on the plans or in the special provisions. Use pipe meeting the lowest strength class specified or greater, unless a higher strength pipe is shown on the plans or specified in the special provisions. Perform special fabrication or jointing as shown on the plans. Provide pipe sewers with the coating type shown on the plans or specified in the special provisions.

A.1 (Blank)

A.2 Reinforced Concrete (RC).....3236

A.3 Corrugated Aluminum (CA).....3225

A.4 Corrugated Steel (CS) 3226

A.5 Corrugated Aluminized Steel (CAS).....3222

A.6 (Blank)

A.7 (Blank)

A.8 (Blank)

A.9 Corrugated Polyethylene (CP).....3247

A.10 (Blank)

A.11 (Blank)

A.12 Polymeric Coated-Corrugated Steel (PC-CS).....3229

A.13 (Blank)

A.14 Polyvinyl Chloride (PVC).....3248

B Flap Gates.....3399

C Pipe Joint Sealer Materials

C.1 Hot-Poured Sealing Compound 3724

C.2 Preformed Rubber, Type A 3726

C.3 Preformed Plastic, Type B 3726

C.4 Bituminous Mastic.....3728

D Granular Materials.....3149

2503.3 CONSTRUCTION REQUIREMENTS

A General

Construct sewer installations in accordance with 2451, "Structure Excavations and Backfills," for excavation, foundation construction, and backfilling of prefabricated structures and in accordance with the following requirements:

B Excavation

For locations with cover over the top of the pipe at least 15 ft [4.5 m], ensure the excavation dimensions meet the following:

(1) For the portion of the required excavation below a point 1 ft [300 mm] above the top of the pipe, provide nearly vertical side slopes, and

(2) Excavate the width of the trench meeting the requirements specified in Table 2503-1:

Table 2503-1
Maximum Trench Width for Pipe Sewer

Pipe Diameter, *in [mm]*	Maximum Trench Width*
< 42 [1,050]	Outside diameter plus 24 in [600 mm]
42 – 54 [1,050 – 1,350]	1.5 times outside diameter
> 54 [1,350]	Outside diameter plus 36 in [900 mm]

* 1 ft [300 mm] above pipe

If the Contractor excavates the trench to a width greater than the values specified in Table 2503-1, the Engineer may direct the Contractor to provide a higher class of bedding, a higher strength pipe, or both, than that required by the contract, at no additional cost to the Department.

C Laying Pipe

C.1 General

Lay the pipe to the line and grade shown on the plans.

Use standard or specially manufactured fittings for pipe junctions and turns.

At sewer connections with an existing manhole or catch basin, make a suitable connection as approved by the Engineer through the wall of the manhole or catch basin.

Use vitrified clay or concrete stoppers sealed in place to plug branch openings or service connections provided for future use.

C.2 Metal Sewer Pipe

Lay corrugated metal pipes containing circumferential joints with the outside laps pointing upgrade and with the longitudinal joints on the sides.

Use approved metal connecting bands shown on the standard plate, centered over the joint, to join metal pipe sections. Place the metal pipe joints as close together as possible. Tighten the band to ensure a tight joint.

C.3 Concrete Sewer Pipe

Lay concrete pipe with the bell or grooved ends upgrade. Provide joints meeting the requirements of AASHTO M 198.

Use rubber gasket, preformed plastic, or bituminous mastic elastic joint sealer material to seal joints in concrete pipe to provide a flexible water tight joint. Use gasket type joint sealer material to seal pipe designed to accommodate preformed gasket type seals, as shown on the plans.

Apply mastic joint sealer as recommended by the manufacturer. Wipe joints clean on the inside after sealing. Use precast concrete plugs to plug lifting holes. Seal and cover concrete plugs placed in lifting holes with mastic or mortar.

Use approved fasteners shown on Standard Plate 3145 to tie concrete pipe sections together as required by the contract, unless otherwise shown on the plans or specified in the special provisions.

C.4 Plastic Sewer Pipe

Make connections with bell and spigot joints using an elastomeric rubber seal (gasket) meeting the requirements of ASTM F 477 and capable of passing a laboratory pressure test of at least 2 psi [14 kPa]. Provide water-tight joints that do not allow soil, silt or water to migrate through the joint and meet the requirements of ASTM D 3212 as modified by the following:

(1) Perform the internal pressure test at a minimum of 10 psi [68 kPa] with the pipe in straight alignment, and
(2) The Department will not require the vacuum test.

Submit to the Engineer a laboratory certification provided by the pipe manufacturer that the pipe coupler for each size pipe meets or exceeds the requirements in this section. Submit the shop drawings of each pipe coupler provided by the pipe manufacturer and any additional mechanical connections as required by the contract.

Follow minimum cover, maximum cover and trench width requirements shown in detail "PLASTIC PIPE INSTALLATION REQUIREMENTS".

Place pipes and backfill in dry conditions by controlling the water conditions. Dewater groundwater and surface runoff to keep the water level below the pipe foundation.

Place pipes on the bedding starting at the downstream end of the pipe installation with the female end of each section upgrade.

Install joints so connected pipe sections form a continuous surface free of irregularities in the flow line. Tightly join the pipe sections so that the interior of the pipe sections abut each other. Keep gaskets and joint surfaces clean and free from soil during installation.

Provide bedding and embedment as shown in the plan. The Department defines the embedment envelope as the zone of structural backfill around the pipe. Provide embedment material in accordance with 3149.2.D1, "Granular Backfill," modified to 100 percent passing the 1 in [25 mm] sieve. Use the embedment material to provide 1 ft [300 mm] of fill over the pipe and fill for a trench width as specified by the contract. Use compaction equipment in the pipe zone that is capable of compacting the embedment material to the required density. Compact embedment material to the requirements of the Penetration Index Method per 2105, "Excavation and Embankment."

Maintain a minimum cover depth of material above the pipe of at least 2 ft [600 mm] and meeting the requirements of AASHTO *LRFD Bridge Construction Specifications*, Section 30, Table 30.6-1 before allowing vehicles or heavy construction equipment to travel over the pipe trench.

Perform deflection testing at least 30 calendar days after installation. Evaluate the pipe to determine if the specific internal diameter of the barrel has deflected more than 5 percent. Use the following methods to perform the deflection test unless otherwise specified in the plan:

(1) Use a nine-point mandrel approved by the Engineer to perform deflection testing for pipes with an inside diameter 2 ft [600 mm] or smaller. Mandrel testing can also be used for larger pipe diameters. Use non-mechanical means to pull the mandrel through the pipe.

(2) Direct measurements can be used to perform deflection testing of pipes with an inside diameter 30 in [600 mm] or greater when approved by the Engineer. If the Department allows direct measurements, the Engineer will randomly select locations. Take measurements as selected, at least every 10 ft [3 m] throughout the pipe length, and at the pipe ends. Visually inspect the pipe and take additional measurements at points of observed anomalies or deflections. Ensure personnel making direct measurements meet confined space entry requirements in accordance with 1706, "Employee Health and Welfare."

(3) Visual inspection alone will not be allowed for deflection testing.

The Engineer will consider pipe unacceptable if the mandrel cannot pass through the pipe or if the direct measurements show a deflection of greater than 5 percent in the pipe. Remove unacceptable pipe and install new pipe or undamaged deformed pipe. Re-test the re-laid pipe for deflection after at least five calendar days.

D Backfill

Backfill sewer installations as shown on the plans and in accordance with 2451, "Structure Excavations and Backfills."

Surplus excavated materials not used for backfill shall become the property of the Contractor. Dispose of surplus material in accordance with the disposal form submitted to and approved by the Engineer.

E Installation by Jacking

Install pipe by jacking in accordance with 2501.3.C.1, "Laying Pipe, General."

F Cleanout

Clean sediment and debris from sewers before final acceptance.

2503.4 METHOD OF MEASUREMENT

A Excavation

The Engineer will measure excavation specified or directed as extra work in accordance with 2451.4, "Structure Excavations and Backfills, Method of Measurement," for prefabricated structures.

B Sewer Pipe

The Engineer will separately measure each type of pipe by length along the center line of the sewer. The Engineer will begin and end measurements at the following locations:

(1) Pipe end at free outlets,

(2) Point of junction with in-place pipe, or

(3) Center of manholes, catch basins, or multiple junction points.

The Engineer will measure pipe transition sections as the larger size of pipe.

The Engineer will classify sections of metal pipe at the outlets of clay or concrete sewers as metal sewers.

The Engineer will measure Department-provided sewer materials required by the contract by the length of installed sewer, separated by type but not by size.

C Sewer Appurtenances

The Engineer will separately measure flap gates and other specially identified appurtenant items designated for payment on a per each basis by the number of units of each type and size incorporated in the sewer structures.

D Granular Materials

The Engineer will measure granular materials for special backfill and bedding in accordance with 2451.4.B, "Granular Materials."

The Engineer will measure compacted volume of granular materials based on the maximum trench widths specified in accordance with 2503.3, "Pipe Sewers, Construction Requirements."

2503.5 BASIS OF PAYMENT

The contract unit price for the contract items for sewer pipe of each size, type, kind, and strength class include the costs of providing and installing the pipe complete-in-place as required by the contract, except as otherwise specified in this section.

The contract unit prices for plastic pipe sewers will include the cost of deflection testing and buoyancy protection as required by the contract.

The Department will pay for elbow, tee, or wye sections and additional connectors directed by the Engineer, but not shown on the plans, by the invoice cost of the materials.

The Department will pay for installing Department-provided sewer materials including all work and additional materials used to complete the sewer installation by the relevant install only contract pay item, except for "Extra Work" or work included in other relevant contract pay items.

The Department will include the cost of granular materials for special bedding or backfill with relevant pay items in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment."

The contract unit prices for excavation contract items include the cost of disposing of surplus excavated material.

If the Engineer approves of sewer pipe installation by the jacking method and contract item does not exist, the Department will pay for a jacking installation on the basis of contract unit prices relevant for the trenching method.

The Department will include the cost of aprons required in connection with the sewer construction with relevant pay items in accordance with 2501.5, "Pipe Culverts, Basis of Payment."

The Department will pay for required excavation greater than 1 ft [300 mm] below the bottom of the pipe as shown on the plans as extra work in accordance with 1402, "Contract Revisions."

If the plans do not include a contract pay item, the Department will pay for the removal of ledge rock or rocks larger than ½ cu. yd [0.4 cu. m] in volume from the excavation as extra work in accordance with 1402, "Contract Revisions."

The Department will include the cost of alternatives as shown on the plans, including cost differences in installation requirements, deflection testing, trench width, or embedment material specifications and quantities, in the contract unit price of the pipe.

The Department will include the cost of trench excavation with the relevant contract pay item for sewer installation.

The contract unit price for the relevant pipe contract item includes the cost of pipe cleaning except when specifically designated under other items..

The Department will pay for sewers on the basis of the following schedule:

Item No.:	Item:	Unit:
2503.511	___ in [mm]* Pipe Sewer‖	linear foot [meter]
2503.519	Flap Gate for Pipe†	each
2503.521	___ in [mm] Span* Pipe-Arch Sewer‖	linear foot [meter]
2503.531	___ in [mm] Span* Elliptical Pipe Sewer‡	linear foot [meter]
2503.541	___ in [mm]* Pipe Sewer, Design# ‖	linear foot [meter]
2503.571	Install §	linear foot [meter]
2503.573	Install §	each

* Specify kind in accordance with 2503.2.A, "Pipe."
‖ Specify strength class if other than minimum requirement
† Specify size and kind
‡ Specify HE or VE, and strength class, if other than minimum requirement
\# Specify pipe or joint designs and provide standard plate number
§ Special item name

2506 MANHOLES AND CATCH BASINS

2506.1 DESCRIPTION

This work consists of constructing or reconstructing brick or concrete block masonry, cast-in-place concrete, precast sectional concrete, or pipe structures for access and drainage into underground drainage or other systems.

The Department defines precast concrete median drains as casting assemblies.

2506.2 MATERIALS

A Concrete 2461

Use 3G52 concrete.

B Mortar

B.1 Mortar (Type S or M) 3106

B.2 Masonry Cement (Type S or M) 3107

B.3 Mortar Sand 3128

C Clay Brick 3612

D Concrete Brick 3616

E Concrete Masonry Units 3621

F Sectional Concrete Manhole and Catch Basin Units 3622
G (Blank)

H (Blank)

I (Blank)

J Reinforced Concrete Pipe 3236

K Corrugated Steel Pipe 3226

L Metal Drainage Castings 3321

M Concrete Drainage Castings 3622

N Granular Materials 3149

O (Blank)

P Corrugated Aluminum Pipe 3225

Q Corrugated Aluminized Steel (CAS) 3222

2506.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Combination Construction

The Engineer may allow a combination of cast-in-place and prefabricated concrete construction, if the contract does not specify the type of construction for a structure and if the Contractor maintains the structural strength and continuity.

A.2 Intercepting Existing Facilities

Where the new structure will intercept an existing underground facility, incorporate the existing facility into the new structure to the extent required, including any necessary removal, replacement, or special connections, without detriment to the planned function of the facility.

A.3 Abandoned Pipes

When abandoning a pipe that enters a structure that will not be abandoned, detach the pipe from the structure wall and permanently plug the wall opening and the upgrade end of the abandoned pipe with concrete or masonry.

A.4 Excavation, Bedding, and Backfill

Excavate, bed, and backfill in accordance with 2451, "Structure Excavations and Backfills."

A.5 Inspection Before Construction

Do not place mortar in any unit or section of work before the Engineer has inspected and approved the foundation preparations, materials, and provisions for cold weather protection.

A.6 Temperature Restrictions

Do not place mortar on a frozen foundation or against any surface with a temperature below freezing.

Do not start or continue production of concrete or mortar when the ambient air temperature at the construction site, away from artificial heat, is less than 36 °F [2 °C]. The Engineer may otherwise approve in accordance to the following:

(1) When the air temperature is rising and has reached 34 °F [1 °C], or
(2) If the Contractor makes provisions for cold weather protection in advance, as approved by the Engineer.

Do not use masonry units or aggregate in temperatures 32 °F [0 °C] or less, except as directed by the Engineer.

Maintain concrete and mortar mixes at a temperature from 50 °F to 90 °F [10 °C to 32 °C] until incorporated into the work.

The Engineer may approve heating of masonry units, mix materials, or mortar. Do not spot heat these materials using steam jets or direct application of combustion heating devices as the work progresses.

B Cast-in-Place Concrete 2411

C Masonry

Provide masonry in accordance with the requirements in this section if at least part of the structure is constructed using clay brick or concrete masonry units. The Department defines "unit" as the brick or concrete block unless otherwise qualified in this section.

Do not moisten concrete masonry units before placement in the work. Moisten all other types of masonry units before placement.

Place units in a full mortar bed, in horizontal courses, using the "shove joint" method, as described in this section. Fill joints with mortar. Strike joints on the inside of the structure, providing a joint width no greater than 0.5 in [13 mm] wide. Plaster the outside of the structure with mortar to a smooth surface.

Install steps, pipes, or other fixtures required by the contract, as the work progresses. Fit the units around pipes that penetrate the structure, using only part of the unit to form a neat juncture at the pipe as approved by the Engineer. Bond attachments to the structure using mortar to fill voids.

For manholes or catch basins constructed of brick, meet the following additional requirements:

(1) In circular type structures, lay the bricks flat and radially with the ends exposed on the inside of the structure. Where the thickness of the wall is greater than the length of one brick, the Contractor may lay the outside bricks circumferentially using full header construction in at least each sixth course.
(2) In rectangular type manholes, lay the bricks in regular courses of stretchers using full header construction in at least each sixth course. Do not use bats or spalls except for shaping around openings or for finishing out a course. When shaping around openings or finishing out a course, place full bricks in the corners and the bats in the interior of the course. Ensure the least dimension of the exposed faces of bats is at least 50 percent of the width of a brick.

When using the alternate method of constructing the tapered portion of a manhole with concrete block as shown on the plans, use concrete units specifically shaped to transition between the vertical and the sloped walls.

D Sectional Concrete

Set the bottom pre-cast section in a full mortar bed and fill the joints between sections and around pipes with mortar or a plastic cementing compound approved by the Engineer.

E Pipe

Construct metal or concrete pipe manholes as shown on the plans.

F Castings

Set the frame or ring castings to the designated elevation on a full mortar bed. If using metal pipe construction, set casting as shown on the plans, as specified in the specifications, or as approved by the Engineer.

Place a 4 in [100 mm] thick concrete encasement around the outside of the manhole or catch basin as detailed in MnDOT Standard Plate 4026. Place this encasement at the time of final casting placement.

If the plans shown castings not bonded to the manhole or catch basin, finish the mortar bed to the required grade and allow the mortar bed to set. After the mortar bed sets, apply a lubricant approved by the Engineer to the bed and install the casting.

G Adjusting Frame or Ring Castings

Provide vertical adjustment of access castings made to the planned elevation on the structure. Meet the criteria that full support for the casting is obtained above the cone section and ensure that structure construction above the cone does not exceed 6 in [150 mm], not including the frame. Use no more than 3 adjusting rings. Limit thickness of each adjusting ring to 6 in or less. If these criteria cannot be met by vertical adjustment work, reconstruct the structure.

For upward adjustment of castings, the Contractor may use any of the structure materials or applicable construction methods specified in this subsection, provided they are compatible with the in-place construction. The Contractor may use auxiliary ring castings and adjusting rings as shown on the *plans*.

H Reconstructing In-Place Structures

If the plans require reconstructing the manhole or catch basin or if raising or lowering the frame or ring casting beyond the limits specified in 2506.3.G, "Adjusting Frame or Ring Castings," reconstruct the structure as shown on the plans or directed by the Engineer.

Perform reconstruction to be consistent with the type of construction used for the in-place structure meeting the requirements specified in this section for new construction. The Contractor may use salvaged material, if approved by the Engineer. Thoroughly bond new work to the in-place structure.

I (Blank)

J Construction in Conjunction with Pavement Construction

If constructing, reconstructing, or adjusting manholes and catch basins in connection with the construction of a concrete pavement or base, use the telescoping type of ring unless otherwise shown on the plans.

If using the telescoping type of ring, set the frame or ring casting to the proper elevation before placing the pavement.

K Backfilling

If the structure consists of cast-in-place concrete or of bricks or blocks laid in mortar, do not place the backfill until the concrete or mortar has cured for at least 3 days.

Excavated materials not required for backfill shall become the property of the Contractor. Dispose of the excavated material off the right-of-way in accordance with 2105, "Excavation and Embankment," at no additional cost to the Department.

L Cleaning

Clean sediment and debris from manholes and catch basins before final acceptance.

2506.4 METHOD OF MEASUREMENT

The Engineer will measure manholes and catch basins as drainage structures.

A Constructing Drainage Structures

If the plans specify measurement by length for vertical structures constructed on a concrete base, the Engineer will measure the height as the difference in elevation between the bottom of the casting and the invert elevation of the outlet pipe, plus an allowance of 0.70 ft [200 mm] for the depth of the concrete base, regardless of its actual thickness.

If the plans specify measurement by length for pipe structures designed with a "tee" section in the sewer or culvert line, the Engineer will measure the length as the difference in elevation between the bottom of the casting and the flow line elevation of the sewer or culvert pipe for vertical construction, or as shown in the plans for other special designs not constructed vertically. The Engineer will measure the "run" of the pipe structure "tee" section as culvert or sewer pipe.

If the plans specify the measurement of each structure complete in place, the Engineer will separately measure drainage structures of each design as individual units complete in place, including any castings provided and installed.

B Reconstruction

The Engineer will measure reconstruction to the nearest 0.1 ft [30 mm], of the height from the bottom of the reconstructed portion to the bottom of the newly set casting, regardless of type.

C Castings

The Engineer will measure casting assembly by the number of casting assemblies provided and installed.

The Engineer will measure install casting by the number of castings installed.

The Engineer will not measure castings for structures measured as a unit. The Engineer will consider all castings required for an individual structure as one assembly.

D Adjusting Castings

The Engineer will measure adjusting castings by the number of casting assemblies adjusted. The Engineer will consider all castings required for an individual structure as one assembly.

2506.5 BASIS OF PAYMENT

The contract unit price for constructing or reconstructing drainage structures includes all costs for completing the work, including the cost of excavation, except for the cost of specific contract items, in accordance with the following:

(1) The Department will pay for excavation in ledge rock and the removal of boulders or detached rocks with a volume greater than 0.5 cu. yd [0.4 cu. m] as extra work in accordance with 1402, "Contract Revisions," unless the existence of the rock is shown on the plans.

(2) The contract unit price for reconstructing drainage structures includes the cost of removing the existing casting, but does not include placement of a casting on the reconstructed structure.

(3) The contract unit price for reconstructing drainage structures includes the costs of removing and replacing all or a portion of the structure as shown on the plans, adjacent pavement aggregate base, and excavation if, except for the structure construction, the surface would not otherwise have been disturbed. The Department will pay for the cost of this work at the contract unit price based on the area to the nearest 0.1 sq. yd [0.1 sq. m] within a rectangle with sides that lie 1.5 ft [0.5 m] outside the structure limits. The Department will include the cost of removing and replacing pavement outside of these limits or for replacing any other type of surfacing with other applicable pay items.

(4) The contract unit price for drainage structure construction by the structure as individual units complete in place includes the cost of providing and installing any castings required.

(5) The contract unit price for adjust frame and ring castings will include the cost of the removing and replacing concrete surfacing in connection with the item of adjust frame and ring castings.

(6) The casting encasement detailed in Standard Plate 4026 will be placed at the time of final casting placement, with no additional cost to the Department.

(7) The Department will pay for granular materials for special bedding or backfill in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment."

(8) The contract unit price for *Adjust Frame and Ring Casting* includes the cost of salvaging and installing the in-place casting; removing deteriorated rings; and providing and installing all sewer blocks, bricks, rings and grout necessary to raise or lower in-place castings to the elevation shown on the plans or directed by the Engineer.

The Department will pay for manholes and catch basins as drainage structures based on the following schedule:

Item No.:	Item:	Unit:
2506.501	Construct Drainage Structure, Design ___	linear foot [meter]
2506.502	Construct Drainage Structure, Design ___	each
2506.503	Reconstruct Drainage Structure	linear foot [meter]
2506.516	Casting Assembly	each
2506.521	Install Casting	each
2506.522	Adjust Frame and Ring Casting	each

2507 CULVERT LINER

2507.1 DESCRIPTION

This work consists of inserting a polyethylene (PE) or polyvinyl chloride (PVC) pipe liner inside an in-place culvert.

2507.2 MATERIALS

A Pipe

Provide one of the following types of culvert liner pipe as shown on the plans or specified in the special provisions:

A.1 Polyethylene (PE).....3249

A.2 Blank

2507.3 CONSTRUCTION REQUIREMENTS

A General

The Department will specify the diameter of the in-place pipe to be lined in the contract item. Follow liner dimensions as shown on the plans and as specified by the special provisions. Use a liner and grout method that has adequate space between the in-place pipe and liner to grout the annular space.

Use slings, boom-type trucks, or an equivalent approved by the Engineer to unload liners at the project. Do not dump liners from the truck or use chains or wire rope for handling. The Contractor may use a winch truck or equivalent equipment approved by the Engineer, to install the liner.

The Department will consider any damaged culvert liner pipe to be unacceptable. Unacceptable pipe includes but is not limited pipe liner that is damaged during handling or installation, or rejected because it does not meet plan requirements.

B Installing Pipe

B.1 General

Inspect the interior of the culvert to identify conditions which may prevent proper installation and to confirm that the pipe liner and installation method proposed by the contractor are adequate for existing site conditions.

Use jet rodding equipment, hydro-mechanical methods or other methods approved by the Engineer to clean and dry the liner pipe before inserting the culvert liner. Remove or repair all obstructions that would prevent installation or damage the liner during installation. Remove debris or other materials from the existing pipe culvert to prevent the inserted liner from resting on or against, or be irregularly supported by, these materials.

The Contractor may use a flange connector or a full encirclement with neoprene connects and stainless steel clamps to make final connection. Allow the pipe liner to stabilize from 8 h to 10 h before tying the last joint or pressure grouting the annular space between the in-place culvert and the inserted liner.

Use fasteners, blocks, or multiple grout layers to secure pipe liners equal to or greater than 2 ft [600 mm] in diameter to the invert of the existing culvert to prevent the pipe liner from floating during the grouting operations.

B.2 Inserting Liner

The Contractor may pull or push pre-fused lengths of solid wall PE pipe into place. The Contractor may combine the push and pull techniques to insert the liners.

B.2.a Pull Technique

Use a cable or winch arrangement to pull the pipe liner pipe into place. Feed the cable from the winch through the existing pipe culvert. Fasten the cable to the liner pipe to allow the liner pipe to be pulled through the existing pipe and into place. The Contractor may fabricate the pulling head out of a few extra feet of the liner pipe by cutting out evenly spaced wedges from the leading edge, collapsing the fingers towards the center, and fastening the cable to the fingers.

B.2.b Push Technique

Place a choker strap around the liner outside the access point. Use a tractor mounted backhoe, backhoe, or an equivalent piece of equipment approved by the Engineer to pull the choker, thus pushing the liner through the existing culvert. Ensure that with each stroke of the backhoe, the choker grips the pipe and pushes the leading edge of the liner further into the existing culvert. The Contractor may use a front-end loader or bulldozers to simultaneously push on the trailing end of the liner segment.

B.3 Pipe Joints

Use heat fusion or grooved press-on joints approved by the Engineer to join PE pipe meeting requirements of ASTM F 714 (SDR 32.5). Heat fuse pipe joints as recommended by the pipe manufacturer, using an experienced operator of the heat fusion equipment.

Use a threaded joint to join closed-profile PE pipe with an ASTM D 3350 cell classification of 345464C as approved by the Engineer.

C Grout

Block off culvert ends before filling the annular space between the culvert liner and the host pipe. Provide CLSM Low Density or CLSM High Density grout in accordance with 2519, "Cellular Concrete Grout – Controlled Low Strength Material (CLSM)," and as shown on the plans or as required by the contract. Use CLSM High Density grout if the plans or the contract do not specify the grout type. Do not allow grouting pressure to exceed the external hydrostatic collapse resistance of the liner.

D Culvert Cleaning

Clean sediment and debris from lined pipe before final acceptance.

2507.4 METHOD OF MEASUREMENT

A Culvert Pipe Liner

The Engineer will measure culvert pipe liner by length, as determined by summation of the nominal laying lengths of the individual pipe sections incorporated in each structure. The Engineer will separately measure culvert pipe liner by size, type, and kind in accordance with the contract items.

B Culvert Appurtenances

The Engineer will separately measure aprons or other appurtenances required to the installation of the culvert lining in accordance with 2501, Pipe Culverts."

C Grout

The Engineer will measure grout in accordance with 2519, "Cellular Concrete Grout – Controlled Low Strength Material (CLSM)."

2507.5 BASIS OF PAYMENT

The contract linear foot [meter] price for *Lining Culvert Pipe* will include the cost of excavating, cleaning, inserting the pipe liner, backfilling, and providing pipe liner, fittings, seals, and joint system.

The Department will pay for grouting with the contract unit price for contract item No. 2519.501, "CLSM Low Density," or No. 2519.502, "CLSM High Density," as shown on the plans and in accordance with 2519, "Cellular Concrete Grout – Controlled Low Strength Material (CLSM)."

The Department will pay for culvert appurtenances in accordance with 2501, "Pipe Culverts."

The Department will pay for culvert liner on the basis of the following schedule:

Item No.:	Item:	Unit:
2507.501	Lining Culvert Pipe ___ in [mm]*	linear foot [meter]

* Specify kind in accordance with 2507.2, "Culvert Liner, Materials." If the contract allows alternatives, do not specify kind.

2511 RIPRAP

2511.1 DESCRIPTION

This work consists of providing and placing stone riprap, with or without grouting, as a protective covering on earth slopes, piers, abutments, walls, or other structures, where the soil is susceptible to erosion.

The Department classifies riprap by type as random riprap or handplaced riprap, depending on the method of placement and the stone size specified.

2511.2 MATERIALS

A Riprap Materials 3601

B Filter Materials

B.1 Granular Filter 3601

B.2 Geotextile Filter 3733

C 3A-Grout 2461

2511.3 CONSTRUCTION REQUIREMENTS

A General

Provide and place stone riprap as shown on the plans or as directed by the Engineer.

Excavate and shape the foundation for the riprap, with or without filter material, to the cross-sections as shown on the plans, unless otherwise directed by the Engineer. Compact loose foundation material before placing the riprap or filter material.

If the contract requires, place a layer of riprap at least a 1 ft [300 mm] thick on a filter material, unless otherwise required by the contract or directed by the Engineer.

Grout riprap as required by the contract or as directed by the Engineer. Place the riprap on a filter layer consisting of granular material or geotextile. Fully grouted riprap is not allowed in public waters.

B Filter Material

Place filter material under the riprap unless otherwise required by the contract. The Contractor may choose the type of filter material, except as required by the contract.

B.1 Granular Filter

Spread granular filter material to a minimum thickness of at least 6 inches [150 mm] over the prepared foundation, or as required by the contract. Deposit granular material, placed under water, directly on the foundation using a bucket or similar container. Do not discharge the granular material above the water surface.

B.2 Geotextile Filter

When placing geotextile filter material ensure that the foundation surface is relatively smooth and free of stones, sticks, and other debris or irregularities that might puncture the fabric. Place the filter material and conduct construction operations without tearing, puncturing, or shifting the fabric.

Place the fabric with the longest dimension parallel to the direction of water flow. If using fabric that is not seamed, overlap splices and joints at least 18 in [0.5 m], except overlap splices and joints placed under water 36 in [1 m]. Provide shingled joint laps in the flow direction and from top to bottom of a slope to direct water flow over the joint without undermining the geotextile filter. The Contractor may sew multiple fabric pieces together, as specified in 3733, "Geotextiles," in lieu of joint overlapping. Bury the upgrade edges of the fabric a minimum of 6 in [150 mm] to direct water flow over the fabric and prevent undermining. If not seamed, place washered steel pins, edge stakes, stones, or other material at locations and in quantities as approved by the Engineer, to prevent movement of the geotextile filter during placement of the riprap.

Do not dump stone at the top of the slope and roll stone down the slope. If placing stones directly on the geotextile filter without a granular cushion, do not operate equipment on top of the stones after placement. Do not operate construction equipment directly on top of the geotextile.

Do not use geotextile filter material under hand placed or grouted riprap, unless otherwise required by the contract.

The Contractor may place geotextile filter on slopes no steeper than 1:3. For slopes steeper than 1:3, retrench the geotextile at least every 15 ft [4.6 mm] or as required by the contract. Do not use geotextile filter on slopes steeper than 1:2.

C Riprap Stone

Do not drop stones on the fabric from a height greater than 1 ft [0.3 m] unless the fabric is covered with a 6 in [150 mm] thick granular cushion course. If covered, the Contractor may drop riprap stones from a height no greater than 3 ft [1 m].

When placing riprap, start at the lowest elevations and work upwards.

Before placement of riprap stone on geotextile, the Engineer may require the Contractor to demonstrate that the placement methods will not damage the fabric. The Engineer may order the removal of at least 4 sq. yd [3 sq. m] of riprap to inspect for fabric damage in accordance with 1511, "Inspection of Work."

C.1 Random Riprap

Position random riprap to provide a uniform distribution of the various sizes of stone and produce a dense, well-keyed layer of stones with the least practical voids volume. Level the surface flush with the surrounding ground to produce a reasonably uniform appearance and the thickness required by the contract.

Wash riprap clean before placing underwater.

C.2 Hand-Placed Riprap

Embed the stones for hand-placed riprap in the foundation material, with the axis of the stone that most nearly approximates the contract-required thickness of riprap laid perpendicular to the foundation slope. Lay stones with the least practicable space between them. Position the stones to stagger the joints up the slope. Place each stone to allow the foundation material and adjacent stones to carry its mass.

Use selected stones set to line and grade to define the ends and edges of each riprap area.

After laying the larger stones, fill the spaces between the stones with firmly seated, smaller stones to produce a uniform surface.

Wash riprap clean before placing underwater.

D Grouting

For fully grouted riprap, ensure that grout fills the spaces between stones throughout the entire thickness of the riprap.

Immediately before placing the grout for grouted riprap, thoroughly wet the stones with water. Do not pour grout over stones that have become surface dry. Sweep the surface of the grouted riprap with a stiff broom to finish.

E Thickness Requirements

Ensure the riprap placed on each separate area has a minimum thickness of at least 80 percent of the thickness required by the contract and an average thickness of at least 95 percent of the thickness required by the contract when measured at right angles to the face.

2511.4 METHOD OF MEASUREMENT

A Riprap

If measuring riprap of each type and class by volume, the Engineer will calculate the volume based on the actual surface dimensions as staked and the thickness shown on the plans or specified in the special provisions.

If measuring riprap of each type and class by mass, the Engineer will calculate the mass based on scale tickets of materials delivered and placed within the staked areas.

B Filter Materials

If measuring filter materials by weight, the Engineer will calculate the weight based on scale tickets of material delivered and placed within the staked areas.

If measuring filter materials by volume, the Engineer will calculate the volume based on the actual surface dimensions as staked and the thickness as shown on the plans.

The Engineer will measure geotextile filter material by area based on the actual surface dimensions as staked, with no allowance for overlaps or seams.

2511.5 BASIS OF PAYMENT

The contract unit price for riprap of each type and class includes the cost of providing the materials, excavating and preparing the foundations, and placing the riprap stone, grouting, and filter materials as required by the contract.

The Department will pay for filter materials of the type specified, if included in the contract.

The Department will pay for riprap and filter material based on the following schedule:

Item No.:	Item:	Unit:
2511.501	Random Riprap, Class ___	cubic yard [cubic meter]
2511.502	Random Riprap, Class ___	ton [metric ton]
2511.505	Hand-placed Riprap	cubic yard [cubic meter]
2511.507	Grouted Riprap	cubic yard [cubic meter]
2511.511	Granular Filter	cubic yard [cubic meter]
2511.513	Granular Filter Material	ton [metric ton]
2511.515	Geotextile Filter, Type ___	square yard [square meter]

2512 GABIONS AND REVET MATTRESSES

2512.1 DESCRIPTION

This work consists of constructing gabions and revet mattresses at the locations shown on the plans or as directed by the Engineer.

2512.2 MATERIALS

A Riprap Materials 3601

B Filter Materials

B.1 Granular Filter 3601

B.2 Geotextile Filter 3733

C Gabions 3602

D Revet Mattresses 3602

2512.3 CONSTRUCTION REQUIREMENTS

A General 2511.3

Excavate, shape, and compact the foundation to the elevation and alignment as required by the contract.

Provide and place filter material, unless otherwise required by the contract.

Provide and place gabions and revet mattresses.

B Filter Material

Place filter material over the entire area before placing the gabions and revet mattresses.

B.1 Granular Filter 2511.3

B.2 Geotextile Filter 2511.3

The Contractor may place geotextile filter material under gabions and revet mattresses on slopes without stepping if specified by the contract or approved by the Engineer.

C Baskets and Fasteners

C.1 Documentation
Provide the following:

(1) Certification that the baskets and fasteners meet the requirements of this section (2512),
(2) Manufacturer's drawings of the baskets and fasteners, and
(3) Manufacturer's assembly recommendation and instructions for the baskets and fasteners.

C.2 Construction
Install the baskets to the dimensions, profile, and alignment as required by the contract or as directed by the Engineer.

Assemble the baskets in accordance with the manufacturer's recommendations unless otherwise specified in this section (2512), 3602, "Gabions and Revet Mattresses Materials," or as shown on the plans.

Place and fasten the diaphragms in the baskets to the side and bottom mesh to create cell dimensions no greater than 3 ft [1 m].

Fasten adjoining empty baskets together at their perimeters.

Place stones in the cells of baskets in a manner that will minimize voids, does not allow sharp edges to protrude through the mesh, and maintains the basket dimensions as shown on the plans. Hand place stones as necessary.

Fill cells in 1 ft [300 mm] layers. Fill cells no greater than 1 ft [300 mm] in one layer. Fill cells no greater than 18 in [450 mm] in two equal layers. Do not fill cells greater than 1 ft [300 mm] higher than stone layers in adjacent cells or baskets.

For twisted wire gabions, place horizontal connecting wires on top of the stone layer in both directions if no supporting basket exists, to prevent the sides from bulging. For welded wire gabions, install preformed stiffeners across the corners of the gabions before filling. Provide two rows of stiffeners, four per cell, for the front face and the side faces. Provide a single row of stiffeners, two per cell, on the back face. The Department will not require stiffeners in interior cells. Provide preformed stiffeners with a nominal length of 18 in [450 mm]. Hook the stiffeners at crossing wires. The Contractor may use lacing wire as a stiffener.

After filling the basket, fold the top of baskets shut and fasten to the ends, sides, diaphragms, and adjacent baskets.

Stack empty baskets on filled baskets and fasten to the filled baskets at front, exposed sides, and back before filling.

Stagger the vertical joints between the baskets of adjacent rows and layers unless otherwise required by the contract.

Backfill behind a gabion structure simultaneously with the cell filling operation.

C.3 Fasteners
The Contractor may use lacing wire, an alternative fastener approved by the Engineer, or a combination, to fasten the baskets.

C.3.a Lacing Wire
Place lacing wire at each joint alternating single and double loops every 3 in to 6 in [75 mm to 150 mm].

C.3.b Alternative Fastener
Place alternative fasteners at each joint at every mesh opening. Adequately secure spiral binders at the ends to prevent unwinding.

D Acceptance
The Engineer may consider the work unacceptable if visible baskets vary by greater than 6 in [150 mm] from the profile or alignment as shown on the plans or as directed by the Engineer.

2512.4 METHOD OF MEASUREMENT

A Gabion and Revet Mattress
The Engineer will measure gabion and revet mattress construction by volume based on the nominal basket dimensions and the number of baskets incorporated into the work.

B Filter Materials 2511.4

2512.5 BASIS OF PAYMENT
The contract unit price for both Gabions and for Revet Mattresses include the cost of providing the materials as required by 3601, "Riprap Material," and 3602, "Gabions and Revet Mattresses Materials," excavating and preparing the foundations, providing and installing filter materials, and constructing and filling the gabions and revet mattresses.

The Department will separately compensate for filter materials if the contract contains the relevant contract items as listed in 2511, "Riprap."

The Department will pay for gabions and revet mattresses based on the following schedule:

Item No.:	Item:	Unit:
2512.517	Gabion	cubic yard [cubic meter]
2512.519	Revet Mattress	cubic yard [cubic meter]

2514 SLOPE PAVING

2514.1 DESCRIPTION

This work consists of paving embankment slopes and waterways with portland cement concrete or crushed aggregate to provide erosion protection.

2514.2 MATERIALS

A Concrete 2461

Provide concrete meeting the requirements for Mix Designation 3F52, except that the Contractor may adjust the slump requirement as approved by the Engineer.

B Reinforcement Bars 3301

Provide reinforcement bars meeting the following requirements:

(1) Either Grade 40 [Grade 300] or Grade 60 [Grade 420],
(2) Deformed billet steel, and
(3) Meeting the requirements of ASTM A 615/ASTM A 615M.

C Preformed Joint Filler 3702

D Bituminous Material 3151

Provide liquid asphalt, Grade MC-250, MC-800, or emulsified asphalt, Grade CSS-1, CSS-1H, RS-1, or CRS-2 for bituminous material for stabilizing aggregate slope paving.

E Aggregate

Provide aggregate for slope paving in accordance with Table 2514-1 for gradation class CA-1, CA-2, or CA-3, and in accordance with the quality requirements in 3137.2.D, "Quality."

Table 2514-1
Coarse Aggregate Fraction Size,
percent by weight passing square opening sieves

	Aggregate Designation		
	CA-1	**CA-2**	**CA-3**
2 in [50 mm]	100	100	—
1½ in [37.5 mm]	80 – 100	90 – 100	100
1¼ in [31.5 mm]	—	—	85 – 100
1 in [25.0 mm]	—	—	—
¾ in [19.0 mm]	5 – 30	5 – 35	5 – 35
⅝ in [16.0 mm]	—	—	—
½ in [12.5 mm]	—	—	—
⅜ in [9.5 mm]	—	—	—
No.4 [4.75 mm]	0 – 5	0 – 5	0 – 5

2514.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Prepare the foundation to the dimensions and elevations shown on the plans or directed by the Engineer. Excavate the high spots, and fill and compact low spots of the foundation to meet the elevation and slope requirements. Prepare the foundation with a uniform density meeting 2105.3.F.2, "Quality Compaction."

For rough grading performed by others under another contract, if the Engineer determines that a material shortage or excess exists to construct the planned foundation elevations, the Engineer may require one of the following to achieve acceptable foundation elevations:

(1) Make minor adjustments to the grade to balance out the available material,

(2) Order the placement of additional material from other sources, or
(3) Order the removal and outside disposal of excess material.

B Aggregate Slope Paving

Use mechanical or hand methods to deposit, spread, consolidate, and shape the aggregate to provide a uniform depth and density and to produce a uniform surface appearance. Apply liquid asphalt at a rate of 1.8 gal per sq. yd [8 L per sq. m] and only when the ambient air temperature is at least 40 °F [5 °C]. Apply emulsified asphalt at a rate of 2.5 gal per sq. yd [11 L per sq. m] and only when the ambient air temperature is at least 50 °F [10 °C]. Ensure bituminous materials penetrate to a depth of at least half the thickness of the aggregate slope paving as shown on the plans. Protect adjacent structure surfaces from bituminous splatter.

C Concrete Slope Paving

Construct concrete slope paving in accordance with 2401, "Concrete Bridge Construction." Place, consolidate, strike-off, and hand float the concrete to provide a dense pavement relatively free of voids and cavities, and to produce a uniform surface appearance. Set and support side forms and finish the concrete so surfaces do not deviate from a true plane and the grade shown on the plans by greater than ±½ in [13 mm]. Place metal reinforcement and preformed filler material shall as shown on the plans. Support the metal reinforcement and preformed filler material as shown on the plans to maintain correct position during concrete placement.

Form and cast toe walls and side walls before placing concrete for contiguous slope paving. Moisten the subgrade at the time of concrete placement. Take care to prevent subgrade displacement and contamination of the concrete. Place the slope paving either in equally spaced alternate strips running in the direction of maximum slope or in full width sections with mechanical equipment capable of placing and finishing the slope paving.

Immediately after placing, consolidate and strike off the concrete. When the concrete is capable of maintaining shape, perform the following to the concrete:

(1) Strike off the surface again,
(2) Hand float with a cork or wood float to provide a final finish, and
(3) Broom to produce a uniform texture and appearance.

After the final floating, finish edges not formed with v-strip inserts with an edging tool and cut panel lines with grooving tools. The Contractor may saw the panel lines as directed by the Engineer. Float edging and grooving flange trails to secure uniform surface appearance.

Provide curing protection to exposed surfaces after completing the concrete finishing operations in accordance with 2401.3.G, "Concrete Curing and Protection," and maintain until the concrete attains a strength gain of at least 30 percent.

2514.4 METHOD OF MEASUREMENT

The Engineer will separately measure slope paving of each type by area of top surface, bounded by the outside edges of abutment faces, toe walls, side walls or timber planks, as constructed and accepted for payment.

2514.5 BASIS OF PAYMENT

The contract unit price for slope paving of each type includes the cost of constructing the work complete in place.

The Department will pay for the cost of providing and placing additional material, or the removal and outside disposal of excess material requiring loading and hauling, directed by the Engineer, as extra work in accordance with 1402, "Contract Revisions." The Department will include the cost of excess material disposed on areas adjoining the slope paving without loading and hauling, as directed by the Engineer, with the contract unit prices for slope paving.

The Department will pay for slope paving based on the following schedule:

Item No.:	Item:	Unit:
2514.501	Concrete Slope Paving	square yard [square meter]
2514.503	Aggregate Slope Paving	square yard [square meter]

2515 REVETMENT SYSTEMS

2515.1 DESCRIPTION

This work consists of providing and placing closed or open cell precast block or articulated concrete mat revetment systems as a protective covering for earth slopes, river channels, vehicle accesses, spillways, and susceptible soil erosion areas.

Articulated concrete consists of hand placed Articulated Interlocking Block or Articulated Block Mat (cabled blocks).

2515.2 MATERIALS

A Precast Articulated Concrete **3604**

B Geotextile Filter **3733**

C Bedding Material **3149**

D Concrete **2461**

2515.3 CONSTRUCTION REQUIREMENTS

A General

Excavate for the foundation for the articulated concrete revetments, with geotextile filter, using toe, terminal, and upper bank trenches. Shape the foundation excavation to the cross-sections as shown on the plans unless otherwise directed by the Engineer. Grade and compact termination trenches, embankment crests, and toes to prevent water from migrating under the block and geotextile material. Grade final subgrade smooth before placing the base course material to allow uniform contact with the geotextile and articulated concrete.

B Subgrade Preparation

Prepare the subgrade in accordance with 2112, "Subgrade Preparation." Provide subgrade material free of stones, sticks, and other debris or irregularities that might puncture the geotextile fabric or create other system failures. If the system is subject to vehicle loading, install a geogrid for extra support, as shown on the plans.

C Bedding Material

Provide bedding material consisting of at least 6 in [152 mm] of cohesive soils spread evenly over the compacted subgrade, made of the following materials as approved by the Engineer:

(1) Common borrow in accordance with 2105, "Excavation and Embankment,"
(2) Granular borrow in accordance with 3149, "Granular Material," or
(3) Granular bedding, avoiding sand, in accordance with 3149, "Granular Material."

Compact the material to the specified density method in accordance with 2211.3.C, "Placing and Compacting."

D Geotextile Filter

Place a geotextile filter under the articulated concrete unless otherwise required by the contract. Place the geotextile filter material on the entire area supporting the articulated concrete. Secure the geotextile filter material with 6 in [152 mm] steel pins or staples, unless otherwise shown on the plans. If installing anchors, cut the geotextile to allow the anchors to penetrate the geotextile.

Place and compact prepared subgrade and bedding material, and place geotextile filter material without tearing, puncturing, or shifting the fabric. The Contractor may place a 1 in [25 mm] sand layer on the geotextile fabric before placing the block.

Place the required multiple fabric widths or lengths with the longest dimension parallel to the direction of water flow. Place unseamed fabric with splices and joints overlapped at least 18 in [0.5 m], except overlap splices and joints underwater at least 36 in [1 m]. Shingle the joint laps in the flow direction and from top of slope to bottom to direct water flow over the joint without undermining. As an alternative to joint over-lapping, the Contractor may sew multiple fabric pieces together to meet the seam breaking strength requirements of 3733, "Geotextiles." Bury upgrade edges of the fabric area to direct water flow over the fabric without undermining. For unseamed geotextile, place steel pins with washers or staples at locations and in quantities as approved by the Engineer to prevent movement of the geotextile filter during placement of the articulated concrete revetment system.

Do not operate construction equipment directly on top of the geotextile.

E Precast Articulated Concrete

E.1 Articulated Block Mat

Place the mats in accordance with the appropriate manufacturer recommendations. Place the mats no greater than 2 in [51 mm] apart. After cable clamping and anchoring, use Type 3A grout in accordance with 2461, "Structural Concrete," to close gaps greater than 2 in [51 mm]. Entrench and bury the outside edges of the mat system at least one block into the ground filled with compacted fill. Do not allow mats to overlap and blocks to project vertically greater than 1 in [25 mm] beyond the adjacent block. Fasten the protruding longitudinal and transverse cable connections together along the adjacent sides of the mats.

E.2 Articulated Interlocking Block

Install articulated interlocking blocks by hand. Do not overlap blocks and allow blocks to project vertically by greater than 1 in [25 mm] beyond the adjacent blocks. Place anchors through cuts in the geotextile and position the anchors on the concrete block to maximize the pull out resistance.

F Clamps

Use wire rope clamps to join cable loops of horizontal and vertical adjoining concrete revetment mats as specified by the manufacturer, unless otherwise directed by the Engineer.

G Anchors

Provide helical or duckbill type anchors. Install anchors at 8 ft [2.4 m] intervals at lead edge and around perimeter of the revetment system, and as shown on the plans, as specified by the manufacturer, or as directed by the Engineer. Embed anchors at least 3½ ft [1.0 m] deep. Fasten the exposed cables of the concrete mats to the anchors driven into the anchor trench.

H Filling and Vegetation

If vegetating is shown on the plans, fill voids with topsoil borrow in accordance with 3877, "Topsoil Borrow," and with mesic general roadside mix in accordance with 3876, "Seed," unless otherwise shown on the plans, after installing the mat or block system. Place the surface application after the Engineer completes inspection of the clamping and anchoring systems.

2515.4 METHOD OF MEASUREMENT

The Engineer will measure precast articulated concrete of each type by area on the basis of actual surface dimensions as staked.

The Engineer will measure geotextile filter material by area on the basis of actual surface dimensions as staked. The Engineer will not include allowance for overlaps or seams in the measurement for geotextile filter.

2515.5 BASIS OF PAYMENT

The contract unit prices for revetment systems include the cost of excavating and preparing the foundations, providing system materials, geotextile filter, base, and bedding materials, placing the precast articulated concrete, grouting, clamping, and anchoring.

The Department will pay for revetment systems on the basis of the following schedule:

Item No.:	Item:	Unit:
2515.501	Articulated Block Mat Open Cell, Type ___	square yard [square meter]
2515.502	Articulated Block Mat Closed Cell, Type ___	square yard [square meter]
2515.503	Articulated Interlocking Block Open Cell, Type ___	square yard [square meter]
2515.504	Articulated Interlocking Block Closed Cell, Type ___	square yard [square meter]
2515.515	Geotextile Filter, Type ___	square yard [square meter]

2519 CELLULAR CONCRETE GROUT – CONTROLLED LOW STRENGTH MATERIAL (CLSM)

2519.1 DESCRIPTION

This work consists of pressure grouting the area and voids between the existing pipe culvert and the inserted liner pipe.

2519.2 MATERIALS

A Cement 3101

B Fly Ash 3115

C Fine Aggregate 3126

D (Blank)

E Water 3906

F Admixtures 3113

2519.3 CONSTRUCTION REQUIREMENTS

A Mix Design

Submit a mix design on the MnDOT Concrete Mix Design Submittal Sheet to the Engineer for review and approval, in conjunction with the Concrete Engineer, at least 15 days before placing the grout. Design the CLSM in accordance with Table 2519-1 or Table 2519-2 and meeting the requirements of ASTM C 403.

A.1 CLSM Low Density

Use the CLSM low density design when no water is present and no water intrudes during the setting process based on the following proportions per unit batch:

Table 2519-1 CLSM Low Density Design	
Materials	**Proportions per unit batch and mix parameters**
Portland cement	≥100 lb [45 kg]
Total cementitious (portland cement and Class C fly ash)	≥500 lb [300 kg]
Water/cementitious ratio	0.50
Pre-formed foam*	20 cu. ft [0.60 cu. m]
Grout (cast density)	30 lb ±3 lb per cu. ft [480 kg ±48 kg per cu. m]
Slump	10 in ± 1 in [250 mm ± 25 mm]
28-day compressive strength	75 psi – 400 psi [0.5 mPa – 2.8 mPa]

* Provide foaming agent meeting the requirements of ASTM C 869 when tested in accordance with ASTM C 796. The Contractor may use other admixtures, if approved by the mix designer and the Engineer, in conjunction with the Concrete Engineer. Provide cementitious material from the Approved/Qualified Products List. The Engineer, in conjunction with the Concrete Engineer, will review the concrete mix design submittal and approve if the concrete mix design meets contract requirements. The Engineer will base final approval for payment on satisfactory field placement and performance.

A.2 CLSM High Density

Use the CLSM high density design when it is not possible to dewater, keep water out of the annular space during grouting, or both, based on the following proportions per unit batch:

Table 2519-2 CLSM High Density Design	
Materials	**Proportions per unit batch and mix parameters**
Portland cement	≥150 lb [90 kg]
Total cementitious (portland cement and Class C fly ash)	≥500 lb [300 kg]
Fine aggregate	1,100 lb [650 kg]
Water/cementitious ratio	0.50
Pre-formed foam*	13.5 cu. ft [0.50 cu. m]
Grout (cast density)	70 lb ±3 lb per cu. ft [1,120 kg ±48 kg per cu. m]
Slump	10 in ±1 in [250 mm ±25 mm]
28-day compressive strength	75 psi – 400 psi [0.5 mPa – 2.8 mPa]

* Provide foaming agent meeting the requirements of ASTM C 869 when tested in accordance with ASTM C 796. The Contractor may use other admixtures, if approved by the mix designer and the Engineer, in conjunction with the Concrete Engineer. Provide cementitious material from the Approved/Qualified Products List. The Engineer, in conjunction with the Concrete Engineer, will review the concrete mix design submittal and approve if the concrete mix design meets contract requirements. The Engineer will base final approval for payment on satisfactory field placement and performance.

B Grouting Procedure

Selected grouting pressures external to the liner pipe may collapse the liner pipe. Design a grouting procedure to fill voids between the existing culvert and the liner pipe, but will not collapse the liner pipe. Provide a pressure gauge to measure the grouting pressure and a method to measure the volume of injected grout. Submit a grouting plan to the Engineer for approval.

C Placement

Use grout to fill voids between the existing culvert and pipe liner, including breaks or holes in the existing culvert.

Secure the pipe liner to the invert of the existing culvert by fasteners or blocks, or construct multiple grout lifts to prevent the pipe liner from floating during the grouting operations.

After grouting the liner to the in place culvert, encapsulate the remaining length of liner with Mix No. 3G52 concrete at least 6 in [150 mm] thick.

Finish the inlet end with a 45° mitered fillet-transition between the in place culvert and the inside of the liner.

Use cylindrical wooden plugs, or other equivalent material approved by the Engineer, to plug grout holes. After the grout has set, remove the plugs and fill with concrete.

2519.4 METHOD OF MEASUREMENT

The Engineer will measure by the volume of grout injected into the void between the existing pipe culvert and the liner pipe. The Engineer will deduct accountable waste from the quantities measured for payment.

2519.5 BASIS OF PAYMENT

The contract cubic meter [cubic yard] price for CLSM includes the cost of dewatering, cement for securing the pipe liner to the existing culvert, and inlet bevel construction.

The Department will pay for CLSM on the basis of the following schedule:

Item No.:	Item:	Unit:
2519.501	CLSM Low Density	cubic yard [cubic meter]
2519.502	CLSM High Density	cubic yard [cubic meter]

2520 LEAN MIX BACKFILL

2520.1 DESCRIPTION

This work consists of placing a lean cementitious, controlled-density backfill into utility and culvert trenches, or other excavations, where the use of conventional compacting equipment is impractical.

2520.2 MATERIALS

A Cement 3101

B Fly Ash 3115

C Fine Aggregate 3126

D Coarse Aggregate 3137

E Water 3906

F Admixtures 3113

G Mix Design and Control

Create lean mix backfill designs using the absolute volume relationships and basic mix proportions specified in this section (2520) for the control of cement, fly ash, water, and aggregate content and workability necessary for proper placement.

G.1 Mix Requirements

The Department will provide mix proportions for lean mix backfill in accordance with Table 2510-1.

Table 2520-1 Concrete Mix Design Requirements for Lean Mix Backfill									
Mix Number	**Maximum w/c ratio**	**Water Content (pounds)**	**Cement Content (pounds)**	**Fly Ash (pounds)**	**Fine Aggregate Content (pounds)** *	**Coarse Aggregate Calculation (pounds)** *‖	**Slump Range**	**28-day Unconfined Compressive Strength (psi)**	**3137 Spec.**
Lean Mix	1.00	250	125	250	50%	50%	10 in ±1 in	75 – 400	2D1

* After adding the specified quantities of cement, fly ash, and water, provide the remaining volume consisting of fine aggregate and coarse aggregate.
‖ Meeting ASTM #67 gradation as shown in Table 3137-4.

2520.3 CONSTRUCTION REQUIREMENTS

A Job Mix Proportioning

After adding the specified quantities of cement, fly ash, and water, provide the remaining volume consisting of fine aggregate and coarse aggregate. The Contractor may use admixtures in accordance with 2461.2.E, "Concrete Admixtures." Adjust the mix at any time to maintain the consistency and strengths specified in Table 2520-1.

The Engineer will base final approval for payment on satisfactory field placement and performance.

B Batching and Mixing Requirements

Provide ready-mixed lean mix backfill in accordance with 2461, "Structural Concrete," except replace the word "concrete" with "lean mix."

C Lean Mix Backfill Placement

Plug openings below the level of the desired backfill that would allow the mix to escape. Place the lean mix so that it flows around and beneath footings, foundations, walls, pipes, or other structures that it was designed to support. The Department will not require compaction or mechanical vibration when lean mix backfill is placed as approved by the Engineer. Vent or eliminate air pockets that water would normally fill to preclude voids remaining in the completed backfill.

C.1 Curing and Protection

Maintain the air in contact with lean mix backfill surfaces at temperatures above freezing for at least 72 h.

The Department will not require additional curing after the evaporation of the substantial water gain on the surface.

2520.4 METHOD OF MEASUREMENT

If the contract specifies *Lean Mix Backfill* as a contract item, the Engineer will measure lean mix backfill as the computed, theoretical volume based on the weight of the individual batch ingredients. The Engineer will deduct the volume of accountable waste from the measurement of lean mix backfill.

2520.5 BASIS OF PAYMENT

The Department will include the cost of lean mix backfill and common backfill with other relevant contract items unless otherwise shown on the plans.

The contract cubic yard [cubic meter] price for *Lean Mix Backfill* includes the cost of providing the lean mix backfill and the cost of forming, plugging, placing, venting, and protecting.

Item No.:	Item:	Unit:
2520.501	Lean Mix Backfill	cubic yard [cubic meter]

2521 WALKS

2521.1 DESCRIPTION

This work consists of constructing concrete or bituminous walks.

2521.2 MATERIALS

A Concrete 2461

A.1 Concrete Walk ..... Mix No. 3F52

A.2 Concrete Walk, Exposed Aggregate Finish ..... Mix No. 3F52EX or 3F53EX

B Preformed Joint Filler 3702

C Bituminous 2360

C.1 Bituminous Walk ..... Mix No. SPWEB230B

D Curing Materials

D.1 Burlap Curing Blankets 3751

D.2 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound 3754

D.3 Linseed Oil Membrane Curing Compound 3755

D.4 Plastic Curing Blankets 3756

E Granular Materials 3149

2521.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Excavate, shape, and compact the foundation to a firm, uniform bearing surface to the dimensions and grade as shown on the plans and in accordance with 2105, "Excavation and Embankment," 2112, "Subgrade Preparation," and 2211, "Aggregate Base."

B Sawing Concrete Walk

Saw existing concrete walk to produce a neat line for the new work.

C Forms

Provide forms made of non-reactive metal or wood, or other material in accordance with 1805, "Method and Equipment," capable of maintaining the concrete until the concrete can retain the molded shape. Provide forms with a height at least equal to the walk thickness of the formed concrete shown on the plans. Support the forms on the foundation to maintain the line and grade shown on the plans.

Before placing the concrete, coat the contact surfaces of the forms with an approved form treating material in accordance with 3902, "Form Coating Material."

D Placing and Finishing Concrete

The Concrete Contractor, or Subcontractor, shall have at least two people with a current ACI concrete flatwork technician or flatwork finisher certification, and at least one of them must be onsite for all concrete pours.

Wet the foundation and forms before placing the concrete.

Prevent segregation of the concrete during placement. Consolidate the concrete to fill voids using hand tamping or internal vibrating. Strike-off the concrete to the grade shown on the plans, and float the surface smooth. After the water sheen disappears, edge the joints and lightly brush the surface to a uniform texture.

The Engineer will use a 10 ft [3 m] straight edge to measure the surface. The Department considers deviations in the surface greater than $^{3}/_{16}$ in [5 mm] and deviations in formed concrete greater than ½ in [13 mm] from the required location as unacceptable work. Remove and replace unacceptable work as directed by the Engineer.

Leave forms in place for at least 12 h after placing the concrete unless otherwise approved by the Engineer.

D.1 Exposed Aggregate Finish

Provide concrete Mix No. 3F52EX or 3F53EXEX with multi-colored rounded stone, modified for exposed aggregate construction.

Use surface retardation, meeting the Type B requirements in 3113, "Admixtures for Concrete," to produce a medium to deep exposure on the aggregate finish making the aggregate the dominant surface feature. Do not embed or top seed the aggregate.

Apply retardant coating immediately after completion of the concrete surface screeding, edging, and jointing. Apply retardant as recommended by the manufacturer to produce a ¼ in ± ⅛ in [6 mm ± 2 mm] etch of mortar removal after final concrete set.

Use pressurized water to remove surface mortar. Do not loosen individual aggregate particles with the pressurized water.

After the Engineer approves the exposed aggregate finish, apply a 10 percent muriatic acid solution to the exposed aggregate surfaces. Allow the acid solution to interact with the exposed aggregate surface for 5 min to 10 min before flushing the surface with water.

Cover the concrete with white polyethylene sheeting to continue curing. Before applying sealer, remove staining or streaking from the exposed aggregate surface resulting from the moist curing.

Seal the exposed aggregate finish with two coats of a clear acrylic based compound with at least 18 percent solids meeting the requirements of ASTM C 309.

D.2 Joint Construction

Divide the walk into square panels of uniform size no greater than 36 sq. ft [3 sq. m] and outlined with contraction or expansion joints as shown on the plans.

Provide vertical and straight joints parallel with or at right angles to the walk centerline. Align the joints with joints in adjoining work unless isolated by a ½ in [13 mm] preformed joint filler.

The Contractor may form or saw the joints in walking surfaces as approved by the Engineer. If forming the joints, round joints within the walking surface with a ¼ in [6 mm] radius grooving tool and round edges of the walk with an edging tool having a radius no greater than ½ in [13 mm].

Extend contraction joints to a depth of at least 30 percent of the walk thickness. If saw cutting, provide ⅛ in [3 mm] wide contraction joints.

Provide joint filler in accordance with 3702, "Preformed Joint Fillers," that is ½ in [13 mm] wide and equal in depth to the full thickness of the walk.

Modify joint construction if a fixed object or structure extends through the walk, as directed by the Engineer. Place preformed joint filler material ½ in [13 mm] thick adjacent to fixed objects to separate the object from the abutting concrete edges.

E Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 minutes of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2521.3.E.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets, unless the contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2521.3.E.1.b, "Curing Blanket Method."

Failure to comply with these provisions will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the contract does not contain a separate contract item for *Structural Concrete*, the Department will apply a monetary deduction of $50.00 per cubic yard ($65.00 per cubic meter) or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

E.1 Curing Methods

E.1.a Membrane Curing Method

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound with an approved airless spraying machine in accordance with the following:

(1) At a rate of 1 gal per 150 sq. ft (1 L per 4 m²) of surface curing area.
(2) Apply homogeneously to provide a uniform solid white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some MnDOT approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.

The Engineer will approve the airless spraying machine for use if it is equipped with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

If the Engineer determines that the initial or corrective spraying may result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method, at no additional cost to the Department.

E.1.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

E.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

E.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 36 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plans.

Protect the concrete from damage, including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

E.3.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plans.

F Bituminous

Place the bituminous mixture in accordance with 2360.

G Backfill Construction

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Perform vibratory operations and backfilling 72 h after placing the concrete or after the concrete reaches a compressive strength of at least 3,000 psi [20.7 Mpa]. The Engineer will cast, cure, and test the concrete control specimens in accordance with 2461.3.G.5.b, "Control Strength Cylinders." If damage results from any of these operations, the Engineer will suspend all operations until the Contractor takes corrective action and obtains the Engineer's approval of a new method. The Engineer may require removal and replacement of the damaged concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may use hand-operated concrete consolidation equipment and walk behind vibratory plate compactors 24 h after placing the concrete, and other equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

As soon as possible after the curing is complete and without subjecting the concrete work to damaging stresses, perform the backfill or embankment construction to the elevations shown on the plans. Use suitable grading materials from the excavation for backfill material in accordance with 2105, "Excavation and Embankment," unless otherwise required by the contract. Place and compact the backfill material in accordance with 2105, "Excavation and Embankment."

Dispose of surplus excavated materials in accordance with 2105, "Excavation and Embankment."

2521.4 METHOD OF MEASUREMENT
The Engineer will measure each uniform thickness item separately by top surface area.

2521.5 BASIS OF PAYMENT
The Contract Unit Price for concrete or bituminous construction includes furnishing the materials and placement of the Work to the lines and grade of the Plan as specified.

The Department will pay for walks based on the following schedule:

Item No.:	Item:	Unit:
2521.501	___ in [___ mm] Concrete Walk	square foot [square meter]
2521.511	___ in [___ mm] Bituminous Walk	square foot [square meter]

2531 CONCRETE CURBING

2531.1 DESCRIPTION
This work consists of constructing cast-in-place concrete curbs, curb and gutter, medians, driveway pavement, and other similar traffic delineation or service items.

2531.2 MATERIALS
A Concrete 2461
For each method of placement, use the following mix designations:

A.1 Manual Placement ..... Mix No. 3F52

A.2 Slip-form Placement ..... Mix No. 3F32

B Reinforcement Bars 3301

C Steel Fabric 3303

D Preformed Joint Filler 3702

E Curing Materials

E.1 Burlap Curing Blankets 3751

E.2 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound 3754

E.3 Linseed Oil Membrane Curing Compound 3755

E.4 Plastic Curing Blankets 3756

F Granular Materials 3149

2531.3 CONSTRUCTION REQUIREMENTS
A Foundation Preparations
Excavate, shape, and compact the foundation to a firm, uniform bearing surface that conforms to the dimensions and grade shown on the plans and in accordance with 2105, "Excavation and Embankment," 2112, "Subgrade Preparation," and 2211, "Aggregate Base."

B Forms
Provide forms, made of metal, wood, or other materials in accordance with 1805, "Methods and Equipment," capable of maintaining the concrete until the concrete can retain its molded shape. Provide side forms with a depth at least equal to the edge thickness of the concrete being formed. Support the forms on the foundation and restrain at the line and grade as shown on the plans.

For curves with a radius no greater than 100 ft [30 m], use flexible or curved forms approved by the Engineer.

Before placing concrete, coat the contact surfaces of forms with an approved form treating material in accordance with 3902, "Form Coating Material."

C Placing and Finishing Concrete

The Concrete Contractor, or Subcontractor, shall have at least two people with a current ACI concrete flatwork technician or flatwork finisher certification, and at least one of them must be onsite for all concrete pours.

Immediately before placing the concrete wet the foundation and the forms.

Place the concrete in a manner that will prevent segregation. Consolidate the concrete to fill voids using hand tamping or internal vibrating. Strike-off the concrete to the grade shown on the plans, and float the surface smooth.

After the water sheen has disappeared, round joints and edges to the radii shown on the plans. Lightly brush concrete surfaces exposed to view to a uniform texture.

Keep side forms in place for at least 12 h after casting the concrete.

D Slipform Machine Placement

Instead of using fixed forms, the Contractor may use a slipform machine capable of placing and forming concrete to the dimensions, quality, workmanship, and appearance as required by the contract. Hand finish the surface to the finish and texture as required by the contract.

E Joint Construction

Place transverse expansion joints, filled with ½ in [13 mm] preformed joint filler material, at the ends of curved sections and at the ends of the curved portions of entrance and street returns. Place longitudinal expansion joints as shown on the plans. Place expansion joints with filler material at locations where the concrete surrounds or adjoins an existing fixed object, such as a fire hydrant, building foundation, or other rigid structure.

Provide contraction joints at the following intervals, except as otherwise shown on the plans:

(1) Adjacent to bituminous mainline, every 10 ft [3.0 m],
(2) Adjacent to concrete mainline, match the adjacent concrete pavement joints, and
(3) In solid median construction, every 10 ft [3.0 m].

Form or saw the contraction joints, as approved by the Engineer, to a depth of at least 2 in [50 mm] from exposed surfaces.

Construct joints perpendicular to the subgrade. Align joints with joints in adjoining work unless a ½ in [13 mm] preformed joint filler isolates the work. Place transverse joints at right angles to the longitudinal axis of the work, unless otherwise required by the contract.

Use an edging tool with a radius no greater than ½ in [13 mm] to round edges of longitudinal construction joints between a concrete median or gutter section and a concrete pavement.

Do not saw or seal longitudinal construction joints between a concrete median and concrete pavement, or between a gutter section and concrete pavement.

F Metal Reinforcement

Provide and place metal reinforcement as shown on the plans and in accordance with 2472, "Metal Reinforcement."

G Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 min of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2531.3.G.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 min after permanent removal of the forms or curing blankets, unless the contract requires otherwise.
(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2531.3.G.1.b, "Curing Blanket Method."

Failure to comply with these provisions will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the contract does not contain a separate contract item for *Structural Concrete*, the Department will apply a monetary deduction of $50.00 per cu. yd [$65.00 per cu. m] or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

G.1 Curing Methods

G.1.a Membrane Curing Method

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound with an approved airless spraying machine in accordance with the following:

(1) At a rate of 1 gal per 150 sq. ft [1 L per 4 m²] of surface curing area.
(2) Apply homogeneously to provide a uniform solid white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some Mn/DOT approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.

The Engineer will approve the airless spraying machine for use if it is equipped with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

If the Engineer determines that the initial or corrective spraying result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method at no additional cost to the Department.

G.1.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

G.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 36 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plan.

Protect the concrete from damage including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.3.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plans.

H Backfill Construction

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Perform vibratory operations and backfilling at least 72 h after placing the concrete or after the concrete reaches a compressive strength of at least 3,000 psi [20.7 Mpa]. The Engineer will cast, cure, and test the concrete control specimens in accordance with 2461.3.G.5.b, "Control Strength Cylinders." If damage results from any of these operations, the Engineer will suspend all operations until the Contractor takes corrective action and obtains the Engineer's approval of a new method. The Engineer may require removal and replacement of the damaged concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may use hand-operated concrete consolidation equipment and walk behind vibratory plate compactors 24 h after placing the concrete, and other equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

As soon as possible after the curing is complete and without subjecting the concrete work to damaging stresses, perform the backfill or embankment construction to the elevations as shown on the plans. Use suitable grading materials from the

excavations in accordance with 2105, "Excavation and Embankment," unless the contract requires otherwise. Place and compact the backfill material in accordance 2105, "Excavation and Embankment."

Dispose of surplus excavated materials in accordance with 2105, "Excavation and Embankment."

I Workmanship and Finish

Ensure the surface contour and texture of the completed concrete work is uniform and meets the lines and grades as shown on the plans. Finish the flow line surface of gutters to eliminate low spots and avoid entrapment of water.

The Engineer will use a 10 ft [3 m] straightedge to measure the surface. The Engineer will consider concrete work with deviations $^{3}/_{8}$ in [10 mm] or greater in any 10 ft [3 m] length of finish curb and gutter, either horizontal or vertical, as unacceptable work. Remove and replace unacceptable work as directed by the Engineer.

If the Engineer does not direct the removal and replacement of unacceptable work, the Engineer will reduce the contract unit price for the unacceptable concrete work in accordance with the following:

(1) For deviations from ⅜ in to $^{9}/_{16}$ in [10 mm to 14 mm], payment at 75 percent of the contract unit price; and
(2) For deviations greater than $^{9}/_{16}$ in [14 mm], payment at 50 percent of the contract unit price.

2531.4 METHOD OF MEASUREMENT

The Engineer will not make deductions for castings or minor fixtures in the work.

A Length

For curbs and curb and gutter, including the curb returns, the Engineer will measure the length along the face of the curb at the gutter line. In the case of transitions from one size or design to another, the Engineer will measure the entire transition for payment under the item with the higher contract unit price.

For solid medians and other construction with uniform widths and symmetrical cross sections, the Engineer will measure the length along the center of the longitudinal axis. Unless a variance from the basic design results in an increased cross-sectional area, the Engineer will include the measurements of short sections of modified design, such as tapers and depressions, for payment with the basic design if the contract does not contain a separate pay item for the modified design.

B Area

For area measurements, the Engineer will measure the staked length and the extreme width between the outside faces as shown on the plans. The Engineer will disregard variations in concrete thickness caused by integral construction. The Engineer will separately measure driveway pavement of each specified thickness.

2531.5 BASIS OF PAYMENT

The Contract Unit Price for concrete construction includes furnishing the materials and placement of the Work to the lines and grade on the plans as specified.

The Department will pay for concrete curbing, median, and driveway construction on the basis of the following schedule:

Item No.	Item:	Unit:
2531.501	Concrete Curb and Gutter, Design	linear foot [meter]
2531.502	Concrete Curb, Design	linear foot [meter]
2531.503	Concrete Median	square yard [square meter]
2531.505	Concrete Median	linear foot [meter]
2531.507	____ in [mm] Concrete Driveway Pavement	square yard [square meter]

2533 CONCRETE MEDIAN BARRIERS

2533.1 DESCRIPTION

This work consists of constructing or reconstructing cast-in-place or precast median barriers for traffic lane separation.

2533.2 MATERIALS

A Concrete **2461**

A.1 Fixed Form Cast-In-Place ..... **Mix No. 3M52**

A.2 Slipform Placement ..... **Mix No. 3M12**

A.3 Precast ..... **Mix No. 3M82**

B Reinforcement Bars **3301**

C Dowel Bars **3302**

D Precast Concrete Median Barrier **3630**

E Curing Materials

E.1 Burlap Curing Blanket **3751**

E.2 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound **3754**

E.3 Linseed Oil Membrane Curing Compound **3755**

E.4 Plastic Curing Blankets **3756**

F Granular Materials **3149**

2533.3 CONSTRUCTION REQUIREMENTS

A General

The Contractor may combine cast-in-place and precast concrete construction as approved by the Engineer if the plans do not specify the construction type and if the construction maintains structural strength, continuity, or both.

Use a tongue and groove joint with tied dowels or reinforcement bars or other positive connection to interlock the connection between a new median barrier and an existing barrier to prevent movement, as approved by the Engineer.

Excavate, shape, and compact the foundation to a firm, uniform bearing surface and grade as shown on the plans and in accordance with 2105, "Excavation and Embankment," 2112, "Subgrade Preparation," and 2211, "Aggregate Base."

B Cast-In-Place Fixed Form Construction

Provide forms made of non-reactive metal, wood, or other material in accordance with 1805, "Methods and Equipment," capable of maintaining the concrete until the concrete can retain the molded shape. Provide side forms with a depth at least equal to the edge thickness of the formed concrete. Support the forms on the foundation to maintain the concrete line and grade as shown on the plans. Before placing the forms, coat the contact surfaces of the forms with an approved form treating material in accordance with 3902, "Form Coating Material."

Wet the foundation and forms immediately before placing the concrete.

Prevent segregation during placement of concrete. Use internal vibration to consolidate the concrete and fill voids. Strike-off the concrete to the grade as shown on the plans and float the surface smooth. When the concrete can retain the molded shape, remove the forms from the roadway face of the median barrier. Keep non-roadway face forms in place for at least 12 h after casting the concrete.

Round concrete edges to the radii as shown on the plans after removing the roadway face forms.

C Cast-In-Place Slipform Construction

Rather than using fixed forms, the Contractor may use a slipform machine capable of placing and forming concrete to the dimensions, quality, workmanship, and appearance as required by the contract. Hand finish the concrete surface to the finish and texture as required by the contract.

D Surface Finishes

D.1 Cast-In-Place

Apply an ordinary surface finish in accordance with 2401.3.F, "Finish of Concrete," on cast-in-place concrete median barriers.

D.2 Precast

Place the barrier in its final location. Obtain the Engineer's approval of the surface condition of the barrier before applying the special surface finish treatment on precast concrete median barrier in accordance with 2401.3.F, "Finish of Concrete."

E Concrete Curing and Protection

When the contract requires additional surface finishing (i.e. painting), cure in accordance with 2533.3.E.1.b. "Curing Blanket Method."

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 min of concrete placement or once the bleed water has dissipated, unless otherwise directed by the Engineer in accordance with 2533.3.E.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 min after permanent removal of the forms or curing blankets, unless the contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2533.3.E.1.b, "Curing Blanket Method."

Failure to comply with these provisions will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the contract does not contain a separate contract item for *Structural Concrete*, the Department will apply a monetary deduction of $50.00 per cubic yard [$65.00 per cubic meter] or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

E.1 Curing Methods

E.1.a Membrane Curing Method

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound with an approved airless spraying machine in accordance with the following:

(1) At a rate of 1 gal per 150 sq. ft [1 L per 4 m²] of surface curing area.
(2) Apply homogeneously to provide a uniform solid white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some MnDOT approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.

The Engineer will approve the airless spraying machine for use if it is equipped with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

If the Engineer determines that the initial or corrective spraying result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method, at no additional cost to the Department.

E.1.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

E.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

E.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 36 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plan.

Protect the concrete from damage including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

E.3.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plans.

F Workmanship and Finish

The Engineer will use a 10 ft [3 m] straight edge to measure the surface. The Engineer will consider horizontal or vertical irregularities of $^{5}/_{16}$ in [8 mm] or greater in the surface of any 10 ft [3 m] length of the finished concrete median barrier as unacceptable work. Remove and replace extensive (more than 10 percent of the median barrier length) with deviations greater than ½ in [13 mm]. Remove and replace unacceptable work as directed by the Engineer.

If the Engineer does not direct removal of unacceptable work, the Contractor may leave the work in place and the Department will make the following adjustments to the contract unit prices:

(1) For deviations from $^{5}/_{16}$ in [8 mm] to ½ in [13 mm], 75 percent of the contract unit price, and
(2) For minor areas (equal to or less than 10 percent of the median barrier length) with deviations greater than ½ in [13 mm], 50 percent of the contract unit price.

2533.4 METHOD OF MEASUREMENT

The Engineer will lineally measure each Type A and Type AA concrete median barrier on the top of the barrier, measured along the midpoint of the top width. The Engineer will lineally measure Type A barrier with glare screen in accordance with Type A and Type AA barrier or measured along both sides the barrier with a computed average of both measurements. The Engineer will take both measurements at the interface of the barrier and adjacent pavement. The Engineer will lineally measure transitions, and special and modified barriers by the length on the top of the barrier, measured along the midpoint of the top width.

The Engineer will separately measure each type of concrete median barrier.

When portable median barrier is removed from the Project roadway and the Engineer directs stockpiling the portable median barrier on or near the Project site for use again in a later phase of the work, the Engineer will separately measure the stockpiled length of barrier and also the length of barrier re-installation on the Project roadway. The Engineer will only measure the stockpiled barrier when the contract unit price for double payment of Relocate Portable Precast Concrete Barrier, Design 8337* and/or Relocate Portable Precast Concrete Barrier, Design 8337* - Anchored would equate to lower price than furnishing Portable Precast Concrete Barrier, Design 8337*.

2533.5 BASIS OF PAYMENT

The Contract Unit Price for concrete median barrier construction includes furnishing the materials, placement of the Work to the lines and grade on the plans, and surface finish as specified.

The Contract Unit Price for portable precast concrete barrier includes all costs of installation and removal once.

The Contract Unit Price for relocating portable precast concrete barrier includes all removing, stockpiling and reusing as directed by the Engineer.

The Department will pay for concrete median barrier on the basis of the following schedule:

Item No.:	Item:	Unit:
2533.501	Concrete Median Barrier, Design ___* Type ___‖	linear foot [meter]
2533.506	Concrete Median Barrier and Glare Screen, Design ___* Type ___‖	linear foot [meter]
2533.507	Portable Precast Concrete Barrier, Design ___*	linear foot [meter]
2533.508	Relocate Portable Precast Concrete Barrier, Design ___*	linear foot [meter]

* Current standard plate
‖ Type A, Type AA, Type AL, Transition, A Step, or AA Step

2535 BITUMINOUS CURB

2535.1 DESCRIPTION
This work consists of constructing a curb using bituminous material.

2535.2 MATERIALS
Use the same type of bituminous mixture for the curb as the type specified for the pavement wearing course in accordance with 2360, "Plant Mixed Asphalt Pavement."

2535.3 CONSTRUCTION
A Tack
Apply a tack coat as specified in 2357, "Bituminous Tack Coat," on the pavement wearing course beneath the curb.

B Equipment
Place bituminous curb using an automatic curb machine that shapes and compacts the mixture to the profile shown on Standard Plate 7065. The Contractor may only manually place the bituminous curb in locations unreachable by the machine, if approved by the Engineer.

C Finishing
Place curb uniform in appearance and texture, and true to line and grade.

2535.4 METHOD OF MEASUREMENT
The Engineer will measure bituminous curb by length along the face of the curb at gutter line.

2535.5 BASIS OF PAYMENT
The contract linear foot [meter] price for *Bituminous Curb* includes the cost of construction and providing the bituminous mixture.

The Department will pay for bituminous curb on the basis of the following schedule:

Item No.:	Item:	Unit:
2535.501	Bituminous Curb	linear foot [meter]

2545 LIGHTING SYSTEMS

2545.1 DESCRIPTION

A General

This work consists of constructing lighting systems and electric service systems as specified in the contract.

B Qualifications of Workers

The provisions of 1802 are hereby supplemented with the following:

Signal and Lighting Certification: When the Contractor is working on Traffic Signal System(s) or Lighting System(s), provide at least one Contractor employee on the site who is MnDOT Signal and Lighting Certified to perform or directly supervise the installation and testing of any MnDOT Traffic Signal System or Lighting System.

MnDOT's Office of Traffic, Safety, and Technology (OTST) provides Signal and Lighting Certification. For information contact OTST at phone number (651) 234-7055.

C Definitions

Refer to 1102, "Abbreviations," and 1103, "Definitions," and this section for the definitions of abbreviations, words and phrases pertaining to lighting systems and related work.

Refer to the National Electric Code, article 100 for the definition of the term "Listed."

Refer to the National Electric Code, article 100 for the definition of the term "Labeled."

Refer to the National Electric Code, article 100 for the definition of the term "Service."

Use a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. Ensure the testing laboratory is listed by OSHA in its scope of recognition for the tests conducted as required by this section (2545).

Use the definitions in these referenced publications unless otherwise defined in these Standard Specifications or the contract.

Bell End
The end of a piece of rigid PVC conduit that flares out to allow connection of an additional piece of conduit.

Cut Sheet, Catalog Sheet, or Specification Sheet
A document showing a finished product including part numbers and an ordering matrix if required.

Lighting System
A complete lighting system consisting of lighting units, lighting service cabinet, electrical conductors and other components required for complete and operational lighting system.

End Bell
The rigid PVC conduit fitting that is glued on at the end of a conduit to protect the conductors during pulling operations.

Feed Point
The lighting service cabinet which includes the point of connection between the service conductors and the circuitry of the lighting system.
HPS – High Pressure Sodium.

LED – Light Emitting Diode

Lighting Service Cabinet
A NRTL listed enclosure containing electric power distribution components and control circuitry for lighting systems.

Light Pole
The light pole, which may include other external attachments such as transformer base and a mast arm(s) or davit(s).

Lighting Unit
Includes the light pole, internal wiring with fuse holder and fuse to the luminaire, above ground splices, wire holder, stainless steel woven wire cloth, and luminaire. Underpass luminaires are lighting units even though they do not include some of these components. The foundation is not considered as part of this definition.

Shop Drawing
A detailed document showing how a specific product will be fabricated and constructed. This document will also include required material specifications and requirements.

Source of Power (S.O.P.)
The electric utility transformer.

D Electrical Distribution System

Provide a distribution circuit of the lighting system consisting of three conductors plus an equipment grounding conductor (EGC). Configure the conductors to constitute a photoelectric controlled 120 V or 240 V circuit as shown on the plans. Install branch circuit conductors or cables with equipment grounding to each light pole and underpass luminaire.

2545.2 MATERIALS

A General

A.1 Regulations and Code

Provide electrical equipment in accordance with 2565.2, "Traffic Control Signals, Materials," and meeting the applicable requirements of IES, ANSI, ICEA, AASHTO, or ASTM.

Provide copper electrical conductors based on the American Wire Gage (AWG) wire sizes for electric systems as specified in the contract

A.2 Materials and Electrical Equipment List 2565.2

A.3 Material Samples for Testing.....2565.2

A.4 Tests.....2565.2

A.5 Warranties, Guarantees, and Instruction Sheets

In addition to the individual warranties provided by product manufacturers, provide warranties, guarantees, and instruction sheets in accordance with 2565.2, "Traffic Control Signals, Materials," warrant and guarantee in-service operation of all materials and electrical equipment for 1 year beginning with the "turn-on" of the lighting system. The Department defines "turn-on" as the time when the complete and operational lighting system meets all installation, operational, and testing requirements specified in the contract.

A.6 MnDOT's Approved/Qualified Products List

Access lighting system materials listed on MnDOT's Approved/Qualified Products List.

A.7 Shop Drawing Submittals

Prepare shop drawing submittals in accordance with 1502 for all products not on MnDOT's Approved/Qualified Products List (APL).

Submit products showing compliance with contract documents. Review shop drawings for accuracy, completeness, and compliance with contract documents prior to submittal.

A.8 MnDOT Approved Products Materials List

Before performing the Work, submit to the Engineer, in accordance with 1502, a Signals and Lighting product materials list of the products selected from MnDOT's Approved/Qualified Products List to be used on the Project for Signals and Lighting. Ensure the products selected meet the requirements of this section.

For MnDOT's approved products, see MnDOT's Approved/Qualified Products website.

In the Signals and Lighting product materials list submitted to the Engineer, provide the following information:

(1) Title the document "MnDOT's Approved/Qualified Products List for Signals and Lighting," centered at the top of the document.

(2) Directly under the title include the Trunk Highway, County, and State Project number.

(3) For each product listed from MnDOT's Approved/Qualified Products List, provide a separate line that includes the following:

- (3.1) Name of the manufacturer,
- (3.2) Name of the product,
- (3.3) Catalog number, and
- (3.4) Quantity ordered for the project.

This submittal and the Engineer's review of the submitted list do not relieve the responsibility for providing products that comply with MnDOT's Approved/Qualified Products List.

A.9 Cut Sheets, Catalog Sheets, or Specification Sheets

Provide cut sheets, catalog sheets, or specification sheets for MnDOT's Approved/Qualified Products List products to the Engineer upon request.

B Hardware

Galvanize ferrous metal hardware, except stainless steel, in accordance with 3392, "Galvanized Hardware."

B.1 Fasteners **3391**

B.2 Lighting System Anchorages **3813**

B.2.a Lighting Service Cabinet Cast-In-Place Equipment Pad Anchorages **3813.A**

B.2.b Lighting Service Cabinet Precast Equipment Pad Anchorages **3813.B**

B.2.c 4 Bolt Anchorages for Light Pole Foundations **3813.C**

B.2.d 6 Bolt Bridge and Barrier Anchor Bolt Clusters **3813.D**

B.2.e Light Pole Steel Screw-In Foundation and Fasteners **3813.E**

B.2.f Anti-Seize Lubricant

Coat the threaded portions of anchor rods above concrete foundations with a brush-on anti-seize lubricant meeting the requirements of MIL-PRF-907E before installing lighting service cabinets, lighting units, or other cabinets on the anchor rods.

B.3 Cap Screws, Set Screws, and Tap Bolts

Provide commercial brass or bronze cap screws, set screws, and tap bolts. Provide galvanized steel or commercial brass washers.

C Conduit and Accessories

C.1 Rigid Steel Conduit (RSC) **3801**

C.2 Intermediate Metal Conduit (IMC) **3802**

C.3 Non-metallic Conduit Rigid PVC and HDPE **3803**

C.4 Liquid Tight Flexible Non-Metallic Conduit (LFNC-B) **3804**

C.5 PVC Coated Hot Dipped Galvanized Rigid Steel Conduit (PVC Coated RSC) **3805**

C.6 Electrical Junction Boxes **3838**

Provide malleable iron metal electrical boxes and conduit bodies as shown on the plans.

C. 7 Conduit Expansion and Deflection/Expansion Fittings **3839**

D Electrical Cables and Conductors

Provide conductors for feeders and branch circuits sized in accordance with the NEC and as follows:

(1) Provide No. 8 or larger conductors for feeders.
(2) Provide No. 12 or larger conductors for branch circuits.

D.1 Direct Buried Lighting Cable **3815**

D.2 Electrical Conductors **3815**

D.3 Overhead Lighting Cable **3815**

E Light Poles **3811**

Provide light poles of the style and type required by the contract.

F Luminaires **3810**

Provide luminaires of the style and type required by the contract.

F. 1 Lamps

Provide lamps in accordance with 3810 and in the wattage and of the type specified for the luminaires in the contract.

G Concrete **2565.2E**

H Service Equipment **3837**

I (Blank)

J Type A Service Cabinet **3850**

K Type B Service Cabinet **3850**

L Type L1 Service Cabinet **3850**

M Type L2 Service Cabinet **3850**

N Type Rural Lighting and Flasher (RLF) Service Cabinet **3850**

O (Blank)

P Electrical Junction Boxes **3838**

Q Wood Poles **3840**

R Handholes **3819**

Use only handholes for non-deliberate heavy vehicular traffic unless otherwise indicated in the Plans. Emboss "MnDOT Lighting" on the cover.

S Pulling Vaults

Provide pulling vaults specified in the contract and listed on MnDOT's Approved/Qualified Products List under "Traffic Management Systems/ITS."

Emboss "MnDOT Lighting" on the cover.

T Photoelectric Control **3812**

U Miscellaneous Materials

If the contract does not specify requirements for materials and electrical equipment, provide these materials and equipment as approved by the Engineer.

V Safety Switch **3837**

W Lighting Units

Provide lighting units which include the following:

(1) Light poles in accordance with 3811.
(2) Luminaires and lamps (if required) in accordance with 3810.
(3) Wire holders, and fuse holders in accordance with 3812.
(4) Miscellaneous equipment required for installation as specified in the contract.

X Stainless Steel Woven Wire Cloth **3836**

Y Air Obstruction Lights **3816**

Z Navigation Lanterns **3817**

AA Luminaire Wire Holders **3812**

BB Insulated Wire Splice Connector Blocks **3812**

CC Fuse Holders **3812**

DD Grounding Electrodes (Ground Rods and Plate Electrodes) **3818**

EE Power Cable Splice Encapsulation Kits

Only use Department-approved power cable splice encapsulation kits on MnDOT's Approved/Qualified Products List under "Roadway lighting."

FF Sponge Rubber Expansion Joint **3841**

2545.3 CONSTRUCTION REQUIREMENTS

A General

The contract indicates approximate locations of component parts. The Engineer will establish the exact locations on the project.

Do not perform work on the project until all underground utilities have been located in accordance with 1507, "Utility Property and Service."

If damage due to Contractor's negligence occurs to electrical cable, within 24 hours replace the entire run of lighting system electrical cable at no additional cost to the Department.

If damage due to Contractor's negligence occurs to individual conductor(s) in conduit and to the conduit, or only to the conduit, within 24 hours replace all the individual conductors in the conduit and the conduit at no additional cost to the Department.

Do not splice electrical cable and bury underground.
Do not splice damaged conductors and place back in conduit.

Keep highways, streets, and roads open to traffic during construction in accordance with 1404, "Maintenance of Traffic." Protect any openings or uncompleted work that may cause a hazard to vehicle or pedestrian traffic as approved by the Engineer.

A.1 Compliance with Electrical Codes and Standards.....2565.3

A.2 Permits and Inspections.....2565.3

A.3 Utility Property and Service.....2565.3

A.4 Installation Requirements.....2565.3

A.5 Removal Requirements 2104

B Existing Electrical Systems.....2565.3

Maintain and keep in operation the new and existing lighting system within the limits of the project in accordance with 1514, "Maintenance During Construction," but not including 1404.7, "Winter Suspension", until the Engineer accepts the project in writing as specified in 1716, "Contractor's Responsibility for Work." Maintain and keep in operation new and existing lighting systems during periods of suspension at no additional cost to the Department. Maintenance of the new and existing lighting system includes the following:

(1) Lighting units,
(2) Lamps (after at least 30 percent of the lamps burn out),
(3) Lighting service cabinets,
(4) Photoelectric controls,
(5) Foundations and equipment pads,
(6) Electrical Cable, and conductors,
(7) Electrical conduit, and,
(8) Damage and knockdowns resulting from Contractor operations.

The Department considers maintenance of the lighting system as incidental work, included in the unit prices of the pay items that are part of the lighting system.

If the Engineer determines that others, not the Contractor, have damaged the work, maintain and repair damage as directed by the Engineer. The Department will pay for the maintenance and repair the damage as extra work in accordance with 1402, "Contract Revisions."

Provide the Department with the names and phone numbers of contact personnel for both day and night operation for the maintenance of the existing lighting system.

C Excavation and Backfill 2565.3

D Conduit, Fittings, and Junction Box Installation 2565.3

E Handhole Installation.....2565.3

Install a handhole within a direct buried cable run if required by the contract. Install a PVC conduit stubout with the following characteristics for each cable entering and exiting the handhole:

(1) 2 in [50 mm],
(2) At least 36 in [1 m] long, and
(3) Non-metallic end bells on each open end to prevent damage to the direct buried cable.
(4) Conduits entering handholes or pulling vaults must enter thru the barrel or side wall of the enclosure.

Install the approved power cable splice encapsulation kit for direct buried cable and individual conductors for splices in handholes and pulling vaults in accordance with contract documents.

When pulling vaults are required, adjust the compacted aggregate drain bed to match the size and shape of the pulling vault. Make the drain bed 6 inches wider than the base on all sides of the pulling vault.

F Concrete Light Foundation and Equipment Pad Installation

F.1 General

Construct light foundations and equipment pads in accordance with 2565.3, "Traffic Control Signals, Construction Requirements," and as specified in the Contract, and in accordance with following:

Use a rigid metal template to properly align anchor rods, conduits, and ground rod electrode. Leave the rigid metal template in place until concrete has cured.

Orientate roadway light foundation anchor rods so that mast arms or davits of light poles are perpendicular to the centerline of the roadway unless specified elsewhere in contract documents.

F.2 Light Foundations

For light foundations provide one 2 in [50 mm] rigid PVC conduit 90 degree elbow and 6 in to 8 in stubout for each direct buried cable that enters the foundation. Provide one spare 2 in [50 mm] rigid PVC conduit 90 degree elbow, capped at each end, for expansion of the lighting system. Install non-metallic end bells on each open end of the 2 in rigid PVC conduits.

Install roadside light foundations located in the clear zone in accordance with the most current edition of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, Breakaway Supports" and as follows:

Foundations placed on roadside slopes must not allow impacting vehicles to snag on either the foundation or anchor rods. Shape the terrain around the foundations to ensure anchor rods do not project more than a maximum of four (4) in above a horizontal line between the straddling wheels of a vehicle on 60 in centers. The horizontal line from wheel to wheel connects any point on the ground surface on one side of the light standard foundation, including anchor rods, to a point on the ground surface on the other side of the light standard foundation, including anchor rods. The horizontal line is aligned radially or perpendicular to the centerline of the roadway.

Use erosion control products to reinforce vegetation around the foundations in accordance with 3385, "Rolled Erosion Control Products".

F.3 Equipment Pad

Install a ground rod electrode in the load side of the equipment pad. Install a second supplemental ground round electrode outside of the equipment pad not less than 8 ft from the outer edge of the equipment pad with the upper end of the ground rod electrode 3 in to 6 in below ground line or 7 in to 8 in if under sidewalk.

Provide a continuous grounding electrode conductor without a splice or joint, terminating one end to the ground busbar in the service cabinet, then connecting it to the ground rod electrode in the equipment pad, and terminating the other end to the supplemental ground rod electrode. Provide NRTL listed clamps or exothermic welded connections to connect or terminate the grounding electrode conductor to the ground rod electrodes.

If the equipment pad requires reinforcement bars as specified in the contract, provide a continuous grounding electrode conductor without a splice or joint, terminating one end to the reinforcement bar in the pad, then connecting it to the busbar in the lighting service cabinet as specified in the contract. Use NRTL listed clamps for concrete encasement or exothermic welded connections suitable to connect to the reinforcement bar.

Provide rigid PVC conduit raceway to carry the grounding electrode conductor as specified on the Standard Plates.

Use RSC conduit between a pole mounted transformer S.O.P. and the lighting service cabinet.

Use rigid PVC conduit between a pad mounted transformer S.O.P. and the lighting service cabinet.

Install threaded insulated grounding bushings with lay in ground lugs on all RSC conduit ends.

Install end bells on all rigid PVC conduit ends.

G Wiring and Conductor Installation

G.1 General

Install wiring and conductors in accordance with 2565.3, "Traffic Control Signals, Construction Requirements," and the following:

Run three (3) No. 2 AWG service conductors in a separate 2 in RSC conduit system from other conductors.

The Contractor may place separate lighting branch circuits in a single conduit, maintaining the electrical independence of the circuits. Run conductors of a lighting branch circuit in a single conduit.

G.2 Underground Wiring Direct Buried Lighting Cable, Conductors, and Conduit

Trench or plow to install direct buried lighting cable to a depth of at least 2 ft [0.6 m]. If plowing, provide a vibratory plow with a feed blade that is capable of performing the following:

(1) Breaking the ground,
(2) Placing the cable to a predetermined depth,
(3) Guiding the cable into the bottom of the break through the guide blade chute so that little or no stress is placed on the cable during installation to avoid damage,
(4) Not pulling the cable in place,
(5) Placing a warning tape 12 in [0.3 m] above the cable, and
(6) Closing the break in the ground.

Feed the cable through the plow blade chute and ensure the plow blade does not pull the cable. Obtain the approval of the Engineer for the plowing method before installing the cable.

If encountering solid rock or other obstructions, install the cable in a 3 in conduit at least 6 in [153 mm] deep with a 2 in [50 mm] thick concrete slab above conduit, Install conduit underground when required in accordance with 2565.3.

Install direct buried lighting cable in rigid PVC or HDPE conduit if located under bituminous, concrete, or other material not considered a top soil. Provide 3 in conduit if the contract does not specify size of conduit.

Install direct buried lighting cable or conductors in conduit at the same distance behind the bituminous shoulder or back of curb as the light foundations. When an obstruction has been encountered in the path of the direct buried lighting cable or conduit, re-route the direct buried lighting cable or conduit around the obstruction away from the roadway.

Install an additional 2 ft [600 mm] of slack direct buried lighting cable near the light foundation in an "S" shape before the cable enters the foundation conduit.

Install plastic warning tape meeting the following characteristics at least 12 in (300mm) above the direct buried lighting cable or conduit.

(1) 3 in (75 mm) wide,
(2) Permanent Red,
(3) Stretchable,
(4) Non-biodegradable, and
(5) Imprinted with the inscription," CAUTION-MnDOT LIGHTING CABLE BELOW"

Extend direct buried lighting cable 2 ft [600 mm] above the top of the light foundation. Leave in place a minimum of 4 in [100 mm] and a maximum 6 in [152 mm] of the outer jacket extending above the conduit.

Pull single conductors directly from reels or spools. Do not pull off and lay conductors on the ground before installation.

Install direct buried lighting cable from the reel or spool immediately into the ground. Do not lay direct buried lighting cable for the new lighting system on the ground and use as temporary.

Install conductors in conduit with sufficient slack to allow for contraction.

Run an equipment grounding conductor through conduit as shown in the plans. Electrically bond the equipment grounding conductor to all metal poles and equipment along the run.

Install conduit expansion and deflection/expansion fittings with an internal grounding jumper in sections of conduit raceway shown on the plans and in accordance with 3839 "Conduit Expansion and Deflection/Expansion Fittings."

Pull conductors through conduit or raceways by hand to prevent damage to the conductors or their covering. Provide end bells on PVC conduit openings and prevent damage to the end bells when pulling conductors. Provide threaded insulated grounding bushings with lay in ground lugs for RSC. Ensure the conduit is clean and dry when installing the conductors. Ensure the cable or conductors are clean and dry. Use a liquid wire pulling lubricant when placing conductors or cable assemblies.

Mark the new construction of the direct buried lighting cable and conduits with red flags and red paint immediately after installation. Throughout the course of the project protect and preserve the locate flags and paint on the newly installed underground lighting facilities. In the event the locate marks have been obliterated or are obscured or missing refresh and remark the area.

G.3 Above Ground Wiring

G.3.a Light Pole Wiring

Provide one continuous length without splice 12-2 (with ground) UF cable within the roadway light pole from the required terminations in the light pole base to the luminaire.

Provide a MnDOT approved luminaire wire holder that supports the luminaire cable/conductors within the end of the light pole tenon near the connection point of the luminaire.

Provide a fuse holder listed on MnDOT's Approved/Qualified List under "Roadway lighting" with fuse and position the fuse holder inside the light pole base where it can be easily seen and removed when the access door is removed.

Use a 6 A 1.5 in X .406 in [38.1mm X 10.31mm] time delay cartridge fuse.

Connect the UF cable at one end by properly terminating the individual conductors to their designated tunnel lug terminals in the luminaire. At the other end of the UF cable, properly terminate the individual conductors to the correct circuit conductors located in the light poles base in accordance with the following:

(1) The individual black "Hot" conductor to the "Load" side terminal of the fuse holder,
  (1.1) After the conductor has been terminated to the fuse holder apply two layers of protective vinyl tape over the area where the conductor is terminated to the fuse holder,
  (1.2) Cover any uninsulated portion of the fuse holder barrel and extend the wrap at least 1 in over the incoming conductor insulation,
(2) The individual white "neutral" conductor to above ground white "neutral" circuit conductor, and
(3) Bare grounding conductor to the equipment grounding conductor splice.

Provide a continuous, without splice, short piece of 10 AWG stranded insulated conductor and terminate one end to the "Hot" branch circuit conductor splice located in the light pole base. Properly terminate the other end of the conductor to the "Line" side terminal of the fuse holder. Cover any uninsulated portion of the fuse holder barrel and extend the wrap at least 1 in over the incoming conductor insulation.

G.3.b Temporary Overhead Lighting Cable

The Contractor may use aluminum conductor, steel reinforced (ACSR) cable meeting the requirements of 3815, "Electrical Cables and Conductors," to provide temporary power distribution through aerial lines. Do not support overhead light cable by the luminaires.

G.4 Splices

Do not splice unless required by the contract or approved by the Engineer. If required by the contract or approved by the Engineer, only splice in handholes, pulling vaults, service cabinets, junction boxes, or in bases of poles.

Do not splice underground cable unless specifically required by the contract.

G.4.a Above Ground Splices

Provide electrical splices for conductors and cables as required by the contract.

(1) Electrically and mechanically secure splices without solder, except loop detector splices.
(2) Use split bolt connectors or other connector types with splices as specified in the contract.
(3) Do not use pressure spring type connectors.
(4) Unless otherwise required by the contract, use self-fusing electrical insulation putty tape to insulate spliced conductors, except grounding wires, to a thickness of at least 1.5 times that of the original insulation.
(5) Apply two layers of protective plastic electrical tape over the self-fusing electrical insulation putty tape and extend at least 1 in [25 mm] over the regular conductor insulation.
(6) Use waterproof electrical coating to waterproof the entire splice.

If required by the contract for a temporary system, provide NRTL listed connectors designed to prevent direct contact between the aluminum and copper conductors for splices between aluminum and copper conductors. Provide NRTL listed terminals for use with aluminum wire for terminals used on aluminum conductors. Tighten the connections to the manufacturer recommended torque.

The Contractor may substitute insulated wire splice connector blocks in the roadway lighting pole bases with approved insulated wire splice connector blocks listed on MnDOT's Approved/Qualified Products List under, "Roadway lighting.

Apply two layers of protective vinyl electrical tape over the insulated wire splice connector block in the area where the conductors enter the block. Extend the wrap at least 1 in over the incoming conductor insulation.

G.4.b Under Ground Cable Splices

Unless specified in the contract or approved in writing by the District Traffic Engineer, do not use underground splices. Provide power cable splice encapsulation kits listed on MnDOT's Approved/Qualified Products List under "Lighting" if the contract specifies or the Engineer approves the use of underground direct buried splices.

(1) Direct Buried Underground Cable Splice

Provide and install a direct buried underground cable splice as shown on the plan and as follows:

(1.1) Splice each individual cable together using a NRTL listed compression–type butt splice barrel connector that is rated for the size of conductor being spliced.

(1.2) Crimp the barrel connector to the conductors using the manufacturer specific compression tool.

(1.3) Cover the entire wire splice with appropriately sized shrink tubing. The shrink tubing must also cover a minimum of ¼ in of the conductor insulation on both sides of the splice. After the tubing is slid into position, heat-shrink to form a tight seal around the splice and the insulation of the conductor on both sides of the splice.

(1.4) Wrap each conductor splice, after compression and installation of the shrink tubing, with at least two layers of electrical tape to insulate individual conductors prior to encapsulation.

(1.5) Splice together the shielding by drilling a hole in each piece of shield and then bolting the pieces together using brass nuts, bolts, and flat washers to form an electrical bond between the two pieces. The bolt head faces the cables and the shaft of the bolt faces outward.

(1.6) Assemble all splices per the manufacturer's installation instructions.

(1.7) Place the entire cable splice inside the approved power cable splice encapsulation kit, ensuring that when the encapsulating material is poured in the mold it seals up the conductor splices, cable shield and the outer jacket of the direct buried lighting cable and forms one complete assembly. Ensure that no individual conductor insulation or cable shield is exposed when the splice is complete.

(1.8) Provide Power Cable Splice Encapsulation Kits listed on MnDOT's Approved/Qualified Products list under "Roadway lighting".

Assemble the power cable splice encapsulation kit per the manufacturer's installation instructions and as follows:

(1.8.1) Wrap electrical insulating tape around the end of each epoxy resin mold where it meets the outer jacket of the cable assembly to prevent epoxy from leaking out of the mold prior to curing.

(1.8.2) Allow the resin to harden and cool.

(1.8.3) Test all conductors of the splice to ensure compliance with MnDOT 2545.3K1.

(2) Two Way Underground Handhole Cable Splice

Provide and install a two way underground handhole cable splices as shown on the plan and as follows:

(2.1) Provide adequate slack in the cable assembly to allow each individual cable to extend at least 3 ft above the top of the hand hole prior to stripping the cable.

(2.2) Strip off the outer jacket of the cable assembly to within 6 inches of where the cable enters the handhole.

(2.3) Unwind the copper shield to within 6 in of where the cable enters the hand hole.

(2.4) Splice together the shielding by drilling a hole in each piece of shield and then bolting the pieces together with brass nuts, bolts and flat washers to form an electrical bond between the two pieces of copper shielding.

(2.5) Apply pole base terminal block coating to the entire shield splice point.

Provide Pole Base Terminal Block Coatings listed on MnDOT's Approved/Qualified Products list under "Signals"

(2.6) Splice each individual conductor of the 4 conductor cable assemblies separately.

(2.7) Maintain proper circuit color identification within each splice.

(2.8) Splice each conductor pair together using a NRTL listed compression–type butt splice barrel connector that is rated for the size of cable being spliced.

(2.9) Crimp the barrel connector to the conductors using the manufacturer specific compression tool.

(2.10) Separately encapsulate each individual conductor splice using a MnDOT approved loop detector splice encapsulation kit.

Provide Loop Detector Splice Encapsulation Kits listed on MnDOT's Approved/Qualified Products list under "Signals"

Assemble the loop detector splice encapsulation kit per the manufacturer's installation instructions and as follows:

Wrap electrical insulating tape around the end of each epoxy resin mold where it meets the outer jacket of the cable assembly to prevent epoxy from leaking out of the mold prior to curing.

Allow the resin to harden and cool.

Test all conductors of the splice to ensure compliance with MnDOT 2545.3K1.

(3) Three Way Underground Handhole Cable Splice

Provide and install a three way underground handhole cable splices as shown on the plan and as follows:

(3.1) Provide adequate slack in the cable assembly to allow each individual cable to extend at least 3 feet above the top of the hand hole prior to stripping the cable.
(3.2) Strip off the outer jacket of the cable assembly to within 6 in of where the cable enters the handhole.
(3.3) Unwind the copper shield to within 6 in of where the cable enters the hand hole.
(3.4) Splice together the shielding by drilling a hole in each piece of shield and then bolting the pieces together with brass nuts, bolts and flat washers to form an electrical bond between the two pieces of copper shielding.
(3.5) Apply pole base terminal block coating to the entire shield splice point.
Provide Pole Base Terminal Block Coatings listed on MnDOT's Approved/Qualified Products list under "Signals"
(3.6) Splice each individual conductor of the 4 conductor cable assemblies separately.
(3.7) Maintain proper circuit color identification within each splice.
(3.8) Splice the three conductors together using a NRTL listed Split Bolt splice connector that is rated for the size and number of the conductors being spliced**.**
(3.9) Ensure the split bolt is adequately tightened.
(3.10) Separately encapsulate each individual conductor splice using a MnDOT approved 3 way power cable splice encapsulation kit.
Provide 3 way power cable splice encapsulation kits listed on MnDOT's Approved/Qualified Products list under "Roadway lighting"
Assemble the 3 way power cable splice encapsulation kit per the manufacturer's installation instructions and as follows:
Wrap electrical insulating tape around the end of each epoxy resin mold where it meets the outer jacket of the cable assembly to prevent epoxy from leaking out of the mold prior to curing.
Allow the resin to harden and cool.
Test all conductors of the splice to ensure compliance with MnDOT 2545.3K1.

H Light Pole Installation

Set light poles plumb with balanced luminaires. Use a backward rake to counterbalance lateral deflection for poles with unbalanced luminaries or bracket arms.

Install light poles in accordance with the manufacturer installation requirements.

(1) Use shims or leveling nuts to adjust poles to the plumb position before anchoring in position. Only use shims in accordance with Standard Plate 8129 for leveling if installing aluminum light poles on light foundations.

(1.1) Install steel or stainless steel light poles on foundations using only leveling nuts and washers.
(1.2) Install aluminum light poles on foundations using only leveling shims.
(1.3) Ensure the access door of the transformer base is placed 180 degrees from the davit.
(1.4) Ensure the hold down and connecting washers are installed in their proper positions.

(2) Assemble and tighten the light poles to the foundation in accordance with manufacturer instructions and AASHTO "Structural Supports for Highway Signs, Luminaires, and Traffic Signals" Sixth Edition 2013 or the most current version, Section "5.17.5.2-Anchor Bolt Pretensioning" and as follows:

(2.1) Clean exposed part of anchor rods with a wire brush or equivalent.
(2.2) Ensure clean anchor rods and that nuts spin freely along the entire length of all anchor rods.
(2.3) Lubricate anchor rod threads with brush-on anti-seize compound meeting the requirements of MIL-PRF-907E.
(2.4) Install and level heavy hex leveling nuts for light bases that require leveling nuts.
Light bases that do not require leveling nuts skip steps 2.4 and 2.5.
(2.4.1) For steel poles ensure the clearance between the bottom of the leveling nuts and the top of the foundation is less than one bolt diameter.
(2.4.2) Stainless steel light poles on a Design E Foundation install leveling nuts a minimum 5/8 in to a maximum 7/8 in from bottom of the leveling nut to the top of the foundation. Use the minimum distance when possible.
(2.4.3) Stainless steel light poles on a Design H Foundation install leveling nuts a minimum 1/8 in to a maximum 5/8 in from bottom of the leveling nut to the top of the foundation. Use the minimum distance when possible.
(2.5) Install first set of washers for bases that require leveling nuts.
(2.6) Place base or light pole on to anchor rod cluster.
(2.7) Install second set of washers for steel and stainless steel light poles. Install hold down ½ in thick washers for aluminum light pole bases.
(2.8) Install and hand tighten heavy hex top nuts.
(2.9) Using "full force" and a standard 12 in long wrench, or a few impacts of an impact wrench, tighten top

nuts.

(2.10) Using "full force" and a standard 12 in long wrench, tighten leveling nuts when leveling nuts are required.

(2.11) Mark positions of top nuts in relation to its adjacent bolt. Tighten top nuts as follows:
For anchor rods ≤ 1 ½ in in diameter turn the nut one-sixth turn beyond tightening achieved in Steps 2.7 and 2.8.
For anchor rods > 1 ½ in in diameter turn the nut one-twelfth turn beyond tightening achieved in Steps 2.7 and 2.8.

(2.12) After 48 h, with the entire light pole completely assembled and installed, check the tightness of the nuts. Follow step 2.7, step 2.8, and step 2. 9 for additional tightening.

Ensure the end of the anchor rod extends beyond the outside surface of the top nut allowing for full nut engagement to the anchor rod. When the end of the anchor rod is inside the top nut, it is considered incomplete nut engagement and not acceptable.

For barrier and bridge light poles replace "heavy hex top nuts" and "top nuts" in steps 2.6- 2.9 with "first set of jam nuts." After following all steps up to 2.9, install "second set of jam nuts" and tighten as required in step 2.7.

(3) Provide and install Stainless Steel Woven Wire Cloth in accordance with 3836 in steel and stainless steel light pole bases as follows:

(3.1) Insert and wind around the transformer base opening to prevent rodent entry.

(3.2) Cut even and smooth and secure flush with;

(3.2.1) Self-tapping screws to the upper edge of steel transformer base openings, or

(3.2.2) #10 round head screw end stainless steel bolts and nuts in all four (4) equally spaced factory supplied punched holes along the upward lip of the base plate in stainless steel transformer base openings.

(3.3) Ensure the top edge of the woven wire cloth is smooth, flush with the top edge of the transformer base plate, and the bottom edge of the woven wire cloth is tight against the top of the concrete foundation.

(3.4) Overlap the ends of the woven wire cloth at least two (2) in and secure with either a small stainless steel or brass bolt and nut assembly to prevent movement.

(3.5) Bond the entire woven wire cloth assembly as required by the National Electrical Code (NEC).

(3.6) Fill voids between the stainless steel woven wire cloth and the pole base plate with clear 100% silicone sealant.

(4) For aluminum light pole bases do not install Stainless Steel Woven Wire Cloth.

(4.1) Fill any gaps as a result of using leveling shims that exceed a 1/8 in between the foundation and the aluminum light pole base with 100% clear silicone sealant. Do not completely seal around the perimeter between the foundation and aluminum light base.

Replace with new, damaged light poles, mast arms, brackets, or other appurtenances to the light pole as approved by the Engineer.

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J Sign Lighting Installation

J.1 General

Provide sign lighting as specified in the contract.

Use direct buried lighting cable to provide power distribution to the sign structure unless otherwise required by the contract.

Use PVC Coated Hot-Dipped Galvanized Rigid Steel Conduit and conduit fittings in accordance with 3805 and install in accordance with 2565.3 D6.

J.2 Safety Switch

Install the safety switch in accordance with 3837.2 and in a vertical upright position.

J.3 Safety Switch Wiring

Install 12 AWG conductors with a 12 AWG equipment grounding conductor in ¾ in [21 mm] conduit. Install ¾ in LFNC-B between the switch and the first luminaire. Use a wire nut and waterproof coating to splice. Make conduit connections waterproof.

Use a 12 AWG green insulated equipment grounding electrode conductor. Connect the No. 12 insulated grounding conductor to the grounding lug attached to the safety switch enclosure and isolated from the neutral terminal, and the grounding screw attached to each luminaire housing.

Run ¾ in [21 mm] conduit between the sign post and the safety switch. Install 12 AWG conductors between the switch and the sign base.

Splice the existing or new direct buried lighting cable to the conductors from the safety switch with split bolt type connectors as specified in 2545.3G.4. Insulate the splices to the same insulation level as for the power conductors. Waterproof the splices. Dress the splices in the center of the post and up from the base plate with enough excess conductor length to allow withdrawal of the splices through the access opening cover.

The Contractor may substitute insulated wire splice connector blocks in the sign post with approved splice connector blocks listed on MnDOT's Approved/Qualified Products List under, "Roadway lighting" for the specified split bolt connector specified in 2565.3.J.4, "Splices."

Perform a burn test as specified in 2545.3.K.2, "12-Hour Burn Test," after completing the new sign lighting systems for each feed point.

J.4 Lighting System Identification Plate (Overhead Sign)

Provide and install a lighting system identification plate as shown on the plans and in accordance with 2564 "Traffic Signs and Devices".

J.5 Safety Cable

Provide and install brackets, aircraft cable, and hardware required to assemble and attach a safety cable as specified in the plans in accordance with 2564, "Traffic Signs and Devices."

K Electrical System Testing and Acceptance

K.1 Megohm meter test (Test for unwanted grounds)

Perform a megohm meter test, at 500 VDC, indicating the insulation resistance of each circuit. Energize the megohm tester for 15 s on the circuits to check for breakdown of the circuits. Submit a written report of the megohm meter readings for the permanent record with the following information to the Engineer:

(1) Project number.
(2) Project location.
(3) Feedpoint number as shown in the plans.
(4) Branch circuit that identifies each lighting branch circuit being tested by indicating the number of the first light connected to that circuit, as shown on the plans.
(5) Phase conductor insulation resistance. Determine the phase conductor insulation resistance by measuring the resistance between the phase conductors, and the resistance between each phase conductor and the equipment ground bar in the service cabinet. Remove the fuses from the inline fuse connectors in the lighting poles before measuring. The Engineer will not allow a resistance less than 100 MΩ.
(6) Neutral conductor insulation resistance. Determine the neutral conductor insulation resistance by measuring the resistance between each neutral conductor and the equipment ground bar in the service cabinet. Remove the fuses from the inline fuse connectors in the lighting poles before measuring. The Engineer will not allow a resistance less than 100 MΩ.
(7) Circuit insulation resistance. Determine the circuit insulation resistance by measuring the resistance between each phase conductor and the equipment ground bar in the service cabinet. Leave the fuses in place in the lighting poles when measuring. The Engineer will not allow a resistance less than 100 MΩ.

Perform tests at the service cabinet, in the presence of the Engineer, with all grounding connections in place. Disconnect the phase and neutral conductors at the service cabinet for the insulation resistance tests.

If the tests indicate faulty insulation or a faulty connection within the circuit, correct and retest circuits at no additional cost to the Department. Replace circuits or circuit parts to make the circuits meet the test requirements at no additional cost to the Department.

K.2 12-Hour Burn Test

After completing the feed point and before the Department pays for greater than 90 percent of the feed point cost, energize the service cabinet and ensure the entire electrical system can successfully operate without interruption for 12 h during daylight. The Department considers the cost of power as incidental and will not separately pay for power costs to energize the electrical system for the 12-hour burn test.

L Service Equipment Installation

Install components of each lighting service cabinet and include miscellaneous hardware required for a complete lighting service cabinet installation. Coordinate the connection of power to each lighting service cabinet with the electric utility company to perform a visual inspection before making the service connection. Ensure the Contractor's electrician is present when the electric utility company makes the visual inspection.

Position the photocontrol to face north. The photocontrol may face east or west only if facing it north is not an option due to service cabinet orientation.

L.1 Type A or Type B Service Cabinet

Attach service cabinets Type A and Type B to wood poles or mounting bracket assemblies as required by the contract. Provide and install service equipment including the following:

(1) Meter socket in accordance with 3837, "Electrical Service Equipment,"
(2) Mounting brackets as shown on the plans,
(3) Conduit fittings,
(4) Wiring as shown on the plans, and
(5) Other items incidental to a complete meter socket installation.

L.2 Type L1 and Type L2 Service Cabinet

Securely fasten pad mounted lighting service cabinets to the concrete foundation. Anchor rods shall extend 3 in to 4 in above the concrete foundation to accommodate the ½ in [13 mm] thick gasket. Install the supplied rubber gasket sections between the bottom of each cabinet base and the concrete foundation. Leave one ½-in [13-mm] gap in the gasket to ensure proper water drainage.

Position the cabinet door from 90 degrees to 180 degrees to the roadway, away from traffic.

L.3 Type Rural Lighting and Flasher (RLF) Service Cabinet

Securely fasten pad-mounted lighting service cabinets to the concrete foundation using anchor rods, nuts, and washers supplied by the cabinet manufacturer. Anchor rods shall extend 3 in to 4 in above the concrete foundation to accommodate the ½ in [13 mm] thick gasket. Install the supplied rubber gasket sections between the bottom of each cabinet base and the concrete foundation. Leave one ½-in [13-mm] gap in the gasket to ensure proper water drainage. Position the cabinet door from 90 degrees to 180 degrees to the roadway, away from traffic.

M Painting

Paint non-galvanized ferrous metalwork, except for stainless steel, in accordance with 2478, "Organic Zinc-Rich Paint System."

Paint galvanized ferrous metalwork in accordance with 2478, "Organic Zinc-Rich Paint System."

The Department will not require the Contractor to paint the inside of light pole shafts.

Provide anodized aluminum service cabinets meeting the requirements of MIL-A-8625 for Type II, Class I Coating except:

(1) The outer surface coating is 0.0007 in [0.018 mm];
(2) The coating weighs 27 mg per 645 mm^2;
(3) Immerse the coating in a 212 °F [100 °C] aqueous 5 percent nickel acetate solution for 15 min, or submerge the coating in a room temperature fluoride-based sealant for at least 8 min and then immediately dip in water at a temperature of at least 162 °F [72 °C] for 5 min to seal the coating

Protect the factory applied finish when erecting a painted pole. Provide a felt lined collar to handle the pole and leave the protective wrapping on the pole at the lift point area to protect the painted finish. Repair and restore damage to the finish as directed by the Engineer.

N Restoration and Cleanup 2565.3

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P Light System Component Labeling and Numbering

P.1 Lighting System Numbering

Number light poles, underpass luminaires, and lighting service cabinets as shown on the plans with labels listed on MnDOT's Approved/Qualified Products list under, "Roadway lighting."

Verify that the light poles and underpass luminaires to be reinstalled are correctly numbered. If the light poles and underpass luminaires to be reinstalled are not correctly numbered, number the light poles and underpass luminaires in accordance with this specification.

P.1a Lighting Service Cabinet Numbering

Number the service cabinets 4 ft [1.8 m] above the concrete pad with the feed point numbers and letters as shown on the plan on the outside of the front door and the side of the cabinet that faces traffic.

P.1b Light Pole Numbering

Number light poles with feed point numbers and letters shown in the plan above the pole number, 6 ft [1.8 m] above the foundation, and 45 degrees facing oncoming traffic.

Lightly sand the pole shaft to remove oxidation. Wipe the pole shaft with isopropyl alcohol before applying numbers and letters.

Heat the surface of the light pole with a propane torch to ensure the label sticks to the pole when the outside temperature is less than 60 °F [15.5 °C]. Avoid overheating the surface to prevent damage to the label.

P.1c Underpass Luminaire Numbering

Number underpass luminaires with the last letter of the feed point and with the assigned luminaire number as shown on the plan.

P.2 Lighting System Labeling

P.2.a Labeling Branch Circuit Breakers in Lighting Service Cabinets

Label branch circuit breakers on the interior of the lighting service cabinets with the color of the circuit conductor and the luminaire number. Use machine printed labels suitable for use in damp locations. Do not use labels made of paper.

P.2.b Labeling Lighting Cable and Conductors

Label all cable or conductors in conduit in service cabinets and light pole bases indicating the next termination point. For example, in the lighting service cabinet the label would read "TO POLE #1"; in pole No. 1 the label would read "TO LIGHTING SERVICE CABINET" and "TO POLE #2".

Provide labels that consist of white vinyl adhesive tape wrapped around the cable or conductors. Hand write the labeling on the vinyl adhesive tape or produce with a label maker. If label marking is handwritten, accomplish the labeling by using a black permanent marker, in such a manner, that the markings are legible to the satisfaction of the Engineer. Labels produced with a label maker shall be suitable for use in wet locations, and this label must wrap around the cable one complete revolution with some overlap.

P.2.c Labeling Luminaires

(1) Installation Date Luminaires

Label the luminaire with the installation date as follows:

Place an additional date of installation on the bottom of the luminaire so it can be read from the ground underneath the luminaire.

Provide labels for the date of installation both inside and outside of the luminaire meeting the following requirements:

(1.1) Record the installation date on white self-adhering label.
(1.2) Use machine printed numbers.
(1.3) Black text which is ½ in tall,
(1.4) Month/Year numeric format, and
(1.5) Suitable for placement in wet locations.
(1.6) Paper based labels are not acceptable.
(1.7) Place inside of the luminaire and on the bottom outside of the luminaire so the label showing the date can be viewed from the ground below.

Place the date label on the luminaire access door for luminaires mounted on light poles.

Place the date label for underpass luminaires on the housing.

(2) Luminaire Classification

Label the bottom outside of pole mounted luminaires access door with the number 40 for a luminaire listed on MnDOT's Approved/Qualified Products List under "Roadway Lighting" titled "LED Luminaires For Roadway Use Mounted at 40 Feet"
Label the bottom outside of pole mounted luminaires access door with the number 49 for a luminaire listed on MnDOT's Approved/Qualified Products List under "Roadway Lighting" titled "LED Luminaire For Use Mounted at 49 Feet".
Position this label so it is easily viewed from the ground directly underneath the luminaire.

MnDOT approved Labels are listed on MnDOT's Approved/Qualified Products Lists WEB site for Lighting:

Letters and numbers shall have a minimum stroke width of 0.35 in.

(3) Installation Date Labeling HPS Lamps

If HPS lamps are required label the month and year of installation on the lamp socket base by etching or using a black, oil-based paint marker.

Q Luminaire Installation

Q.1 Roadway Luminaire Installation on Light Poles

(1) Do not install luminaires until approved by the Engineer.

(2) Install a MnDOT approved wire holder that supports the luminaire cable/conductors within the end of the luminaire slipfitter near the connection point of the luminaire.

(3) Install and level roadway luminaires in accordance with the manufacturer's installation instructions and as approved by the Engineer.

After the light pole has been installed on its foundation, place a level on the area provided on the top of the luminaire, and level the luminaire from side-to-side and front-to-back.

Install and level luminaires in accordance with the manufacturer's installation instructions and as approved by the Engineer.

If a photocontrol unit is required orient the unit to face north.

Q.2 Underpass Luminaire Installation

Install and level underpass luminaires in accordance with the manufacturer's installation instructions and as approved by the Engineer.

(1) Install the luminaire 17 ft (5.2 m) above the driving surface,
(2) Install the luminaire a maximum of 20 ft (6.1 m) horizontally away from either the most left or right edge of the driving lane or lanes, and
(3) Install #10 AWG stranded green insulated equipment grounding conductor from the underground handhole cable splice to the luminaire without any intermediate splices in the conductor run.

Install components required for a complete and operational underpass luminaire which includes hardware for mounting. Provide liquid tight flexible non-metallic conduit in accordance with 3804.

Q.3 High Mast Luminaire Installation

Install and level high mast luminaires in accordance with the manufacturer's installation instructions and as approved by the Engineer.

R Bonding and Grounding

Provide bonding, grounding, grounding electrodes, grounding electrode conductors, equipment grounding conductors, grounding electrode systems, and grounding connections in accordance with 2565.3, "Traffic Control Signals, Construction Requirements," the NEC, and the following:

Provide mechanically and electrically secure metal poles, conduit, service cabinets, service equipment, and other non-current-carrying metal surfaces to form a continuous, bonded, grounded system and to provide a low impedance path from exposed metal surface to the system ground at the service cabinet or service equipment.

Bond the following to the system equipment grounding conductor as specified in contract documents:

(1) Equipment grounding electrode conductor,
(2) Copper tape shield of the direct buried lighting cable,
(4) Metal Raceways,
(5) Grounding lug of the light pole or sign post, and
(6) Aluminum-conductor steel-reinforced cable (ACSR) equipment ground messenger of overhead light cable.

Use NRTL- listed stainless steel, copper, tin plated copper, brass, or bronze connectors for bonding and grounding unless otherwise specified in contract documents.

Use a lug type connector or bolt to connect the grounding and bonding jumper to the copper tape shield. Use cast clamps or grounding bushings with an integral lug to accommodate the jumper to attach other grounding and bonding jumper attachments.

Provide at least 6 AWG solid bare bonding jumpers and grounding electrode conductors.

Bond light poles to ground as specified below:

(1) Drill the shield for each cable assembly, in each pole base, with a 5/16 in drill bit for stainless steel poles or ½ in hole for aluminum poles for placement under the active clamping grounding lug.
(2) Place a Re-usable screw type active clamping ground lug with a tang on top of the shield.
(3) A 5/16 in or ½ in stainless steel bolt shall be inserted thru the grounding lug and then thru the copper shielding. Non breakaway pole bases will have a 5/16 in stud welded in place for terminating the ground lug. (3.1) Securely fasten to the pole base.
(4) Provide a 6 AWG solid bare grounding jumper and terminate one end to the equipment grounding conductor splice. Terminate the other end of the jumper to the pole base 5/16 in grounding stud by using a NRTL listed Re-usable screw type active clamping ground lug with a tang that connects to the 5/16 in or ½ in pole base grounding bolt.
(5) Tighten the entire assembly (shield and the grounding lug) to form an electrically bonded and grounded connection.
(6) Apply an oxide inhibiting agent to the connection after final connection and assembly.

Install the supplemental ground rod electrodes in the locations specified in the contract.

Provide ground rod electrodes at every other light foundation and at the light foundations located at both ends of a run, unless otherwise specified in the contract.

Provide a direct grounding connection to a ground rod electrode for all main switch cabinets, control cabinets, or service cabinets. For bridges or buildings, bond each cabinet or metal structure to the bridge or building grounding electrode system. Make grounding conductor runs as short as possible.

Apply oxide inhibitor on all bonding and grounding connections after final assembly.

S Service Equipment Installation 2565.3

T Existing Materials and Electrical Equipment
Remove, salvage, reinstall, or stockpile existing materials and electrical equipment as specified in the contract or as directed by the Engineer in accordance with 2565.3"Traffic Control Signals, Construction Requirements."

U Wood Pole Installation 2565.3

V Lighting Units
Install components of lighting units and include hardware required for a complete lighting unit installation.

W Anti-Seize Lubricant
Brush an anti-seize lubricant meeting the requirements of MIL-PRF-907E onto the threaded portions of all steel or stainless steel fasteners before installation.

X Available Fault Current Calculations
Provide available fault current calculations as required by Article 110.24 of the NEC and in accordance with 2565.3CC.

2545.4 METHOD OF MEASUREMENT

A Complete Systems
The Engineer will measure separate items listed in the contract for various types of complete electrical systems. The Engineer will measure the separate systems in accordance with the following:

A.1 Lighting System
The Engineer will measure each separate *Lighting System* as a single unit, complete in place.

A.2 Sign Lighting System - ___ Luminaires
The Engineer will measure each separate *Sign Lighting System - ___ Luminaires* as an integral unit, complete in place.

A.3 Sign Lighting System Bridge Mounted - ___Luminaires
The Engineer will measure each separate *Sign Lighting System Bridge Mounted - ___ Luminaires* as an integral unit, complete in place.

A.4 Conduit System
The Engineer will measure each separate *Conduit System* as an integral unit, complete in place.

B Electrical System Components
The Engineer will measure separate items listed in the contract for the various component parts of an electrical system in accordance with the following:

B.1 Lighting Units

The Engineer will separately measure lighting units of each type of mounting and luminaire design by the number of units of each type, complete in place.

B.2 Luminaires

The Engineer will separately measure luminaires of each type and wattage by the number of luminaires complete in place.

B.3 Light Foundations

The Engineer will separately measure concrete foundations of each design for lighting units as integral units, complete in place.

B.4 Conduit

The Engineer will separately measure conduit of each kind and diameter by the length between end terminals along the centerline of the conduit as installed.

B.5 Underground Wire

The Engineer will separately measure underground wire of each kind and size by the length between end terminals along the centerline of the wire as installed.

B.6 Direct Buried Lighting Cable

The Engineer will separately measure direct buried lighting cable of each kind and size by the length between end terminals along the centerline of the cable as installed.

B.7 Overhead Light Cable

The Engineer will separately measure overhead light cable of each kind and size by the length between end terminals along the centerline of the wire as installed.

B.8 Service Cabinets

The Engineer will separately measure service cabinets of each type by the number of cabinets, complete in place.

B.9 Equipment Pads

The Engineer will separately measure equipment pads of each type by the number of equipment pads complete in place.

B.10 Junction Boxes

The Engineer will measure junction boxes by the number of junction boxes complete in place.

B.11 Handholes

The Engineer will separately measure handholes of each design by the number of handholes complete in place.

B.12 Underpass Luminaires

The Engineer will separately measure underpass luminaries of each design by the number of underpass lighting luminaires complete in place.

B.13 Wood Poles

The Engineer will separately measure wood poles by the number of wood poles complete in place.

B.14 Service Equipment

The Engineer will separately measure service equipment by the number of service equipment complete and in place and fully operational.

B.15 Underground Cable Splice

The Engineer will separately measure underground cable splices by the number of splices complete and in place.

2545.5 BASIS OF PAYMENT

The contract unit price for lighting systems, sign lighting systems, modify sign lighting systems, and conduit systems is full compensation for the cost of furnishing and installing the complete system as required by the contract.

The contract unit price for *Lighting Unit* includes the cost of lamps (if required), luminaire, pole base, pole and bracket, inline fuse, wiring between pole base and luminaire, luminaire wire holder, splice to power circuit, numbering of the light pole, luminaire labeling, stainless steel woven wire cloth, and other miscellaneous items required for a complete installation of the lighting unit.

The contract unit price for *Luminaire* includes the cost of the complete luminaire assembly, mounting, mounting hardware, wiring, connections, numbering of the luminaire if not installed on a light pole, and other miscellaneous items required for a complete installation of the luminaire.

The contract unit price for *Light Foundation* includes the cost of excavation, concrete, reinforcement, anchor rods, ground rod, ground lead, grounding connections, conduit elbows and bushings, and other miscellaneous items required for a complete installation of the light foundation.

The contract unit price for *Conduit Systems* includes the cost of conduit, trenching, jacking, augering, conduit sleeves, couplings, weatherheads, elbows, bushings, sealing around the conduit where it enters a pull box, sealing conduit ends in concrete foundations and in pull boxes, grounding and bonding of conduit, backfilling and restoring sod, sidewalks, pavements, and other miscellaneous items required for a complete installation of the conduit.

The contract unit price for *Underground Wire* includes the cost of wire, pulling, splicing, terminals, making required connections, testing, and other miscellaneous items required for complete installation of underground wire.

The contract unit price for *Direct Buried Lighting Cable* includes the cost of cable, trenching, shield bonding, connections, fittings, fastenings, hangers, backfilling and surface restoration, testing, and other miscellaneous items required for a complete installation of the direct buried lighting cable.

The contract unit price for *Overhead Light Cable* includes the cost of cable, grounding of the messenger wire, connections, fastenings, hangars, testing, and all other miscellaneous items required for a complete installation of overhead light cable.

The contract unit price for *Service Cabinet* includes the cost of panel board enclosure, circuit breakers, switches, relays, photoelectric control, internal wiring, service entrance circuit, service entrance conduit and weatherhead for wood pole mounted cabinets, mounting hardware, grounding, painting, sealing around cabinet base, numbering of the service cabinet, and miscellaneous items required for a complete installation of the lighting service cabinet.

The contract unit price for *Equipment Pad* includes the cost of excavation, concrete, reinforcement, anchoring hardware within the pad, conduits within the pad, ground rods, grounding connections, mounting brackets, mounting hardware, surface restoration, and miscellaneous items required for the complete equipment pad installation.

The contract unit price for *Junction Box* includes the cost of junction boxes, bushings, covers, gaskets, and miscellaneous items required for the complete installation of junction boxes.

The contract unit price for *Handhole* includes the cost of the handhole, frame and cover, excavation, aggregate drain bed, backfilling, sealing conduit entrances, surface restoration, and miscellaneous items required for the complete installation of handholes.

The contract unit price for *Underpass Luminaires* includes the cost of the complete underpass luminaire assembly, mounting, mounting hardware, wiring, connections, luminaire labeling, and miscellaneous items required for the complete installation of underpass luminaires.

The contract unit price for *Wood Pole* includes the cost the class of wood pole, surface restoration, and other miscellaneous items required for the complete installation of wood poles.

The contract unit price for *Service Equipment* includes the cost of meter socket and mounting brackets, conduit and power conductors on wood pole, wiring connections, ground rod electrode, bonding and grounding materials and connections, and incidental items required to a complete meter socket installation.

The contract unit price for *Underground Cable Splice* includes the cost of splice kits and miscellaneous items required for a complete underground cable splice.

The contract unit price for *Flexible Non-Metallic Conduit* includes the cost of conduit, conduit sleeves, couplings, elbows, bushings, sealing around the conduit where it enters a pull box, grounding and bonding, and other miscellaneous items required for a complete installation of the conduit.

The contract unit price for *Air Obstruction Light* includes the cost of the light, mounting bracket (if required) , wiring between pole base and luminaire, splice to power circuit, luminaire labeling, and other miscellaneous items required for a complete installation of the air obstruction light.

The contract unit price for *Grounding Electrode* includes the cost of grounding electrode and splicing of grounding conductors to the grounding electrode and miscellaneous items required for a complete bonded and grounded electrical system.

The contract unit price for *Expansion Fitting* includes the cost of the expansion fitting, grounding, connections, hangars, wrapping with sponge rubber, and all other miscellaneous items required for a complete installation of an expansion fitting.

The contract unit price for *Deflection/Expansion Fitting* includes the cost of the deflection/expansion fitting, grounding, connections, hangars, wrapping with sponge rubber, and all other miscellaneous items required for a complete installation of an expansion fitting.

The Department will pay each pay item at the contract unit price per the specified pay unit as follows:

Item No:	Item:	Unit:
2545.501	Lighting System	lump sum
2545.505	Sign Lighting System	system
2545.506	Sign Lighting System Bridge Mounted	system
2545.509	Conduit System ____	lump sum
2545.511	Lighting Unit, Type ___	each
2545.512	Air Obstruction Light	each
2545.513	Luminaire ____	each
2545.514	Underpass Luminaires, Type ___	each
2545.515	Light Foundation, Design ___	each
2545.521	___in [mm] Rigid Steel Conduit	linear foot [meter]
2545.522	___in [mm] Intermediate Metal Conduit	linear foot [meter]
2545.523	___in [mm] Non-metallic Conduit	linear foot [meter]
2545.524	___in [mm] Flexible Non-Metallic Conduit	linear foot [meter]
2545.525	___in [mm] Expansion Fitting	each
2545.526	___in [mm] Deflection/Expansion Fitting	each
2545.531	Underground Wire, ___ Conductor No.	linear foot [meter]
2545.533	Direct buried lighting Cable, ___ Conductor No. ___	linear foot [meter]
2545.537	Overhead Light Cable, ___ Conductor No. ___	linear foot [meter]
2545.541	Service Cabinet - Type ___	each
2545.542	___ft [m] Wood Pole, Class ___	each
2545.543	Underground Cable Splice	each
2545.544	Service Equipment	each
2545.545	Equipment Pad ____	each
2545.551	Junction Box	each
2545.553	Handhole	each
2545.554	Grounding Electrode	each

2550 TRAFFIC MANAGEMENT SYSTEM

2550.1 DESCRIPTION

This work consists of providing and installing Intelligent Transportation System (ITS) and Traffic Management System (TMS) components, including electrical service, for communications, traffic control, surveillance, and motorist information.

Acronyms and Definitions

BD-4	TWP (Twisted Pair) Distribution Pedestal (Splice Cabinet)
BD-7	TWP (Twisted Pair) Distribution Pedestal (Splice Cabinet)
DMS	Dynamic Message Sign
EIA	Electronics Industry Association
FC-PC	Field Connector-Physical Contact
FDF	Fiber Distribution Frame
FO	Fiberoptic
JB	Junction Box
LCS	Lane Control Signal
LED	Light Emitting Diode
MM	Multimode
NRTL	Nationally Recognized Testing Laboratory as defined by the US Department of Labor
OTDR	Optical Time Domain Reflectometer
PTZ	Pan Tilt and Zoom
RCS	Ramp Control Signal
RUS	Rural Utilities Service
SM	Singlemode Cable
ST	Straight Tip
TIA	Telecommunication Industry Association
TWP	Twisted Wire Pair
ZDW	Zero Dispersion Wavelength

2550.2 MATERIALS

A General

Provide materials and equipment and perform work meeting the requirements of the National Electrical Manufacturers Association, the Electronic Industries Association, NRTL, NEC, local codes and ordinances, these specifications, and as required by the contract.

Each component is designed for 10 years of industrial use. Warrant Furnish and Install (F&I) materials and workmanship as well as workmanship on materials paid as Install items for a minimum of 6 months after completion and acceptance of the contract. The Department may require longer warranty periods for specific items. The Engineer will begin the warranty period on the date all construction obligations of the Contractor are completed as documented by the final completion date on the Certificate of Final Acceptance per 1516, "Acceptance."

During the warranty period, make repairs to all equipment and devices provided and installed during the project. The Engineer will notify the Contractor that a warranted item needs repair. Acknowledge the notification within 24 hours and provide the repair within 48 hours, to the satisfaction of the Engineer.

B Rigid Steel Conduit 3801

C Non-Metallic Conduit 3803

D Electrical Junction Boxes 3838

E Electrical Cable and Conductors 3815

E.1 Power Conductors 3815

E.2 Loop Detector Conductor 3815

E.3 Armored Underground Cables 3815

E.4 Signal Control Cable 3815

E.5 Loop Detector Lead-in Cable 3815

E.6 Telephone Cable 3815

F Signal Pedestal 3832/Plan

2550.3 CONSTRUCTION REQUIREMENTS

Before starting work, submit a written statement that identifies all subcontractors performing the work contained in this section (2550).

A Cable Installation

Place conduit and direct buried cables in the same trench only if installing the cable 36 in [900 mm] deep, if adding 6 in [150 mm] of fill, and if installing the conduit on the fill.

A.1 Cable Installed In Conduit

If pulling cable into conduit by hand or machine, use a limiting device to prevent exceeding the pulling tension specified by the manufacturer.

If pulling cable, apply a material compatible, industry accepted lubricant to the cables to reduce pulling tension. Install each cable with slack in accordance with the manufacturer's recommendations to prevent disconnection or damage from contraction. Do not use damaged cable. Remove abandoned cables from each conduit. Ensure the operating TMS remains active while removing the cables.

A.2 Direct Buried Cables

Trench or plow direct buried cables at least 36 in [900 mm] deep. Install direct burial cable by trenching or by plowing. Install direct burial cable in conduit if it is located under bituminous or concrete surfaces.

Install warning tape meeting the following requirements between 18 in [460 mm] above the cable to 12 in [300 mm] below the surface:

(1) 3.15 in [80 mm] wide,
(2) Stretchable,
(3) Orange, and
(4) Bears the permanent legend "CAUTION: MnDOT CABLE BELOW."

A.3 Copper Cable Installation

Repair Contractor damaged TMS cable as approved by the Engineer.

Do not use buried splices.

Splice telephone cables in BD-4 and BD-7 cabinets with a weather resistant, crimp connector designed to splice three No. 19 conductors.

A.4 Fiberoptic Cable Installation

Use manufacturer-recommended equipment to ensure the cable is not damaged by exceeding the maximum tensile strength and violating the minimum bend radius. Make continuous and steady cable pulls between pull points.

Complete direction changes of fiberoptic cable before entering a HH or other conduit access point. Do not pull fiberoptic cables through HH. This applies to both the horizontal and vertical directions.

Install fiberoptic cable in orange colored split conduit through the HH. Extend the conduit 2in [50 mm] beyond the wall of each HH and seal the conduit to the HH with duct seal.

Splice optical fibers only in outdoor fiber splice enclosures and fiber splice panels. Do not splice between cabinets and splice vaults.

Continuously monitor the tensile load on the cable. Pre-rip the fiber optic cable route to prevent harm to a plowed cable.

Place 6 in [150 mm] of aggregate meeting the requirements of 3149.2.G, "Aggregate Bedding," under cables placed in a trench. Backfill the trench in accordance with 2451, "Structure Excavations and Backfills."

The transition from one elevation to another shall not exceed 1 ft vertical per 5 ft horizontal if installing fiberoptic cable in existing conduits in HH. Re-install existing conduits if necessary to provide the transition for the cable installation, at no additional cost to the Department.

B Cabinet Installation

B.1 Two Days' Notice

Notify the Engineer two days before removing an active cabinet from service.

B.2 Secure and Seal

Secure the cabinets to the concrete foundation with anchor rods, nuts, and washers.

Seal the cabinet base to the foundation with a ¼ in × 2 in [6 mm × 50 mm], one piece neoprene gasket.

B.3 Conduit

Install conduits at the center of the cabinet base and extend 3.15 in [80 mm] above the foundation.

C Dynamic Message Signs (DMS)

Provide Dynamic Message Sign (DMS) structures and mounting hardware in accordance with 2564, "Traffic Signs and Devices."

Ensure that the installation of DMS electrical equipment located on the sign structure does not protrude over the walkway, or interfere with moving the walkway safety rail or with opening the sign door.

Install the 120/240 VAC to the sign within one week after installation of the DMS to enable operating the ventilation units.

D LCS

Provide LCS mounting hardware in accordance with 2564, "Traffic Signs and Devices."

E Restore Shrubs and Bushes

Restore shrubs and bushes damaged by Contractor activities in accordance with 1712, "Protection and Restoration of Property."

F HH

Make openings in the side of HH water tight with a compound that is compatible for adherence to both the PVC HH and the conduit material.

Fill HH abandoned in sodded areas, with tamped granular material in accordance with 3149.2.E, "Aggregate Backfill." Salvage useable HH covers from abandoned HH. Provide the salvaged HH to the Department's Electrical Services Section.

Secure the Department-provided HH locator ball to an eye bolt with a ¼ in [6 mm] wide wire wrap. Locate the Department-provided HH locator ball within 1 ft [0.3 m] of the HH cover.

G RCS

Cover each installed RCS until starting the system operational test.

H Conduit
Install conduit in accordance with 2565.3.D, "Conduit and Fittings," and the following:

H.1 Conduit on Bridges
Provide and install deflecting expansion joints meeting NEC requirements.

H.2 Factory Bends
Factory bends in conduit 3 in [76 mm] in diameter or greater require a minimum bend radius of 36 in [900 mm].

H.3 Foundation Locations
The Engineer will stake the actual locations of the foundations, outside the clear zone, and as far from the paved portion of the roadways as practical.

I (Blank)

J Bonding and Grounding..... 2565.3.J
Include a ground rod with each foundation.

J.1 Ground Cable
Wrap ground cable with green electrical tape in cabinets and HH through which the cable passes.

J.2 Shield Continuity
Maintain the electrical continuity of the cable shields while terminating and splicing cables. Install shield bonding meeting the requirements of RUS splicing Standard PC-2, Section 3.3. Provide bonding connectors meeting the requirements of RUS Specification PE-33 for Cable Shield Connectors. Bond and ground the cable sheaths to a 15 ft × ⅝ in [4.6 m × 16 mm] diameter ground rod.

K Loop Detector Installation
Install loop detectors as required by the contract and as follows:

K1 Loop Detector Conductors
End loop detector conductors in the near HH. Splice the conductors to the lead-in cable with a soldered butt splice. Wrap the splice with one wrap of electrical tape before placing into the splice encapsulator device.

L Fiberoptic System

L.1 (Blank)

L.2 (Blank)

L.3 Outdoor Fiber Splice Enclosure
Bond each outdoor fiber splice enclosure to the cable armor with a cable clamp and to the closest ground rod with a 1/C No. 6 ground wire and clamp. Provide outdoor fiber splice enclosures with non-oxidizing coating on the connections.

L.4 Fiber Splice, Patch, Splice/Patch Panel
Mount the fiber splice, patch, splice/patch panel as required by the contract. Secure the fiberoptic cables and pigtails to the splice, patch, splice/patch panel. Ground the shields by bonding them to the splice, patch, splice/patch panel ground lug.

L.5 Fiberoptic Splice Vault
Place the fiberoptic splice vault on 12 in [300 mm] of filter aggregate in accordance with 3149.2.H, "Coarse Filter Aggregate." Seal and flash test the vault as recommended by the manufacturer.

Coil 60 ft [18 m] of cable for each entrance and exit in each vault containing splices.

M CCTV Assembly Installation
Do not degrade the existing CCTV signals during CCTV Assembly installation.

Orient the lightning rod away from the road at approximately 90 degrees to centerline. Install the horizontal lockout for the pan and tilt unit over the lightning rod support and set the vertical lockout to 30 degrees above horizontal. Ensure the housing mounting bolts do not hit the pan and tilt unit cover in any tilt position.

2550.4 METHOD OF MEASUREMENT
The Engineer will only measure items for payment that are completed and accepted.

A Complete Systems
The Engineer will measure ___ *System* separately.

B Traffic Management System Components

The Engineer will measure the various system components by the units of measure required by the contract.

2550.5 BASIS OF PAYMENT

The Department will:

(1) Retain 10 percent of the amounts payable on each partial estimate, in accordance with 1906, "Partial Payments."
(2) Pay for material on hand.
(3) Pay the remaining percentage retained upon completion of the work as approved by the Engineer.

The contract lump sum price for ___ *System* includes the cost of providing and installing the system required by the contract, complete in place.

The contract lump sum price for *System Integration* includes the cost of performing the work and incorporating the material required by the contract, into the existing system. The Department will make payments based on the percent of the contract completed, as indicated on the project progress chart. When the Contractor completes 10 percent of the contract as indicated by the chart, the Department will pay 10 percent of the systems integration contract pay item.

The contract unit price for ___ *Foundation* includes the cost of providing the material and providing and installing the foundation required by the contract.

For cabinet foundations included as part of a larger pad, the cabinet foundation includes the concrete and conduit under and adjacent to the cabinet.

For service foundations included as part of a larger pad, the service foundation includes the concrete, conduit and conductors under and adjacent to the service equipment.

The contract unit prices for TMS contract pay items include the cost of providing and installing each item.

The Department will pay for TMS based on the following schedule:

Item No.:	Item:	Unit:
2550.501	___ System	lump sum
2550.509	Systems Integration	lump sum
2550.511	___ Foundation	each
2550.512	Handholes, Type ___	each
2550.513	Junction Box	each
2550.514	Fiberoptic Splice Vault	each
2550.515	Outdoor Fiber Splice Enclosure	each
2550.516	Buried Cable Sign	each
2550.521	___ in [mm] Rigid Steel Conduit	linear foot [meter]
2550.523	___ in [mm] Non metallic Conduit	linear foot [meter]
2550.524	___ in [mm] Pushed Conduit	linear foot [meter]
2550.531	___ Cable ___ Pr. No. ___	linear foot [meter]
2550.532	___ Cable ___ Conductor No. ___	linear foot [meter]
2550.533	___ Cable ___	linear foot [meter]
2550.534	Fiberoptic Trunk Cable ___ MM ___ SM	linear foot [meter]
2550.535	Armored Fiberoptic Pigtail	each
2550.542	Loop Detector Splice	each
2550.551	Ramp Control Signal, Design ___	each
2550.552	Flasher Signal	each
2550.553	Lane Control Signal	each
2550.561	Closed Circuit Television Assembly	each
2550.562	Dynamic Message Sign, Design ___	each
2550.571	___ Cabinet	each
2550.572	Service ___	each

2554 TRAFFIC BARRIERS

2554.1 DESCRIPTION

This work consists of installing guardrail, barrier, end treatments, transitions, permanent barricades, and other devices that protect or prohibit traffic at the locations shown on the plans or as directed by the Engineer. This work also consists of installing posts and guide posts, and resetting existing barriers.

2554.2 MATERIALS

A Metal Posts

A.1 Flanged Channel Sign Post **3401**

A.2 Structural Metal Posts **3406**

B (Blank)

C Wood Posts **3412**

D Timber Plank, S4S **3426**

E Wire Rope **3381**

F Steel Beams

Provide W-beam, thrie-beam rail elements, posts, blocks, soil plates, reducer sections, and end treatments meeting the requirements of *A Guide to Standardized Highway Barrier Hardware*, published by AASHTO, ARTBA, and AGC.

F.1 Steel Plate Beams **3382**

F.2 Rub Rail **3306**

G Hardware and Fittings ..... **3381 & 3382**

H Paints

Provide paints as required by the contract.

I (Blank)

J Concrete **2461**

Provide concrete for anchor blocks and bearing blocks with a compressive strength of at least 2,750 psi [19 MPa] within 14 days. The Department will not require air entrainment.

K Anchorage Rods **3385**

Anchorage assemblies consist of the anchor and the fittings required to connect the anchor to the end post.

2554.3 CONSTRUCTION REQUIREMENTS

A Excavation and Foundations

The Contractor may dig post holes by hand or by using mechanical methods. Excavate to the depth necessary to place the rail elements at the specified height above the ground surface and meeting the requirements for post top and side alignment as shown on the plans. In excavating for anchorages, ensure that anchorages bear on firm, undisturbed earth at the depth shown on the plans.

Use the natural soil at the bottom of the excavation as the foundation of line, guide, and permanent barricade posts. Tamp the natural soil at the bottom of the excavation to provide firm bearing. Found end posts and posts at intermediate guardrail anchorages on concrete bearing blocks. Provide concrete bearing blocks in the dimensions shown on the plans. Firmly install concrete bearing blocks on a foundation prepared as required by the contract.

B Installing Posts

Install posts of the size and type shown on the plans, at the intervals shown on the plans, and to the staked lines. Install posts with post tops from ±⅜ in [10 mm] of the elevation and grade shown on the plans.

Provide Type A guide posts meeting the following requirements:

(1) 5½ in [140 mm] nominal diameter,
(2) Width from 4¾ in to 6 ¼ in [120 mm to 160 mm],
(3) 6 ft [1.8 m] long, and
(4) Made of treated wood in accordance with 3412, "Wood Guardrail Posts."

Install Type A guide posts with the top of the post 30 in [760 mm] above the shoulder P.I. elevation, unless otherwise indicated on the plans.

Provide flanged channel steel Type B guide posts as culvert markers weighing 2 lb per ft [3.0 kg per m] in the lengths specified in 3401, "Flanged Channel Sign Posts." Install Type B guide posts as shown on the plans.

Mechanically drive posts, if required or allowed by the plans, without damaging the posts.

Install and consolidate backfill materials specified on the plans, to maintain the post plumb and in the correct position.

C Installing Barriers

Install traffic barriers as shown in the plans. Install proprietary barrier items as specified by the manufacturer.

Drill holes in wood posts with the same diameter as the bolts or fittings used. In metal posts, drill holes for bolts or other fittings with a diameter no greater than $^{1}/_{16}$ in [1.6 mm] of the diameter of the bolt or fitting. Apply two coats of copper naphthenate or another preservative material meeting the requirements of AWPA Standard M4 to field cuts in treated wood. Allow the first coat to dry for at least 2 h before applying the second coat. The Contractor may leave field bored holes untreated.

Provide bolts no longer than necessary to allow full nut contact after tightening at the overall nominal depth of the assembled parts, plus reasonable allowance as required by the manufacturer for oversize components. In locations of possible vehicle contact, do not allow bolt ends to project beyond the rail contact face. The Contractor may cut off the excess length of bolt to within $^{9}/_{16}$ in [15 mm] of the nut head.

C.1 Wire Rope (Cable Guardrail) Installations

Except where cable clips are allowed by the manufacturer, wire wrap free ends of wire rope to prevent unraveling.

At intermediate anchorages, space the cables to prevent contact between the separate cables.

Install proprietary high-tension cable barriers as specified by the manufacturer.

C.2 Steel Plate Beam Barriers

Provide steel plate beam barriers including box-beam guardrail, W-beam guardrail, and Thrie-beam guardrail.

If offset blocks are required by the plans or the manufacturer, provide blocks made from treated timber or other material as listed on the Approved/Qualified Products List. Treat field cuts on treated wood in accordance with 2554.3.C, "Installing Barriers."

Install rail and end sections to overlap the adjacent section in the direction of traffic.

Install end treatments as shown on the plans and as staked in the field. Install proprietary end treatments as specified by the manufacturer.

Install the guardrail end treatments and the guardrail concurrently.

C.3 Permanent Barricades

Fabricate permanent barricades as shown in the plans.

D Painting and Field Repairs

Apply two coats of paint as shown on the plans and in accordance with 2479, "Inorganic Zinc-Rich Paint System," to steel above ground and not coated in accordance with 3406, "Structural Metal Fence Posts." Perform other field repairs as recommended by the manufacturer.

E Disposal of Surplus Excavated Material

Dispose of surplus excavated material at no additional cost to the Department and as approved by the Engineer.

2554.4 METHOD OF MEASUREMENT

A Traffic Barriers

The Engineer will measure traffic barriers of each design by length, to the nearest 1 ft [0.3 m]. The Engineer will measure between the centers of end posts in each continuous section, including transitions. The Engineer will not deduct expansion assemblies from the measurement.

B Permanent Barricades

The Engineer will measure permanent barricades by length, to the nearest 1 ft [0.3 m] from end to end of the planks of each unit.

C Guide Posts

The Engineer will measure guide posts by the number of posts placed. The Engineer will separately measure each type as shown on the plans.

D Anchorage Assemblies
The Engineer will measure anchorage assemblies by the number of assemblies installed.

E End Treatments
The Engineer will measure end treatments by the number of units of each type installed complete-in-place.

2554.5 BASIS OF PAYMENT
The contract linear foot [meter] price for *Traffic Barrier, Design* ___ includes the cost of providing all barrier appurtenances and installing the barrier as shown on the plans, except the Department will separately pay for anchorage assemblies as shown in the plans.

The contract each price for *End Treatment* of each type includes the costs of providing and installing steel plate beam rail, posts, anchorage, offset blocks, hardware, and other related materials.

The Department will pay for traffic barriers and barricades on the basis of the following schedule:

Item No.:	Item:	Unit:
2554.501	Traffic Barrier, Design ___	linear foot [meter]
2554.505	Permanent Barricades	linear foot [meter]
2554.509	Guide Post, Type ___	each
2554.511	Install Traffic Barrier, Design ___	linear foot [meter]
2554.515	Install Guide Post, Type ___	each
2554.521	Anchorage Assembly	each
2554.523	End Treatment, Type ___	each

2557 FENCING

2557.1 DESCRIPTION
This work consists of constructing fences.

2557.2 MATERIALS
On contracts not specifying types of material for metal fencing products, the Contractor may select the type of material. Use the same type of metal fence components on the entire project.

Cap tubular metal posts.

If the contract requires coated metal posts, use the same coating on posts, post supports, rails, gate frames, expansion sleeves, and other hardware items or fittings in accordance with the following:

(1) Zinc coating with zinc coated fence fabric,
(2) Aluminum or zinc coating with aluminum coated steel fabric, and
(3) Vinyl coating with vinyl coated fence fabric.

Provide black vinyl coated posts, hardware, and fabric with a low to medium gloss, unless otherwise shown on the plans.

Use aluminum alloy posts, rails, frames, and other hardware items with aluminum alloy fence fabric.

A brace assembly consists of a single wood or metal brace, installed as a leg brace or as a horizontal brace between two consecutive posts, including the required brace plate or concrete anchor, post anchorages, and guy wires or truss rods. A brace assembly for a chain link fence consists of two brace bars and a truss rod.

A Fence Wire **3376**

B Fence Gates **3379**

C Fence Posts

C.1 Rolled Steel Posts **3403**

C.2 Structural Metal Posts **3406**

C.3 Vacant

C.4 Treated Wood Posts **3413**

D Hardware and Fittings.....3406

E Concrete
Provide concrete in accordance with 2461, "Structural Concrete," Grade B, Type 3 concrete.

2557.3 CONSTRUCTION REQUIREMENTS

A General
Remove and dispose of brush, trees, and other obstructions that interfere with construction of the fence in accordance with 1405, "Use of Materials Found on the Project," 2101, "Clearing and Grubbing," and 2104.3.C, "Removal Operations." Provide a smooth ground profile at the fence line.

Ensure the bottom of the fence follows the contour of the ground. At small stream crossings, drainage ditches, and other locations where the bottom of the standard size fence cannot conform to the ground contour, construct the fence to span the depression and use extra wire or fabric to close the space below the bottom of the fence, unless otherwise shown on the plans or directed by the Engineer. Provide and install longer posts with intermediate posts, stakes, braces, extra fabric, or wires to span the depression.

Perform field repairs to fence materials as recommended by the manufacturer.

B Installing Posts, Rails and Braces

B.1 General
Set posts plumb, except set posts perpendicular to the slope of the ground at locations as directed by the Engineer.

Install corner posts, pull posts, end posts, and gate posts at locations shown on the plans or as directed by the Engineer. Provide corner post assemblies at horizontal angle points with deflections greater than 20 degrees. Space pull posts to provide a braced post at points where the following occurs:

(1) The vertical alignment deflects by greater than 20 degrees,
(2) The post anchorage is necessary to counteract wire uplift, and
(3) An abrupt grade change on short runs that cannot be avoided by shaping the ground to a uniform contour.

When driving fence posts, protect the post tops from damage. Remove and replace posts damaged during installation.

Anchor posts placed on concrete walls, curbs, or other concrete structures as shown on the plans.

If placing fence posts in solid rock, set the post at least 12 in [300 mm] into the rock or with the post bottom at the elevation shown on the plans, whichever requires the lesser excavation into the rock. Cut the post bottom to provide the height above the ground surface as shown on the plans. Cut holes in rock to provide a clearance of at least 1 in [25 mm] around the posts. Fill the holes around the posts with grout consisting of one part portland cement, two parts mortar sand, and sufficient water to create the proper consistency. The Contractor may add 0.1 part hydrated lime in the grout.

Place and consolidate concrete around the posts and braces. Allow the concrete to cure for at least 3 calendar days before installing the fence wire.

The Contractor may pour the concrete into prebored holes without forming, if no concrete contamination occurs during placement.

Except as otherwise required for posts and braces set in rock or concrete, backfill the annular space around posts set in prebored holes in layers using selected material from the excavation with each layer thoroughly compacted to produce a rigid post setting. Use other backfill material, if required by the contract.

Dispose of surplus excavated material in low areas along the fence line or as directed by the Engineer. Neatly finish the adjacent area.

B.2 Metal Post Installations
Set posts for chain-link fabric fencing in concrete as shown on the plans. The Contractor may drive line posts if the post lengths provide a post embedment of at least 4 ft [1.2 m] into the ground.

Drive rolled steel line posts.

The Contractor may provide rolled steel end posts, corner posts, and pull posts, including the required braces, with anchor plates and brace plates. Set the posts in dug holes. The Contractor may omit the anchor and brace plates and set the posts and braces in concrete. Backfill excavations around the posts and braces using the excavated material. Thoroughly compact the backfill.

Set rolled steel gate posts in concrete.

Provide and install metal post extensions in the lengths directed by the Engineer at the locations shown on the plans. If post splicing is necessary, use a standard thread and coupling of the same material to thread and join the pipe ends at the splice. Avoid splicing in the exposed upper portion of the post. Provide a suitable plug in the bottom end of each extended post.

B.3 Wood Post Installations

The Contractor may drive posts or set wood posts in prebored holes. Place the larger end of the post in the ground. When driving posts, place the square cut or pointed end in the ground. Except for holes in rock, cut post holes to a diameter providing a clearance of at least 3 in [75 mm] around the post to allow backfill and compaction.

Provide wood braces in accordance with 3413, "Wood Fence Posts (Treated)." Provide wood braces with diameters at the small end equal to the minimum permissible diameter as shown on the plans. Ensure the diameter at the small end does not exceed the top diameter of the smaller adjacent post.

C Installing Fence Wire

Install and pull tight the fence wire as recommended by the manufacturer.

C.1 Chain Link Fabric

Place chain link fabric in continuous runs between corner, end, and gate posts. Install the fabric on the side of line posts that face away from the main road except as otherwise directed by the Engineer. Ensure impacts from snow plowing stress the posts rather than the fasteners.

At ends of chain link fabric, thread a stretcher bar through the fabric loops and use clamps to fasten the bar to the posts as shown on the plans.

Weave pre-bent wire of the same kind as the fabric to make splices in the chain link fabric.

C.2 Barbed Wire and Woven Wire

Unless otherwise directed by the Engineer, place barbed wire and woven wire installed on tangent alignment or on curves no greater than 1 degree on the side of line posts that faces away from the main road. If placing the fence on horizontal curves greater than 1 degree, place the wire on the side of line posts on the outside of the curve. Offset posts at corners to the inside so that the wire will bear against the post.

Fasten fence wire to end, corner, gate, or pull posts before fastening to intermediate line posts. Stretch woven wire to make longitudinal wires taut and to remove 30 percent of the factory fabricated fence crimp.

When required by the plans, cut and splice woven wire at the pull posts to obtain and maintain uniform tension in horizontal wires. The Contractor may use a wire crimping tool to increase the number or depth of tension curves to maintain tension in horizontal wires.

Use wire clips or clamps in accordance with 3376, "Fence Wire," to fasten wires to metal line posts. Use galvanized staples to fasten wires to wood posts. Where the wire loops around end, corner, or pull posts, wrap the wire around the post at least four complete turns.

Use U-shaped wire staples at least 1¾ in [45 mm] long in pine posts and at least 2 in [50 mm] long in cedar posts. The Contractor may use L-shaped staples with serrated, barbed or ring shanks at least 1½ in [38 mm] long.

Diagonally drive U-shaped staples across the wood grain to prevent both points from entering between the same grain. Slope staples upward, against the pull of the wire, in depressions with wire up-lift. Slope staples downward on level ground and over knolls. Staple the wires at corner, end, and pull posts. On line posts, drive the staples to the point that allows movement of the wire. Do not damage the wire while driving the staples.

To splice wire between posts, use an approved splicing sleeve as indicated in 3376, "Fence Wire," or wrap each wire end around the other wire from 4 turns to 6 turns to form a lasting connection. Use a splicing tool in place of hand wrapping to obtain uniformly tight wraps as directed by the Engineer.

If using splicing sleeves on woven wire, maintain the same horizontal distance between vertical wires as in the fabricated wire. If using the wrap method to splice woven wire, allow the two end stay wires to abut each other and enclose the wires within the wrap.

D Installing Gates

Install gates designed to allow locking with a Department-provided padlock and equipped with a padlock keeper at the locations shown on the plans.

E Electrical Grounds

Install electrical grounds consisting of copper coated steel rods with a nominal diameter of at least ⅝ in [15 mm] and a length of at least 8 ft [2.4 m] along each fence line at the staked locations.

Drive ground rods to an elevation flush with the ground surface at points directly below or adjacent to the fence wire. Connect each ground rod to the fence with a solid No. 6 copper wire. Use approved type metal clamps as indicated in 3376, "Fence Wire," to attach the ground wire to the ground rod and to the fence wires to electrically ground each longitudinal fence wire. The Department will not require greater than one connection on woven wire and chain link fabric near the bottom at each ground rod.

Install electrical grounds in the following locations:

(1) On each fence line at the point of crossing beneath an electric power line.
(2) Two grounds at each pedestrian gate, one on each side of the gate opening, as close to the gate posts as practicable.
(3) Additional grounds on each fence line to maintain spacing between grounds of 1,500 ft [450 m] on fences with metal posts and 1,000 ft [300 m] on fences with wood posts.
(4) At least one electrical ground on each separate section of fence. The Department defines a separate section of fence as a run with unbroken electrical continuity.
(5) On each separate section of fence, uniformly space electrical grounds and locate a ground within a distance from each end no greater than half of the desired maximum spacing interval.

2557.4 METHOD OF MEASUREMENT

A Wire Fence

The Engineer will separately measure fence of each design by length along the bottom of the fence, from center to center of end posts, excluding the lengths of gates as measured between gate posts.

B Brace Assemblies

The Engineer will separately measure wood or metal brace assemblies by the number of each kind constructed complete-in-place, regardless of length, design, or anchorage.

C Electrical Grounds

The Engineer will measure electrical grounds by the number of ground rods and connections provided and installed complete-in-place.

D Gates

The Engineer will measure gates by the number of individual units constructed complete-in-place.

E Metal Post Extensions

The Engineer will measure metal post extensions by length of extensions, based on the difference between the standard driven post length and the actual post length as installed.

2557.5 BASIS OF PAYMENT

The contract each price for *Metal Brace Assembly* includes the cost of the brace plate or concrete anchor, post anchorages, and guy wires or truss rods.

The contract each price for *Electrical Ground* at includes the cost of the ground wire and connectors.

The Department will include the cost of removing and disposing of brush, tree, and obstructions with relevant contract unit prices for fence construction, unless the contract provides specific pay items for the work. The Department will include the cost of providing and installing longer fence posts, intermediate posts, stakes, braces, extra fabric, or wires as required with relevant contract unit prices for fence construction, unless the contract includes specific contract pay items for the work.

The Department will pay for fencing on the basis of the following schedule:

Item No.:	Item:	Unit:
2557.501	Wire Fence, Design___	linear foot [meter]
2557.516	Pedestrian Gate	each
2557.517	Vehicular Gate	each
2557.519	Metal Post Extensions	linear foot [meter]
2557.521	Wood Brace Assembly	each
2557.522	Metal Brace Assembly	each
2557.523	Metal Brace Assembly (Chain Link Fence)	each
2557.527	Electrical Ground	each

2564 TRAFFIC SIGNS AND DEVICES

2564.1 DESCRIPTION

This work consists of fabricating, packaging, and delivering, or installing traffic signs and devices.

2564.2 MATERIALS

A General

Provide electrical material and equipment meeting the requirements of 2545.2, "Electrical Lighting Systems, Materials."

B Structural Steel

Fabricate structural steel posts and trusses from steel meeting the requirements of 3306, "Low-Carbon Structural Steel," unless otherwise required by the contract.

Provide structural bolts, nuts, and washers meeting the requirements of 3391.2.B, "High Strength Structural Steel Bolts," and 3392, "Galvanized Hardware."

Provide bolt anchorages as specified in the contract or if not specified, as approved.

C Concrete (Mix 3G52) 2461

D Reinforcement Bars 3301

All reinforcement bars shall be as indicated in the contract and shall be epoxy coated.

E Spiral Reinforcement 3305

F Signs, Delineators and Markers 3352

Fabricate sign panels in accordance with the following, unless otherwise required by the contract.

Fabricate all standard signs, lighting system identification plates, overhead sign identical plates, markers, and delineators according to the standard sign drawings in the MnDOT Standard Signs Manual.

Provide sheet aluminum sign base material for Type C, Type D, Type Overlay sign panels, lighting system identification plates, overhead sign identical plates, delineators, markers, and Type OH sign panels on sign supports in accordance with 3352.2.A.1.a, "Sheet Aluminum," except provide non-reflectorized lexon-black, flexible plastic sign-base material for cylinder-style delineators.

Provide extruded aluminum sign base material in accordance with 3352.2.A.1.b, "Extruded Aluminum, Bolted Type," covered with 0.063 in [1,600 µm] sheet aluminum meeting the requirements of 3352.2.A.1.a, "Sheet Aluminum." for Type A, Type EA, Type EO, and Type OH sign panels on panel mounting posts. Provide $^{3}/_{16}$ in [5 mm] aluminum alloy pull-through rivets as fasteners to attach the sheet aluminum to the extruded panel. Tightly butt the sheet aluminum vertically and rivet to the extruded panel on centers no greater than 12 in [300 mm] vertically and horizontally. Rivet the edges and corners of each sheet. Do not place rivets within 1 in [25 mm] of the extruded panel joints. After attaching the sheet, ensure the sheet aluminum is free of waviness.

Fabricate all rigid permanent signs, markers, and delineators with materials from the MnDOT Approved/Qualified Products List.

Provide retroreflective sign sheeting material for sign panels, lighting system identification plates, overhead sign identical plates, delineators, and markers meeting the requirements of 3352.2.A.2.f, "Sign Sheeting Type XI," for Type XI, unless otherwise specified in this section (2564). Provide black sign legend material according to *3352.2.A.5.c, "Signs, Delineators, and Markers: Requirements: Materials: Screen Processed Painted Legend"* or *3352.2.A.5.d,* "*Signs, Delineators, and Markers: Requirements: Materials: Pigmented Plastic Film Legend*."

Provide Type V or Type VIII retroreflective sheeting material for white X4-13 Cylinder Style Delineators.

Provide Type III MT or Type V retroreflective sheeting material for yellow X4-13 Cylinder Style Delineators.

Provide all warning signs, yellow markers, yellow delineators, yellow background on Sign Panel Type Overlays, and the yellow background on Type A and Type OH sign panels with fluorescent yellow retroreflective sheeting, except if indicated differently below:

For W11-1, W11-2, W11-9, W11-15 series, W15-1, S1-1, S3-1, S3-2a, and S4-5 standard signs, provide retroreflective sheeting sign face material meeting the requirements of 3352.2.A.2.f, "Sign Sheeting Type XI," for Type XI FL fluorescent yellow-green.

When warning sign plaques are mounted on the same structure as a warning sign, match the plaque color and sheeting type with the primary warning sign color and sheeting type.

When a S4-3P sign plaque is to be installed above a regulatory speed limit sign, fabricate the sign plaque with fluorescent yellow-green retroreflective sheeting.

Fabricate the R1-6 series, the R1-9, and the S5-1 standard signs with fluorescent yellow-green retroreflective sheeting on only the warning color parts of the sign, according to the design in the *MnDOT Standard Signs Manual*.

Provide non-reflectorized black sign face material and fluorescent yellow retroreflective sheeting for sign legend material for X4-2 Hazard Markers.

Provide non-reflectorized black sign face material and red retroreflective sheeting for sign legend material for X4-11 End of Roadway Markers.

For the sign face material on the M1-5A Route Marker and the M1-5B Type Overlay, obtain the gold color with a screen-processed color using a transparent gold paint. Obtain the blue color with a screen-processed color using transparent blue paint. Ensure the overlap of the blue and gold screen-processed colors does not exceed $^{3}/_{32}$ in [3 mm].

For sign panels with brown sheeting, provide white retroreflective sheeting for sign face material meeting the requirements of 3352.2.A.2.f, "Sign Sheeting Type XI." Provide sign legend material with brown (1179) Electronic Cuttable (EC) film produced by the same manufacturer that fabricates retroreflective sheeting meeting the requirements of 3352.2.A.2.f, "Sign Sheeting Type XI," for Type XI. If splicing is required to apply brown EC film on sign panels, provide vertical butt splices spaced so splices do not occur through letters or arrows. Before applying the brown EC film to the sign face material, perform the following:

(1) Cut and weed-out the legend and border from the brown EC film as shown on the sign panel details in the contract. Do not cut and weed-out the brown EC film covered by Sign Panels Type Overlay;
(2) Apply the weeded brown EC film to the white, retroreflective sheeting sign-face material; and
(3) Apply the brown EC film "corner" pieces located outside the border that fill in the square corners of the sign panel.

Sign panels for signs with black, blue, green, and red backgrounds may be provided through the method described for sign panels with brown sheeting.

Screen the sign legend material for colors other than black and white in accordance with 3352.2.A.5.c, "Screen Processed Painted Legend."

G Anchor Rods 3385

H Flanged Channel Sign Posts 3401

I Square Tubular Sign Posts.....3402

2564.3 CONSTRUCTION REQUIREMENTS

A General

Fabricate and install traffic signs and devices in accordance with the MN MUTCD for Streets and Highways and the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Do not perform work on the project until underground utilities are located in accordance with 1507, "Utility Property and Service." Replace electrical cable damaged due to Contractor-negligence at no additional cost to the Department. Replace damaged electrical cable from terminal point to terminal point.

Construct electrical systems or conduit systems for conveying electrical cables and conductors, or portions of electrical cables and conductors, as required by the contract, in accordance with 1702, "Permits, Licenses, and Taxes," and 2545.3, "Electrical Lighting Systems, Construction Requirements."

Sign locations and post lengths indicated in the contract are approximate. The Engineer will make the final determination of sign locations and the required post lengths for Type A and Type OH Signs in the field. The Contractor shall determine the required post lengths for all other signs.

If refurbishing signs with legends that are pertinent to traffic, do not extend the down-time for the sign beyond the eight-hour period from 8:00 a.m. to 4:00 p.m., unless providing a replacement sign at no additional cost to the Department.

If, in the opinion of the Engineer, the message on a sign panel is not pertinent to existing traffic, delay installation of the sign panel until the message becomes pertinent or install the sign and place an effective cover over the non-pertinent message.

Provide opaque covers that do not hold moisture against the sign face. The Engineer will not approve burlap as an effective cover for retroreflective signs. Install the sign panel with the cover and the Department will assume responsibility for maintaining and removing the cover after the Engineer accepts the work.

Unless the Contractor arranges to reclaim cover material, the material will become the Department's property upon final acceptance of the work. Cover, maintain, and uncover sign panels with non-pertinent messages at no additional cost to the Department.

The Department considers removal and replacement of existing guardrail for the convenience of the Contractor as incidental work.

Replace topsoil, sodded, and seeded areas disturbed by the work and dispose of excess excavated materials as approved by the Engineer.

B Concrete Structures

Produce concrete for footings in accordance with the requirements for Mix No. 3G52 concrete as specified in 2461, "Structural Concrete."

Provide a rubbed-surface finish on exposed concrete surfaces.

Do not install sign posts on concrete footings until the concrete has cured for a minimum of seven days.

B.1 Concrete Footings

If the Engineer approves, the Contractor may use either spread footings or drilled-shaft footings as a substitute.

Construct footings as required by the contract. The Department will only pay for the planned design quantity for each footing at the contract unit price, except for Department required design changes.

If the contract requires drilled shaft footings, the Contractor may submit an alternate design for approval by the Engineer with the understanding that, if approved, the Department will not adjust the contract quantities or unit prices. If the Engineer approves the alternate design, the Contractor may proceed.

Provide design details for alternate drilled shaft footing designs in accordance with one of the following:

(1) Use a constant diameter shaft at least 6 in [153 mm] greater than the diagonal dimension of the column base plate. Use the planned longitudinal reinforcement bars without bending. Use either spiral reinforcement or tie bars spaced at 6 in [153 mm] centers for the full length of the shaft, or

(2) Install a horizontal construction joint at the bottom of the tapered section of the shaft about 6 ft [1.8 m] below the top. Before placing new concrete above the construction joint, coat the surface of the in-place concrete with a Department-approved bonding agent. Lap vertical reinforcement bars a length equal to 40 times the diameter of the reinforcement bar used.

Construct footings in accordance with 2401.3, "Concrete Bridge Construction, Construction Requirements," except as modified by 2564.3.B.2, "Median Barrier Footing."

The Contractor may use undisturbed earth to form concrete placement if the soil is stable enough, as determined by the Engineer, to allow concrete placement and the Contractor takes precautions to prevent contamination of the concrete.

B.2 Median Barrier Footing

Provide NMC conduit and fittings to connect to the non-metallic conduit in adjacent median barrier as detailed on the plans and the special provisions.

Provide a surface finish and color that matches the adjacent median barrier.

C Sign Support

Provide and install a sign support as required by the contract, current AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, and this subsection (2564.3.C).

Provide concrete footings as required by the contract. Determine the reinforcement steel and the anchor rods as required by the contract.

Provide and install an overhead sign identification plate in accordance with 2564.3.P, "Overhead Sign Identification Plate."

D Overhead Sign Structure Repair

Repair an existing overhead sign structure in accordance with the 2123, "Equipment Rental," and the following:

Contact the Department's Structural Metals Inspection Unit (DSMIU) to schedule inspection of sign structures. Perform the inspection before removing the sign structure from storage, or after salvaging the structure.

Correct the following conditions, if encountered, as determined by the DSMIU:

(1) Rusted or missing nuts, bolts or washers,
(2) Defective shop and field splices on main chord angles,
(3) Missing welds,
(4) Cracking welds or structural elements,
(5) Section loss on post base plate,
(6) Flame gouges on base plate or at bolt holes,
(7) Cracks around post handhole,
(8) Zinc coating loss or deterioration, and
(9) Rusting.

Perform repairs in accordance with 2471, "Structural Metals."

Verify that each locking pin fits completely into the locking pin hole in the handrail hinge, while the handrail is in the raised position. For locking pins that do not fit, drill out the handrail hinge to make a proper fit. Repair damage to galvanized surfaces in accordance with 2471.3.L.1, "Galvanizing."

After completing the repairs and before installation, obtain reinspection by the DSMIU.

E Structural Steel

Manufacture and fabricate structural steel in accordance with 2471, "Structural Metals," and the additional requirements and limitations specified in this subsection (2564.3.E).

Provide shop drawings for overhead sign structures and for Type A sign structures in accordance with 2471.3.B, "Shop Detail Drawings."

Assemble the truss sections and posts in the shop before galvanizing. Check truss sections and posts for straightness, alignment and dimensions and correct any variations. Correct warpage from galvanizing before installing structural steel.

Ensure main chord angles for overhead sign structures that are at least ½ in [13 mm] thick, meet a Charpy V-notch impact strength requirement of 15 ft•lb [20 N•m] at 40 °F [5 °C].

Drill or mechanically cut overhead sign post base plate anchor rod holes.

Lubricate the threads of anchor rods and nuts with anti-seize material before installation. Use the following minimum torque values:

Table 2564-1
Minimum Torque Values for Anchor Rods

Anchor Rod Diameter	Torque
2 in [51 mm]	300 ft•lb [400 N•m]
2¼ in [57 mm]	375 ft•lb [500 N•m]
2½ in [64 mm]	450 ft•lb [600 N•m]
2¾ in [70 mm]	550 ft•lb [750 N•m]
3 in [76 mm]	700 ft•lb [950 N•m]

Tighten all leveling nuts and top nuts against the post base plate so that no shifting of top or bottom washers occurs when they are struck with an inspection hammer. After this tightness has been achieved, additionally tighten the top nuts another 1/12th turn (one-half of a flat).

Mar the anchor rod threads directly above the top nuts after tightening is completed.

Mar the threads of the anchor bolts in accordance with 2402.3.H, "Setting Anchor Bolts."

Unless otherwise required by the contract, provide and install galvanized structural steel posts (H-Pile) as footings for Type A signs in accordance with 2452, "Piling," 2471, "Structural Metals," and the following:

(1) Construct footings as required by the contract;
(2) The Department will allow use of a 14 ft [4.3 m] H-Pile post instead of welding a 2 ft [0.6 m] stub post to the12 ft [3.7 m] H-Pile;
(3) Obtain a bearing capacity from 12 ton [107 kN] to 14 ton [125 kN] for each H-Pile in accordance with 2452, "Piling;"

(4) Splice additional length of H-Pile in accordance with 2452, "Piling," and drive to the bearing capacity required in 2452.3.C, "Equipment for Driving," if the driven length of H-Pile specified in the contract fails to reach bearing capacity;
(5) Repair damage to galvanized surfaces in accordance with 2471, "Structural Metals," before back filling.

F Flanged Channel Sign Posts

F.1 Furnish Flanged Channel Sign Post

Fabricate, package, and deliver flanged channel sign posts in accordance with 3352, "Signs, Delineators, and Markers," 3401, "Flanged Channel Sign Posts," this section (2564), and the following:

(1) Band posts of the same weight [mass] and length with banding material, in lots of no more than 20 posts per bundle;
(2) Label each bundle with the following:
  (2.1) Post weight per foot [mass per meter],
  (2.2) Contractor's name,
  (2.3) Project number,
  (2.4) Source of the material, and
  (2.5) Supplier's name;
(3) Deliver the posts to the Department as required by the contract;
(4) Give the Engineer at least three working days' notice; and
(5) Deposit posts as directed by Department personnel.

The Engineer will reject material with damage detected during unloading. The Department will perform final inspection and acceptance of the posts within 14 calendar days after the date of delivery to the Department.

F.2 Furnish and Install Flanged Channel Sign Posts

Install the posts plumb above ground, located and oriented as directed by the Engineer. Remove and replace posts that are bent or damaged and considered unacceptable by the Engineer, at no additional cost to the Department.

Set posts firmly in the ground. After driving, ensure the top of the post has the same cross-sectional dimensions as the post body.

If mounting a delineator on a bridge rail, provide and install a bracket as required by the contract in lieu of a conventional steel post.

Install posts in surfaced medians or sidewalks as detailed on the plans or in the special provisions.

G Modify Post

Do not splice Type A sign post sections below the friction fuse.

Extend Type A sign posts, located above the friction fuse, and panel mounting posts by welding a new or salvaged section of the same size to an existing post in accordance with 2471, "Structural Metals."

The Contractor may extend S4 × 7.7 [S100 × 11] panel mounting posts by bolt splicing as required by the contract and in accordance with 2471, "Structural Metals." Galvanize post extensions in accordance with 2471, "Structural Metals."

If shortening posts, dispose of removed sections in accordance with 2104, "Removing Pavement and Miscellaneous Structures."

The Contractor may use thermal cutting in accordance with 2471, "Structural Metals." Repair galvanized areas marred by cutting or welding in accordance with 2471, "Structural Metals."

H Sign Panels

Fabricate the sign panels in accordance with the standard sign drawings in the Standard Signs Manual or as required by the contract. For sign panels detailed in the contract, provide sign panel layouts with the following characteristics:

(1) The vertical dimension given is for the legend component having the largest vertical dimension in the particular line of copy. Other legend components are centered on the larger legend component unless indicated otherwise.
(2) The horizontal dimensions given within the sign panel are to the tenth of an inch and are cumulative representing the distance from the left edge of panel to the extreme left edge of the legend component.
(3) The position of an arrow is measured in degrees counterclockwise from a right horizontal reference line. The abbreviation MOD used in the sign panel recap = Modified.

Package, deliver, store, and install sign panels in accordance with 1607, "Handling Materials," 3352, "Signs, Delineators, and Markers," and the retroreflective sheeting manufacturer's recommendations.

H.2 Fabrication and Warning Stickers

Provide and affix fabrication stickers to the backside of all Sign Panels Type A, C and D sign panels and Sign Panel Overlay Type A sign panels.

Screen a fabrication sticker with the following information:

(1) Sign fabricator company name and address;
(2) The twelve months of the year in numeric order;
(3) The last two digits of the current year and the following four years.

Indicate the month and year of fabrication of the sign panel on the sticker using one of the following methods:

(1) Punch-out the fabrication month and year of the sign panel on the completed sticker; or
(2) Block out the month and year of fabrication on the screen before applying the black ink so that the month and year of fabrication will not be displayed.

Provide a full-size mockup of the fabrication sticker, measuring 3 in × 1½ in [75 mm × 40 mm] with a black legend on a white, reflectorized background, to the Engineer for approval.

Affix the fabrication sticker to the backside of each new Type C single-post installation and Type D sign panels in the lower right corner of the sign panel, when facing the back of the sign panel. For installations of two posts for Type C sign panels, install the sticker at the bottom center of the sign panel. Affix fabrication sticker to the backside of Type A sign panels in the lower right corner, when facing the back of the sign panel.

For furnished and installed signs or sign panels, affix a Department-provided warning sticker to the backside of each sign panel directly above the fabrication sticker. Warning stickers are available at the Department's Transportation District Office specified in the Contract. The Transportation District's contact person and phone number are specified in the Contract. Give the Transportation District's contact person thirty calendar days advance notice before picking up the stickers.

H.3 Sign Panels Type Overlay

Type Overlays are separate panels mounted on the face of signs to form a part of the legend. Attach Type Overlays to the sign panels with rivets spaced 12 in [300 mm] on centers except at the edges. Attach the edges of each Type Overlay with rivets spaced no greater than 6 in [150 mm] on centers. Do not install rivets within 1 in [25 mm] of extruded panel joints.

H.4 Extruded Sign Panels

Attach extruded sign panels to sign posts or panel mounting posts with new post clips and torque each post clip to 12 ft•lb to 14 ft•lb [16 N•m to 19 N•m].

H.5 Furnish Sign Panels

For sign panels the Contractor furnishes but does not install, group sign panels by type and then size. Ensure each package only contains the sign panels for a specific location and no more than 20 sign panels per package. Label each package with the following:

(1) Sign number,
(2) Contractor's name,
(3) Project number,
(4) Material source,
(5) Supplier's name,
(6) Quantity of sign panels, and
(7) The delivery location required by the contract.

Provide notice at least 3 working days to the Department's sign shop personnel before delivery of sign panels to the Department.

Deposit sign panels as directed by Department personnel. The Engineer will reject sign panels with damage detected during unloading. The Department will perform final inspection and acceptance of sign panels within 14 calendar days of the date of delivery to the Department.

I (Blank)

J Saw Sign Panels

Saw-cut extruded aluminum sign panels and ensure the resulting panel edge is smooth. Dispose of excess material in accordance with 2104, "Removing Pavement and Miscellaneous Structures."

K Sign Panel Overlay Type __

Provide and install overlay panels, including legends, on existing extruded aluminum sign panels. Attach the overlay sheets to the extruded panel with $^{3}/_{16}$ in [5 mm] aluminum alloy, pull-through rivets.

Use 0.063 in [1600 µm] aluminum sign base material for overlay sheets in accordance with 3352.2.A.1.a, "Sheet Aluminum."

Use retroreflective sheeting sign face material in accordance with 3352.2.A.2.e, "Sign Sheeting Type IX," or 3352.2.A.2.f, "Sign Sheeting Type XI," except for the following:

(1) For a yellow background on sign panel overlays, use retroreflective sheeting as specified by 3352.2.A.2.e, "Sign Sheeting Type IX," FL fluorescent yellow, or 3352.2.A.2.f, "Sign Sheeting Type XI," FL fluorescent yellow, and
(2) For a brown background, use white retroreflective sheeting as specified by 3352.2.A.2.e, "Sign Sheeting Type IX," or 3352.2.A.2.f, "Sign Sheeting Type XI."

Use sign legend material as specified by 3352.2.A.2.e, "Sign Sheeting Type IX," or 3352.2.A.2.f, "Sign Sheeting Type XI" for the sign face material on each sign panel, except for the following:

(1) Use brown (1179), electronic Cuttable (EC) film produced by the same manufacturer that fabricates the retroreflective sheeting specified by 3352.2.A.2.e, "Sign Sheeting Type IX," or 3352.2.A.2.f, "Sign Sheeting Type XI," for sign legend material on sign panel overlays with brown sheeting; and

(2) If brown EC film for sign panel overlays requires splicing, make splices vertical and butt spliced and spaced so splices do not occur through letters or arrows.

Before applying the brown EC film to sign face material, perform the following:

(1) Cut and weed-out legends and borders specified on the sign panel overlay details in the contract from the brown EC film. Do not cut and weed-out the brown EC film that will be covered by sign panels Type Overlay.

(2) Apply the weeded brown EC film to the white retroreflective sheeting sign face material.
(3) Apply the brown EC film "corner" pieces, located outside the border that fill in the square corners of the sign panel overlay.

Use direct-applied sign legend material in accordance with 3352.2.A.5.c, "Screen Processed Painted Legend," or 3352.2.A.5.d, "Pigmented Plastic Film Legend" for black legends. Remove demountable legends on existing sign panels and dispose of them in accordance with 2104, "Removing Pavement and Miscellaneous Structures."

Tightly butt the overlay sheets vertically and rivet to the existing panel on 12 in [300 mm] vertical and horizontal centers. Rivet the edges and corners of each overlay sheet. Do not place rivets within 1 in [25 mm] of the extruded panel joints. Attach overlay sheets to the existing panel so sheets are free of waviness.

Remove in-place post clips and attach overlaid, extruded sign panels to sign posts or panel mounting posts with new post clips. Torque each post clip from 12 ft•lb to 14 ft•lb [16 N•m to 19 N•m] when attaching all extruded sign panels to posts.

L Install Sign Panel Type __

Install a salvaged or Department-provided sign panel, as required by the contract and the following:

(1) Install Type A and Type OH sign panels using new post clips;
(2) Install Type EA and Type EO sign panels with new flanged channel posts and post clips;
(3) Torque each post clip from 12 ft•lb to 14 ft•lb [16 N•m to 19 N•m] when attaching extruded sign panels to posts.
(4) Install Type C and Type D sign panels with new nuts, bolts, and washers; and
(5) Use new sign bracket assemblies as shown on the plans for Type OH sign panels installed on sign supports.

M Install Sign Type __

Install Type A signs on breakaway supports at the locations required by the contract. Install salvaged or Department-provided Type A sign panels using new post clips. Torque each post clip from 12 ft•lb to 14 ft•lb [16 N•m to 19 N•m] when attaching all extruded sign panels to posts. Completed installations shall be in accordance with the contract and details shown on the plans. Provide and install a new friction fuse consisting of a friction fuse plate and hinge plate, new bolts, nuts, and washers on each post. Repair damaged galvanized surfaces in accordance with 2471, "Structural Metals."

Provide and install a new sign structure for Type C and Type D signs and install salvaged sign panels as required by the contract, using new nuts, bolts, and washers. Install salvaged sign panels to the mounting heights as shown on the plans.

Install each mast arm mounted, Type D signs at the locations shown on the plans, to the Engineer's satisfaction, and in accordance with the "Structural Details For Signal Mast Arm Mounted Signs" specified in the Standard Signs Manual, page 105A. If the materials specified in the Standard Signs Manual, page 105A are no longer available, provide each mast arm mounted Type D

sign panel with a mounting system approved by the Department. Obtain approval for the mounting system by submitting product specifications and strength calculations that demonstrate compliance with the current AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. Address submittals to the Fabrication Methods Engineer, MnDOT Office of Bridges and Structures, Mail Stop 610, 3485 Hadley Avenue North, Oakdale, Minnesota 55128.

Provide new flanged channel posts for Type EA and Type EO sign panels, and install salvaged sign panels with new post clips as required by the contract. Torque each post clip to 12 ft•lb to 14 ft•lb [16 N•m to 19 N•m].

Install Type OH sign structures obtained by salvage or from storage on new concrete footings in accordance with the torque requirements specified by 2564.3.E, "Structural Steel," and as required by the contract.

Remove, provide, and replace the following with new components:

(1) Safety chains and components of safety chain snap assemblies,
(2) Safety rail locking pins, and
(3) Chains welded to the locking pin heads (one chain/locking pin).

Dispose of removed items in accordance with 2104, "Removing Pavement and Miscellaneous Structures."

Verify that each locking pin fits in the locking pin hole in the handrail hinge while the handrail is in the raised position. Drill out the handrail hinge to make a proper fit for locking pins that do not fit. Repair damaged galvanized surfaces in accordance with 2471.3.L.1, "Galvanizing."

N (BLANK)

O Lighting System Identification Plate

Provide and install a lighting system identification plate that incorporates the lighting system identification number appearing in parenthesis directly below or alongside the sign number in the contract for each new lighted overhead sign as specified in the contract.

Strap-mount the plate on the overhead sign post as required by the contract. Install the plate on the right-hand post when looking in the direction of traffic flow. If signs face both directions of travel on a single structure, provide and install two plates. Install plates directly below the Overhead Sign Identification Plate as specified in this section.

For bridge mounted signs, install the lighting system identification plate on a 2 lb per ft [3 kg per m] delineator post in accordance with 3401, "Flanged Channel Sign Posts." Install the lighting system identification plate and post as close to the bridge as possible and behind the guardrail. If no guardrail is in place, install the plate and post at least 12 ft [3.7 m] outside the edge of the shoulder or face of curb. Install the plate directly below the Overhead Sign Identification Plate as specified in this section.

P Overhead Sign Identification Plate

Provide and install an overhead sign identification plate for each overhead sign installed as required by the contract. Provide a plate that incorporates the overhead sign number directly below the sign panel shown on the plan layout and as required by the contract.

For post mounted signs, strap–mount the plate on the overhead sign post as required by the contract. Install the plate on the right-hand post when looking in the direction of traffic flow. If signs face both directions of travel on a single structure, provide and install two plates. Install the plate 6 ft [1.8 m] above the base plate elevation facing traffic.

For bridge-mounted, Type OH signs with sign lighting, install the overhead sign identification plate 6 ft [1.9 m] above the edge of the pavement on the lighting system identification plate delineator post as specified in this section.

For bridge-mounted, Type OH signs without sign lighting, install the plate on a 2 lb per ft [3 kg per m] delineator post in accordance with 3401, "Flanged Channel Sign Posts." Install the plate and post as close to the bridge as possible and behind the guardrail. If no guardrail is in place, install the plate and post at least 12 ft [3.7 m] outside the edge of shoulder or face of curb. Install the plate so the bottom is 6 ft [1.8 m] above the edge of pavement.

Q Extend Walkway Support

Extend each walkway support on existing Type OH sign structures as required by the contract.

R Friction Fuse

Provide and install a friction fuse on each existing Type A sign post as required by the contract and the following:

(1) Remove the in-place friction fuse, consisting of a friction fuse plate and a hinge plate, and in-place mounting hardware, and dispose of these items in accordance with 2104, "Removing Pavement and Miscellaneous Structures;"

(2) Provide and install a new friction fuse consisting of a friction fuse plate and a hinge plate, new bolts, nuts, and washers on each post as required by the contract; and
(3) Repair damaged galvanized surfaces in accordance with 2471.3.L.1, "Galvanizing."

S Keeper Plate

Provide and install a keeper plate on each existing Type A sign post as required by the contract.

Verify sign post dimensions in the field. Immediately before installing keeper plates, clean the base connection plate to remove grit, dirt, and deleterious material. Reinstall the post in accordance with base connection bolting procedures shown on the plans. Replace missing, damaged, or rusty bolts, nuts, and washers.

T Reference Location Signs

Provide and install the tubular or flanged channel sign post, mounting bracket, or strap mounting hardware, and attach the reference location sign with mounting hardware required by the contract.

For reference location signs attached to Type C or Type D sign structures, install the reference location sign to the left sign post with new stainless steel bolts, nuts, washers, and nylon washers, at the mounting height designated in the Plan.

For reference location signs mounted back to back, install a nylon washer against the face of each reference location sign to prevent damage to the sheeting materials.

U Traffic Control

Provide signs for traffic control meeting the requirements of the Standard Signs Manual. Provide barricades meeting the requirements of MnDOT Standard Plate 8000. Provide all other traffic control devices in accordance with the MN MUTCD. Install nylon washer spacers between the temporary traffic construction sign panels and the in-place sign panels.

Provide Traffic Control Devices (TCDs) as required by the contract and MN MUTCD.

Install TCDs in accordance with the MN MUTCD, before beginning work. Maintain TCDs while in place and remove them if not required.

V Scheduling of Work

Schedule work in accordance with the following requirements:

(1) Ensure one of the following signs is in service at all times for each exit:
  (1.1) The Exit sign in the gore, or
  (1.2) The Exit direction sign just in advance of the gore;
(2) Provide at least one directional sign, either an advance guide sign or an "Exit" directional sign, in service at all times for each exit;; and
(3) Do not remove sign structures until approved by the Engineer. The Engineer's approval for removing an existing sign is contingent upon compliance with Items 1 and 2 above and upon completion of a constructed, functional replacement sign.

W Delineators and Markers

Provide and install the tubular or flanged channel sign post, mounting bracket, or strap mounting hardware, and attach the delineator or marker with mounting hardware required by the contract.

X Safety Cable

To assemble and attach safety cables as shown on the plans for Type OH signs with walkways and no sign lighting, provide and install brackets, aircraft cable, and hardware as shown on the plans.

2564.4 METHOD OF MEASUREMENT

A General

The Engineer will individually measure each of the following items; modify post, install sign panel Type __, overhead sign identification plate, lighting system identification plate, extend walkway support, friction fuse, and keeper plate.

B Concrete Structures

B.1 Concrete Footings

The Engineer will measure concrete footings for Type OH signs by volume based on the dimensions required by the contract. The Engineer will not deduct the volume of metal reinforcement, anchorages, and conduit. The Engineer will measure anchorage assemblies separately.

B.2 Median Barrier Footing

The Engineer will measure median barrier footings by volume based on the dimensions required by the contract The Engineer will not deduct the volume of metal reinforcement, anchorages, and conduit. The Engineer will measure anchorage assemblies separately.

C Sign Support

The Engineer will measure a sign support as a complete unit including concrete footings and overhead sign identification plates.

D Overhead Sign Structure Repair

The Engineer will measure overhead sign structure repair by the number of hours required to complete the repair, including use and operation of equipment, travel time inside the project limits, and work and materials involved.

E Structural Steel

The Engineer will measure the following structural steel items:

(1) Trusses for overhead signs (Design B);
(2) Posts for overhead signs (Design B);
(3) Walkway supports for overhead signs (Design B);
(4) Walkway grating for overhead signs (Design B);
(5) Panel mounting posts for overhead signs (Design B);
(6) Trusses for overhead signs (Bridge Mounted); and
(7) Posts and H-piles for Type A signs.

The Engineer will measure structural steel items separately by the computed weight [mass] of structural steel incorporated in each item in accordance with the measurement provisions of 2402.4.A, "Weight," as modified by the following:

(1) The weight [mass] measurement for Design B overhead sign trusses includes the following:
- (1.1) Structural members of the truss,
- (1.2) The lower chord juncture plate,
- (1.3) Cap plates,
- (1.4) Tie plates,
- (1.5) Collar,
- (1.6) Panel mounting posts,
- (1.7) Walkway grating,
- (1.8) Walkway supports,
- (1.9) Safety rail, and
- (1.10) Fixture mounting channel.

(2) The weight [mass] measurement for Design B overhead sign posts includes the following:
- (2.1) Posts,
- (2.2) The base juncture plate,
- (2.3) Lower chord juncture post plate,
- (2.4) Gusset plates,
- (2.5) Baseplate,
- (2.6) Overhead sign identification plate,
- (2.7) Lighting System Identification Plate (if sign lighting installed) and
- (2.8) The anchorage assembly.

(3) The weight [mass] measurement for Bridge Mounted overhead sign trusses includes the following:
- (3.1) The structural members of the truss,
- (3.2) The panel mounting posts,
- (3.3) Walkway grating,
- (3.4) Walkway supports,
- (3.5) Safety rail, and
- (3.6) Fixture mounting channels.

(4) The Engineer will base the computed weight [mass] on the quantity tables in the contract;

(5) The Engineer will not measure bolts, nuts, rivets, washers, and shims used in the fabrication and erection of signs, and will not apply the provisions of 2402.4.A, "Weight," that provide a percent increase in weight [mass].

F Flanged Channel Sign Posts

The Engineer will measure flanged channel sign posts by the computed weight [mass] for each post size provided.

G Sign Panels

The Engineer will measure each type of sign panel by area based on the nominal dimensions of the sign panels. All signs are considered rectangular for the purpose of measurement except that the Engineer will measure triangular shaped sign panels as the actual area of the triangle. The Engineer will not make deductions for rounded corners.

H Saw Sign Panels

The Engineer will measure sawing of extruded sign panels by the length of the saw cut.

I Sign Panel Overlay Type __

The Engineer will measure sign panel overlays by the area and type of sign panels overlaid.

J Install Sign Type __

The Engineer will measure each type of sign by the number of complete units in place in accordance with 2564.3.M, "Install Sign Type __."

K Delineators and Markers

The Engineer will measure delineators and markers by the number of each type of complete units provided and installed. A complete unit consists of the following as specified by the Standard Signs Manual, Traffic Engineering Manual, or as required by the contract:

(1) Delineator or marker panel,
(2) Tubular or flanged channel sign post,
(3) Mounting bracket or strap mounting hardware,
(4) Delineator or marker panel mounting hardware.

2564.5 BASIS OF PAYMENT

The Department will pay for traffic signs and devices at the contract unit price per unit of measure.

The contract cubic yard [cubic meter] price for *Concrete Footings* includes the cost of constructing the footings, reinforcement bars, replacing topsoil and sodded areas disturbed by the operations, and disposing excess excavated material as approved by the Engineer. The Department will include the cost of excavation for concrete structures with other relevant contract unit prices except for the following:

(1) The Department will pay for the volume of excavation required 12 in [300 mm] below the bottom of the concrete structure, measured as actual material removed, within the limitations set forth in 2451.4.A, "Structure Excavation," as extra work.
(2) The Department will pay for Class R excavation that is encountered and cannot be avoided by adjustment of the concrete structure location as extra work.

The contract pound [kilogram] price for *Structural Steel* (Design B, Posts for OH Signs) includes the cost of anchorage assemblies.

The contract unit price, each, for *Median Barrier Footing* includes the cost of constructing the footing and reinforcement bars in place as shown on the plans. The Department will include the cost of excavation for concrete structures with other relevant contract unit prices except for the following:

(1) The Department will pay for the volume of excavation required 12 in [300 mm] below the bottom of the concrete structure, measured as actual material removed, within the limitations set forth in 2451.4.A, "Structure Excavation," as extra work.
(2) The Department will pay for Class R excavation that is encountered and cannot be avoided by adjustment of the concrete structure location as extra work.

The contract unit price, each, for *Sign Support* includes the cost of providing and installing the sign support, concrete footings, and overhead sign identification plate.

The contract man-hour price for *Overhead Sign Structure Repair* includes the cost of performing the work as required by the contract, except that the contract each price for *Install Sign Type OH* will include the cost of the crane work and materials required to position and block the truss up off the ground. Overhead sign structure repair is exempt from 1903, "Compensation for Altered Quantities." The Department will not make a unit price adjustment for overhead sign structure repair in the event of a quantity underrun or overrun.

The contract pound [kilogram] price for *Structural Steel* includes the cost of providing and erecting the structural steel items as required by the contract including the cost of providing and installing posts in surfaced medians or sidewalks. The contract pound [kilogram] price for *Structural Steel* also includes the cost of manufacturing, packaging, and delivering flanged channel sign posts as required by the contract.

The contract unit price, each, for *Modify Post* includes the cost of modifying each post as required by the contract.

The Department will include the cost of screening and installing fabrication stickers and installing warning stickers with the applicable pay items for traffic signs and devices.

The contract square foot [square meter] price for *Sign Panels Type C* and *Type D* includes the cost of providing and installing the tubular or flanged channel sign posts, stringers, brackets, and attachment angles or strap mounting hardware for sign panel attachment.

The contract square foot [square meter] price for *Sign Panels Type EA* and *Type EO* includes the cost of providing and installing the flanged channel sign posts.

The contract square foot [square meter] price for *Sign Panels Type A* includes the cost of the hardware required to assemble the panel sections and to attach the assembled sign panels to the sign posts.

The contract square foot [square meter] price for *Sign Panels Type OH* includes the cost of the hardware required to assemble the panel sections and attach the assembled sign panels to the panel mountings posts or the sign support.

The Department will include the cost of torquing post clips with the applicable pay items for traffic signs and devices.

The contract unit price, each, for *Furnish Sign Panels Type* ___ includes the cost of providing and delivering the sign panels as required by the contract.

The contract linear foot [linear meter] price for *Saw Sign Panels Type* ___ includes the cost of sawing sign panels as required by the contract.

The contract square foot [square meter] price for *Sign Panel Overlay Type* ___ includes the cost of removing and reinstalling the existing sign panel, and providing, installing, and torquing new post clips, except the contract square foot [square meter] price for *Sign Panels Type Overlays* includes the cost of providing and installing new type overlays.

The contract unit price, each, for *Install Sign Panel Type* ___ includes the cost of installing each sign panel as required by the contract.

The contract unit price, each, for *Install Sign Type* ___ includes the cost of installing each sign as required by the contract. The contract unit price for *Install Sign Type OH* includes the cost of safety chains and components of safety chain snap assemblies, safety rail locking pins, and chains welded to the locking pin heads.

The Department will pay for posts and concrete footings or H-Pile footings for Type A signs, and the footings for Type OH signs separately. The Department will pay for posts and H-Piles for Type A signs under Structural Steel Posts for Type A signs. The Department will pay for the anchorage assembly(ies) under Structural Steel Posts for Type OH Signs (Design B). The Department will pay for concrete footing(s) for Type OH signs under Concrete Footings (Type Spread or Shaft) or median barrier footing(s).

The contract unit price, each, for *Overhead Sign Identification Plate* includes the cost of providing and installing each overhead sign identification plate as required by the contract.

The contract unit price, each, for *Lighting System Identification Plate* includes the cost of providing and installing each overhead sign lighting system identification plate as required by the contract.

The contract unit price, each, for *Extend Walkway Support* includes the cost of extending each walkway support as required by the contract.

The contract unit price, each, for *Friction Fuse* includes the cost of removing an in place friction fuse, and providing and installing a new friction fuse as required by the contract.

The contract unit price, each, for *Keeper Plate* includes the cost of providing and installing a new keeper plate as required by the contract.

The contract unit price, each, for *Reference Location Sign* includes the cost of providing and installing each reference location sign as required by the contract.

The contract unit price, each, for delineators and markers includes the cost of providing and installing each delineator and marker as required by the contract.

The Department will pay for traffic signs and devices on the basis of the following schedule:

Item No.:	Item:	Unit:
2564.511	Concrete Footings Type ___	cubic yard [cubic meter]
2564.513	Median Barrier Footing	each
2564.515	Sign Support ___	each
2564.518	Overhead Sign Structure Repair	hour
2564.522	Structural Steel - (Specify Item & Use)	pound [kilogram]
2564.524	Modify Post	each
2564.531	Sign Panels Type ___	square foot [square meter]
2564.533	Furnish Sign Panels Type ___	square foot [square meter]
2564.534	Saw Sign Panels Type___	linear foot [meter]
2564.535	Sign Panel Overlay Type ___	square foot [square meter]
2564.536	Install Sign Panel Type ___	each
2564.537	Install Sign Type ___	each
2564.539	Overhead Sign Identification Plate	each
2564.539	Lighting System Identification Plate	each
2564.540	Extend Walkway Support	each
2564.541	Friction Fuse	each
2564.542	Keeper Plate	each
2564.550	Delineator, Type ___	each
2564.551	Reference Location Sign	each
2564.552	Object Marker Type___	each
2564.553	Bridge Number Marker X4-12A	each

2565 TRAFFIC CONTROL SIGNALS

2565.1 DESCRIPTION

A General

This work consists of providing and installing materials and electrical equipment, or installing Department-provided materials and electrical equipment, or both to provide a complete, operating traffic control signal system.

This work also consists of providing the following as required by the contract:

(1) Revised traffic control signal systems,
(2) Wood pole span wire traffic control signal systems,
(3) Automatic Traffic Recorder (ATR) systems,
(4) Temporary bridge signal systems,
(5) Conduit systems,
(6) Detection systems,
(7) Materials for future signal systems,
(8) Interconnect systems,
(9) Flasher systems, and
(10) Emergency Vehicle Pre-emption (EVP) systems or a combination.

B Qualifications of Workers 2545.1B

C Definitions

Refer to the ITE, the MN MUTCD, 1102, "Abbreviations," and 1103, "Definitions," for the definitions of words and phrases pertaining to traffic control signal systems and related work. Refer to NEMA Standards Publication for "Traffic Control Systems" for the definitions of words and phrases in conjunction with traffic control signal control equipment and controller units.

Refer to the NEC, Article 100 for the definition of the term "Listed."

Refer to the NEC, Article 100 for the definition of the term "Labeled."

Use a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. Ensure the testing laboratory is listed by OSHA in its scope of recognition for the tests conducted as required by this section.

Use the definitions in these referenced publications unless otherwise defined in these Standard Specifications or the contract.

Bell End

The end of a piece of rigid PVC conduit that flares out to allow connection of an additional piece of conduit.

Cut Sheet, Catalog Sheet, or Specification Sheet
A document showing a finished product including part numbers and an ordering matrix if required.

End Bell
The rigid PVC conduit fitting that is glued on at the end of a conduit to protect the conductors during pulling operations.

Pedestrian Signal Head
A signal head, which contains the symbols WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DONT WALK), and countdown numbers that is installed to direct pedestrian traffic at a traffic control signal. The head is comprised of a pedestrian signal housing and a pedestrian signal indication that fits within the housing.

Pedestrian Signal Housing
Polycarbonate housing that protects the light source and other required components. The housing includes an indication mounting door and sun visor.

Pedestrian Signal Indication
Light Emitting Diode (LED) hand and man countdown indication module that is installed within the pedestrian signal housing.

Shop Drawing
A detailed document showing how a specific product will be fabricated and constructed. This document will also include required material specifications and requirements.

Signal Head
An assembly of one or more signal sections that is provided for controlling vehicle traffic. This assembly of signal sections also includes a background shield.

Signal Section
The assembly of a signal housing, signal lens, if any, and light source with necessary components to be used for displaying the signal indication. The section is comprised of two components; a signal housing and a signal indication that fits within the housing.

Signal Housing
That part of a signal section that protects the light source and other required components. Polycarbonate housing that protects the light source and other required components and includes a hinged opening (with visor) in which the signal indication is mounted. This is one of two components that make up a signal section.

Signal Indication
The illumination of a signal lens or equivalent device. The device is a Light Emitting Diode (LED) indication module that is installed within the signal housing. This is one of two components that make up a signal section.

Source of Power (S.O.P.)
The electric utility transformer.

2565.2 MATERIALS

A General

A.1 Regulations and Code

Provide electrical equipment meeting relevant standards and requirements from the following references:

(1) NEMA,
(2) Underwriters' Laboratories, Inc. (UL), or
(3) The Electronic Components Industry Association (ECIA).

Provide materials, electrical equipment, and workmanship meeting the standards in the current editions of the following references:

(1) NEC,
(2) ASTM,
(3) ANSI,
(4) ITE,
(5) MN MUTCD,
(6) FHWA,
(7) AASHTO, and
(8) Relevant local laws and ordinances.

Provide copper electrical conductors based on the American Wire Gauge (AWG) and as specified in contract documents.

A.2 Materials and Electrical Equipment List

Within 15 calendar days following the Award of Contract date, submit a list of Contractor-provided materials and electrical equipment to the Engineer. Include in the list, the name of the manufacturer, size, and the location where the item is obtained.

Within 15 calendar days following the contract approval-notice mailing date, provide evidence in writing to the Engineer, that orders are placed for all components required on the project.

A.3 Material Samples for Testing

Provide samples of materials for testing and inspection. The Engineer may accept materials on the basis of the manufacturer's certification that material was sampled, tested, and inspected for compliance with the contract requirements. The Department reserves the right to accept or reject material on the basis of its own tests and inspections.

A.4 Tests

Perform the tests necessary to demonstrate that the materials, electrical equipment, and the installation of these items meet the requirements of the contract, at no additional cost to the Department.

Provide instruments, apparatus, tools, materials, and labor necessary to perform the required tests, at no additional cost to the Department. Instruments, apparatus, tools, and materials for performing tests will remain the property of the Contractor after completion of the tests.

A.5 Warranties, Guarantees, and Instruction Sheets

Provide new materials and electrical equipment with warranties and guarantees.

For materials and electrical equipment, submit manufacturers' warranties and guarantees, instruction sheets, and parts lists, to the Engineer before final acceptance of the project or if requested by the Engineer.

Warrant and guarantee that materials and equipment provided to the project are free of defects in materials and workmanship in accordance with the following:

(1) Turn over warranties and guarantees, offered by the material and electrical equipment manufacturer as a customary trade practice, to the Department. Name the Department as the obligee on manufacturers' warranties and guarantees;

(2) Warrant and guarantee in-service operation of materials and electrical equipment for one year. The one-year in-service warranty period begins when the Contractor "turns-on" the traffic control signal system, except the one-year period for materials and electrical equipment components placed into operation after the "turn-on" of the traffic control signal system begins on the date the materials and electrical equipment are initially, individually placed in service. The Department defines "turn-on" as the time the complete traffic control signal system meets the installation and operational requirements of the contract and is placed in automatic operation.

Replace or correct materials and electrical equipment the Engineer finds defective within the one-year in-service warranty period at no additional cost to the Department.

The warranty and guarantee requirements of this section do not apply to parts of materials and electrical equipment that the Engineer determines were subject to misuse, negligence, or accident and not the fault of the Contractor.

A.6 MnDOT's Approved/Qualified Products Lists

Access traffic control signal system materials listed on MnDOT's Approved/Qualified Products List.

A.7 Shop Drawing Submittals 2545.2A.7

A.8 MnDOT Approved Products Materials List 2545.2A.8

A.8 Cut Sheets, Catalog Sheets, or Specification Sheets 2545.2A.9

B Conduit and Accessories

B.1 Rigid Steel Conduit (RSC) and Conduit Fittings 3801

B.2 Intermediate Metal Conduit (IMC) and Conduit Fittings.....3802

B.3 Non-Metallic Rigid PVC and HDPE Conduit.....3803

B.4 Liquid Tight Flexible Non-Metallic Conduit (LFNC-B).....3804

B.5 PVC Coated Hot Dipped Galvanized Rigid Steel Conduit (PVC Coated RSC).....3805

B.6 Conduit Expansion and Deflection/Expansion Fittings 3839

C Handholes.....3819

Only use handholes for non-deliberate heavy vehicular traffic unless otherwise indicated on the Plan.

Emboss "MnDOT Signals" on the cover.

D Electrical Junction Boxes.....3838

E Concrete 2461

E.1 General

Provide Mix No. 3G52 concrete for mast arm pole foundations and light pole foundations.

Provide Mix No. 3F52 concrete for the following:

(1) Ground-mount cabinet foundations (for cabinets),
(2) Equipment pad foundations,
(3) Pedestrian push button station foundations,
(4) Flasher pedestal foundations, and
(5) New sidewalk construction or sidewalk replacement.

Provide concrete Mix No. 3G52 if the contract does not require a specific mix designation.

Construct or replace concrete pavement or base, removed for trenching or construction operations, with Mix No. 3G52HE concrete.

Provide plastic curing blankets in accordance with 3756, "Plastic Curing Blankets."

E.1 Reinforcement Bars.....3301

F Anchor Rods 3385

F.1 Traffic Control Signal Cabinets

For traffic control signal cabinets, provide anchor rods and nuts in accordance with 3385, "Anchor Rods," for Type A anchor rods. Provide anchor rods with the tops stamped AB36. The Engineer will not accept blue-top bolt identification in lieu of stamped anchor rods. Provide anchor rods with a diameter of ¾ in × 19 in, ±0.50 in [19 mm × 483 mm, ±13 mm] long before bending a 2 in [51 mm] ell on one end. Thread the opposite end of each anchor rod with at least 4 in [102 mm] of thread. Hot-dip galvanize each anchor rod full length in accordance with 3392, "Galvanized Hardware." Provide stainless steel washers 2 in [51 mm] in diameter in accordance with 3385, "Anchor Rods."

F.2 Signal Service Cabinets (Type SSB).....3837

F.3 Anti-seize Lubricant

Apply brush-on anti-seize lubricant meeting the requirements of MIL-PRF-907E to threaded portions of signal system components before assembly. Apply brush-on lubricant to the following threaded assemblies:

(1) Mast arm pole standard anchor rods above concrete foundations,
(2) Mast arm pole to transformer base bolts,
(3) Traffic control signal cabinet anchor rods above concrete foundations,
(4) Signal service cabinet anchor rods above concrete foundations,
(5) Pedestal anchor rods above concrete foundations,
(6) Pedestal shaft and pedestal base,
(7) Pedestal reinforcing collars,
(8) Pedestal shaft caps,
(9) Pedestal base cover bolt and nut,
(10) Blind threaded inserts, or rivet nuts,
(11) Threaded hub and flange pole adaptor,
(12) Bolt on hub and flange,
(13) Straight and angle mount plumbizers, and
(14) Signal bracketing.

G Electrical Cables and Conductors 3815

H Traffic Control Signal Mast Arm Poles, Mast Arms, Luminaire Pole Extensions, and Luminaires 3831

I (Blank)

J Emergency Vehicle Preemption (EVP) 3814

K Traffic Control Signal Pedestal 3832
Only use anodized aluminum pedestal shafts unless otherwise indicated on the Plan.

L Vehicle Signal Heads 3834

M Pedestrian Signal Heads 3835

N Wood Poles 3840

O (Blank)

P Electrical Service Equipment 3837

Q Accessible Pedestrian Signal (APS) Push Buttons and Mounting Hardware 3833

R Preformed Pavement Marking Tape 3354

S Fiber Optic Cables and Pigtails 3815

T Signs 2564
Provide pedestal-mounted, pole shaft-mounted, or mast arm-mounted signs of the size required by the contract, and fabricated in accordance with the Standard Sign Manual and 3352, "Signs, Delineators, and Markers."

U Traffic Control Signal Cabinet and Control Equipment
Provide the traffic control signal cabinet, or other pad-mounted cabinet and control equipment, as required by the contract.

V Miscellaneous Materials
If the contract does not specify requirements for materials and electrical equipment, provide the materials and equipment as approved by the Engineer.

W Bent Pipe Monotube Signal Bridges
Fabricate bent pipe monotube signal bridges as required by the contract and in accordance with 2471, "Structural Metals."

X Concrete Walks and Pedestrian Curb Ramps
Construct 6-inch [152 mm] thick concrete walks around traffic control signal bases in accordance with 2521, "Walks," and as required by the contract. If in a curb section, concrete walks may include pedestrian curb ramps. Construct pedestrian curb ramps, if shown on the Plans, in accordance with the Department Standard Plan 5-297.250.

Y Pole Base Connectors
Only use pole base connectors, pins, sockets, and hand crimp tools listed on MnDOT's Approved/Qualified Products List under "Signals."

Z Loop Detector Sealant Material
Only use loop detector sealant material listed on MnDOT's Approved/Qualified Products List under "Signals."

AA Loop Detector Splices
Only use loop detector splice encapsulation kits listed on MnDOT's Approved/Qualified Products List under "Signals."

BB Stainless Steel Woven Wire Cloth 3836

CC Signal Service Cabinet Type SSB 3837

DD LED Luminaires 3810
Use LED Luminaires for mounting at 40 feet.

EE Luminaire Wire Holders
Only use Department-approved luminaire wire holders for signals listed on MnDOT's Approved/Qualified Products List under "Signals."

FF Grounding Electrodes (Ground Rods and Plate Electrodes) 3818

GG Terminal Blocks

Only use terminal blocks when doing a revision to an existing traffic control signal system that has in place terminal blocks, or on temporary wood pole traffic control signal systems.

Provide terminal blocks consisting of a one-piece phenolic molding with 12 double-point terminals, with strap screw contacts for size 10-32 binder head screws. Provide barriers between terminals at least ½ in [13 mm] high. Ensure the holes for the binder head screws do not extend through the plastic. Provide terminal blocks with slots that fit the spade lugs for terminating conductors. Ensure each terminal block meets the 600 V requirements of NEMA. Provide terminal blocks that are NRTL Listed as compliant with the requirements of UL XCFR2.GuideInfo — Terminal Blocks.

HH Sponge Rubber Expansion Joint.....3841

2565.3 CONSTRUCTION REQUIREMENTS

A General

The locations shown on the Plans for component parts having X and Y coordinates are exact locations. Modification of these locations shall only be made with the approval of the Engineer. Component part locations which have no X and Y coordinates supplied on the Plan are approximate. The Engineer will establish the exact locations of component parts including pedestrian curb ramps.

Keep highways, streets, and roads open to traffic during construction in accordance with 1404, "Maintenance of Traffic." Protect openings or uncompleted work that may cause a hazard to vehicle or pedestrian traffic in accordance with 1707, "Public Convenience and Safety."

A.1 Compliance with Electrical Codes and Standards

Perform work meeting the requirements of the NEC, the Minnesota Department of Labor and Industry, Board of Electricity, and state laws and local ordinances governing electrical installations.

A.2 Permits and Inspections

Obtain the necessary permits and inspections at no additional cost to the Department.

Perform work in conjunction with construction of electrical systems or conduit systems for conveying electrical cables and conductors as required by the contract and in accordance with 1702, "Permits, Licenses, and Taxes." Obtain a permit for the performance of this work, including the installation of conduits, in accordance with the Minnesota Electrical Act.

A.3 Utility Property and Service.....1507

Meet the minimum clearance requirements, determined by the electrical utility company, for overhead electrical lines to other overhead structures and equipment operations.

A.4 Installation Requirements

Install materials and devices in accordance with contract documents and in accordance with manufacturer's installation requirements.

A.5 Removal Requirements 2104

B Existing Electrical Systems

Maintain and keep in operation the new and existing electrical systems within the limits of the project in accordance with 1514, "Maintenance During Construction," but not including 1404.7, "Winter Suspension", until the Engineer accepts the project in writing as specified in 1716, "Contractor's Responsibility for Work." Maintain and keep in operation new and existing electrical systems during periods of suspension at no additional cost to the Department.

Maintenance of the existing electrical systems including traffic control signals, ATRs, flasher systems, and roadway lighting, or Department-approved temporary replacements, is considered incidental during the progress of new work, except if the Engineer directs, or the contract requires turn-offs. Notify the Engineer at least 48 h before scheduled turn-offs and before performing work on existing electrical systems. Do not turn off existing traffic control signal systems without the Engineer's approval and the Engineer's presence.

If existing electrical system components are damaged due to Contractor operations, within 24 hours repair or replace the damaged components at no additional cost to the Department, in accordance with 1716 and relevant to specifications for new construction. Failure to repair or replace damaged components within 24 hours will result in the Department repairing or replacing and deducting costs from project money entitled to the Contractor.

Unless otherwise required by the contract, the Department will continue maintenance during the performance of work on existing electrical systems. The Department will provide electrical energy for operation and repair or replace component parts of existing electrical systems, damaged by public traffic or natural causes.

During authorized work suspension, the Department will maintain existing traffic control signal cabinets and control equipment and will maintain existing traffic control signal systems, unless otherwise required by the contract.

C Excavation and Backfill

Provide excavation and backfill for the installation of concrete foundations, cable, conduit, handholes, and other items shown on the Plans in accordance with 2451, "Structure Excavations and Backfills." Do not excavate trenches for conduit and holes for concrete foundations and handholes wider than necessary. Install concrete foundations, conduit, and handholes as soon as possible following excavation. Place excavation material in locations that will not cause damage or obstruct vehicle or pedestrian traffic, or interfere with surface drainage.

Locate trenching at the distance from the edge of the pavement, back of curbing, or edge of surfaced shoulders as required by the contract or directed by the Engineer. Ensure the distance the pavement, curbing, or surfaced shoulders does not cause damage to these improvements. Construct the trench with uniform alignment for accurate referencing of the underground installation.

At locations scheduled for guardrail, utilities, cable, or other below-ground structures, modify locations to prevent damage to the cable or conduit during installation of other components. Before installation, coordinate with and obtain approval from the Engineer for modified locations. Replace cables damaged by Contractor operations due to lack of coordination with the Engineer and lack of the Engineer's approval of the location, at no additional cost to the Department.

If trenching and excavation operations require the removal of concrete pavement or concrete sidewalk, cut the concrete with a concrete saw to a depth of at least 35 percent of the thickness of the concrete along the removal lines before breaking and removing, or remove the concrete to existing joints.

Backfill excavations around the installed concrete foundations, conduit, and handholes. Use backfill material similar to adjacent soils and compact backfill material to the same density. Avoid placing stones immediately adjacent to conduits or direct-buried cable during backfill placement. If required by the contract, or directed by the Engineer, use granular material in designated layers or portions of the backfill provided in accordance with 2451, "Structure Excavations and Backfills." Restore the following to the original condition required by the contract, to the Engineer's satisfaction, and at no additional cost to the Department:

(1) Roadway surfacing, including concrete pavement, bituminous surface, or gravel surface,
(2) Sidewalks,
(3) Curbs and gutters,
(4) Sod, and
(5) Railways.

Remove and dispose of surplus material from excavation and backfill outside the right-of-way in accordance with 2104.3.D.3, "Disposal outside Right of Way."

D Conduits, Fittings, and Junction Box Installation

D.1 General

Provide conduit and fittings of the type and size required by the contract. The Contractor may install conduit and fittings of a larger size than specified. If the contract does not specify the size of conduit, provide conduit at least ¾ in [21 mm] and sized in accordance with the NEC so the area occupied by the electrical cables and conductors does not exceed 40 percent of the internal cross-sectional area of the conduit for rigid steel conduit or 35 percent for non-metallic conduit.

Install conduit in accordance with the NEC. In a single conduit run, provide conduit of the same size and type, continuous from outlet to outlet. The Contractor may incorporate special conduit fittings for pulling electrical cables and conductors or making short radius bends, as necessary, in the run.

The Engineer will reject damaged conduit with sharp kinks or reduced cross sections.

Prevent conduit from being damaged. Rigidly support conduit that will be encased in concrete or masonry in position during casting.

Install non-metallic conduit end bells on HDPE or Rigid PVC conduit prior to installation of cables and conductors to prevent damage.

Install threaded insulated grounding bushings with lay in ground lugs on RSC conduit prior to installation of cables and conductors to prevent damage. Use lay in ground lugs constructed of stainless steel, copper, tin plated copper, brass, or bronze.

Install electrical cables and conductors in conduit, unless otherwise required by the contract.

D.2 Conduit Placement

Install conduit in a straight run to enter handholes and foundations in line with the general direction of the conduit run.

D.2.a Above Ground

Secure conduit attached above ground to wood poles with U-shaped two-hole pipe straps meeting the requirements of the current edition of the NEC and spaced no more than 4 ft [1.2 m] apart.

Secure conduit attached above ground to metal poles with at least ¾ in [19 mm] wide stainless steel banding, spaced no more than 5 ft [1.5 m] apart.

Support conduit within 3 ft [900 mm] of each termination or fitting.

Install expansion or deflection/expansion devices at each structure expansion joint as required by the contract, or directed by the Engineer.

Secure conduit, attached above ground to cabinets, bridges, and other structures as required by the contract and to the Engineer's satisfaction.

D.2.b Underground

Place conduit using the trenching method, vibratory plow, or by directional boring.

Only place conduit under existing pavement or sidewalk by directional boring. If a distortion greater than ¼ in [6 mm] is created in the existing surface, remove the distortion and restore the roadway or sidewalk to the original condition at no additional cost to the Department.

Except under existing pavements, when placing High Density Polyethylene (HDPE) continuous length conduit use trenching, vibratory plow, or directional boring installation methods.

If plowing HDPE conduit, provide a vibratory plow with a feed blade that is capable of performing the following:

(1) Breaks the ground,
(2) Places the conduit to a predetermined depth,
(3) Guides the conduit into the bottom of the break through the guide blade chute so that little or no stress is placed on the conduit during installation to avoid damage,
(4) Does not pull the conduit in place, and
(5) Closes the break in the ground.

Only use RSC or Rigid PVC conduit between foundations and the nearest handhole. HDPE conduit may not be used in any foundation or equipment pad.

Do not use the trenching method, vibratory plow, or push conduit with a pneumatic compaction tool to place conduit under existing concrete, bituminous surfaces, or railways

Grout the voids that result from abandoned boring operations through a roadbed or sidewalk at no additional cost to the Department and as approved by the Engineer.

If placing conduit underground below new or reconstructed roadway surface areas or sidewalk which has not been paved, use the trenching method to place the conduit at a uniform depth below the adjacent ground line and backfill and compact before placing new roadway surfaces or new sidewalk, as approved by the Engineer. Do not place conduit before the Engineer inspects the trench.

Place Department furnished locator balls at open ends of conduit under roadways or slope pavement that do not terminate in a handhole (s), pads, or foundations.

Place underground conduit at least 18 in [450 mm] below the surface of a ground area and at least 24 in [600 mm] below roadway surfaces. Place underground conduit under railroad tracks at least 42 in [1.10 m] below the bottom of railroad ties, or as required by the Railroad Company.

If approved by the Engineer, the Contractor may change conduit runs required by the contract to avoid underground obstructions.

Provide underground conduit runs with provisions for draining moisture. Slope horizontal conduit runs to drain at a rate of at least 0.25 percent, or 3 in per 100 ft [75 mm per 30.5 m]. To drain the low points, not including the open ends of conduit runs, install a standard tee conduit fitting and nipples, at least 6 in [150 mm] long. Extend the fitting and nipple into a hole 24 in × 24 in [600 mm × 600 mm] deep. Backfill the hole with crushed rock or Department-approved granular material.

Position conduit, terminating in handholes or concrete foundations, so the conduit extends inside the handholes, pole bases, cabinet bases, or structure bases by 2 in [50 mm] to 3 in [75 mm]. Slope the conduit toward the access opening. Slope the conduit out of the foundation, toward the handhole opening for drainage.

Locate conduit couplings at least 6 in [150 mm] from the structure surface.

Place conduit entering existing concrete foundations by sawing and breaking the concrete or core drilling so conduit enters the foundation below the adjacent ground surface and projects from 1 in to 2 in [25 mm to 50 mm] above the top of the

foundation and inside the pole shaft or cabinet base. Return the foundation to its original condition by patching with concrete as approved by the Engineer.

Thread conduit, stubbed out of a concrete foundation for future use if installing RSC. Cap stubbed conduit on the open ends with standard pipe caps or rigid PVC caps, based on the type of conduit. Extend conduit from 18 in to 24 in [450 mm to 600 mm] out of the concrete foundation underground in the direction shown on the Plans or as directed by the Engineer.

Following installation of cables and conductors, seal the open ends of conduit entering cabinets or pole foundations, using duct seal compound NRTL classified under general use tapes.

D.3 Conduit Bends

Provide conduit bends, except factory bends, with a radius of at least six times the nominal diameter of the conduit. Make conduit bends without damaging the conduit and without reducing the internal diameter of the conduit.

For bends in conduit runs, provide the minimum radius necessary, but do not exceed 360 degrees of bend per run between handholes, foundations, or both.

D.4 Rigid Steel Conduit and Intermediate Metal Conduit

D.4.a Joints

Thread the ends of the conduit and use a standard threaded conduit coupling to join standard length conduit. If cutting standard length conduit, thread and ream the ends to remove burrs and rough edges.

Conduit ends, joined by coupling, must butt or come together for the full circumference of the conduit to provide an electrical bonding and grounding connection for the length of the conduit run.

Paint coating on conduit damaged by handling or installing with rust preventative paint as approved by the Engineer.

All threaded RSC and IMC conduits and fittings must have all threads protected with a brush on corrosion-resistant compound in accordance with NEC Article 300.6

D.4.b Open Ends

Cap the open ends of conduit in handholes and conduit extending above concrete foundations with standard conduit caps, or other method approved by the Engineer, until wiring installation. Install a threaded insulated grounding bushing with lay in ground lugs for RSC on the open ends when caps are removed. Provide grounding bushings in accordance with the UL 467 for grounding and bonding equipment. Provide a lug compatible with a No. 6 copper bonding conductor and consisting of stainless steel, copper, brass, bronze integral to the bushing. Cover the lug and copper bonding conductor at each bushing with a corrosion inhibiting compound.

Cap the open ends of conduit that terminates on the side of wood poles or other structures with weatherhead entrance fittings.

D.4.c Existing Conduit

Clean and blow-out existing underground conduit, incorporated into a new or revised electrical system, with compressed air before placing new electrical cables and conductors. Replace old insulated grounding bushing with lay in ground lugs and ground wire in existing handholes to maintain a continuously grounded system.

If placing new handholes in existing conduit runs cut the conduit and extend it into the new handhole as approved by the Engineer. Thread the open ends of conduits, fit conduit with grounding-type insulated threaded conduit bushings, and bond and ground the conduit.

D.5 Rigid PVC Conduit

D.5.a Joints

Trim the inside and outside of cut ends of rigid PVC conduit to remove rough edges. Use standard sized couplings or rigid PVC conduit with an attached preformed coupling. Clean rigid PVC conduit sections with a joint cleaner and cement joints with a PVC cement. Allow the PVC cement to set for 6 h before pulling conduit through a directional-bored channel. Conduit ends must butt or come together for the full circumference of the conduit. Use long-line couplings to join conduit sections if placing rigid PVC conduit under existing roadway surfaces.

D.5.b Open Ends

Immediately cap or plug the open ends of rigid PVC conduit to prevent the entrance of moisture until the installation of the electrical cables and conductors. Before installing electrical cables and conductors, provide rigid PVC conduit with standard PVC conduit end bells and end bells for HDPE, continuous length conduit to prevent damage to the electrical cables and conductors.

Cap or plug the open ends of rigid PVC conduit, not containing electrical conductors, using standard sized PVC conduit caps or plugs.

D.5.c Conduit Encasement

If the contract requires use of the trenching method for rigid PVC conduit, place in granular or concrete encasement. For granular encased rigid PVC conduit, ensure the bottom and sides of the trench are free of sharp irregularities before placing conduit. Backfill the first 6 in [150 mm] of the trench with granular material meeting the requirements of 3149, "Granular Material." For concrete encased rigid PVC conduit, extend the trench width 3 in [75 mm] from each side of the conduit. Provide Mix No. 3F52 concrete, or an equivalent, and encase the conduit 3 in [75 mm] on each side.

D.6 Conduit on Bridges

Mount and attach PVC coated RSC conduit and fittings to a bridge as required by the contract and as approved by the Engineer. Provide conduit supports and space the supports as required by the NEC. Use PVC coated hangers or PVC coated pipe clamps, approved by the Engineer before installation, to support conduit. Attach hangers or pipe clamps using two-unit threaded bolt anchorages meeting the requirements of the contract or, if not specified, approved by the Engineer. Provide and install hardware that allows removal of the hanger or pipe clamp and permits conduit expansion, contraction, and deflection.

Provide PVC coated RSC conduit as follows:

(1) All PVC coated installations shall have no exposed metal,
(2) PVC protective sleeves on PVC coated fittings and couplings shall not be cut or altered in any manner,
(3) All threads on conduit shall be treated according to NEC 300.6, using a non-corrosive, conductive substance,
(4) Damaged PVC conduit coating shall be repaired according to manufacturer's instructions,
(5) Installers of PVC coated conduit must be trained and certified by the PVC coated Manufacturer or the Manufacturer's representative to install PVC coated conduit. Documentation demonstrating this requirement must be submitted for review and approval.

D.7 Expansion and Deflection/Expansion Fittings for Conduit on Bridges

Provide expansion and deflection /expansion fittings in accordance with 3839 in conduit runs attached to bridges, as required by the plans in accordance with the NEC or as directed by the Engineer. Provide electrically continuous PVC coated RSC conduit in accordance with 3805 with expansion fittings using a copper bonding jumper sized in accordance with the NEC. Provide an internal bonding jumper across the expansion and deflection/expansion fittings.

Wrap the expansion and deflection /expansion fittings with sponge rubber expansion joint in accordance with 3841 when fittings will be encased in concrete. Ensure the outer seam of the wrap is on the bottom side of the expansion and deflection /expansion fittings assembly. Secure the wrap in place prior to concrete pouring operations.

D.8 Junction Boxes Attached to Bridges

Attach junction boxes in accordance with 3838 using two unit threaded bolt anchorages as required by the contract. If the contract does not specify the anchorages, use anchorages approved by the Engineer and with hardware to allow removal of the junction box.

Attach junction boxes to concrete using masonry anchorages or powder activated studs with the hardware necessary to allow removal of the junction box.

Provide the manufacturer supplied drain fitting as close to the bottom of the enclosure as possible.

D.9 Rigid PVC Conduit Attached to Wood Poles

Securely fasten Rigid PVC conduit to wood poles by appropriate type conduit straps that meet the current edition of the National Electrical Code (NEC). Space the conduit straps 3 - 4 feet apart.

E Handholes

Install handholes as required by the contract and as approved by the Engineer. The Contractor may install additional handholes at no additional cost to the Department.

Set the tops of handholes so the cover is 1 in [25 mm] below grade, except in sidewalk areas.
Set the cover flush with the sidewalk in accordance with ADA requirements.

To facilitate drainage, set handholes on a compacted aggregate drain bed, 2 ft [609m m] larger in diameter or square of the handhole enclosure, and 12 in [300 mm] deep, using coarse filter aggregate in accordance with 3149.2.H, "Coarse Filter Aggregate."

Backfill handholes after installing the cover.

Conduits entering handholes must enter thru the barrel or side wall of the handhole.
Drill conduit holes into the side walls of handholes no more than 1 inch larger than the size conduit being installed.
Remove excess material inside of existing handholes that are to be used in the new system.

After handhole and conduit installation at each handhole location, make the sidewalls inside handholes watertight by patching with concrete for pre-cast concrete handholes, or material-compatible caulking compound, or other sealing material, compatible handhole material, to the Engineer's satisfaction.

After all the cables and conductors have been installed in the handhole install a department provided locator ball as follows:

(1) Use a department furnished locator ball,
(2) Cut ¾ inch PVC conduit to length to allow the locator ball to be installed within 6 inches from the top of the handhole when the conduit is stood vertically against the side of the handhole,
(3) Drill ¼ inch hole thru the top of the conduit providing two holes,
(4) Attach the locator ball with a 3/16 inch nylon cable tie wrap using the drilled holes to the conduit, and
(5) Place the locator ball attached to the conduit against the sidewall of the handhole in a vertical position.

Use red locator balls for handholes containing conductors with an operating voltage of > 50 volts.

Use orange locator balls for handholes containing conductors with an operating voltage of ≤ 50 volts and communications circuits.

For placing pre-cast concrete handholes in accordance with Standard Plate 8117 with metal frame and cover, in areas not surfaced with concrete, support handholes with concrete to the Engineer's satisfaction.
Bond and ground the metal ring and cover in accordance with the NEC Article 314.30.

F Concrete Foundations

F.1 General

Except for portions of concrete foundations that extend into solid rock, use forming tubes or wood forms with the following characteristics to construct concrete foundations in accordance with 2411, "Minor Concrete Structures":

(1) Of the size and shape required by the contract,
(2) With an ordinary surface finish in accordance with 2401.3.F, "Finish of Concrete," on all sides, 6 in [150 mm] below the adjacent ground line, and
(3) Floated smooth top with beveled or chamfered edges.

If soil conditions allow, the Engineer may approve casting of foundations with rigid and securely braced forms or tubes only on the upper portion of the foundation. Brace entering conduits, anchor rods, ground rod electrodes, and other equipment in position with a rigid metal template and at the height necessary until the concrete cures. Do not remove forms or rigid metal template until the concrete cures.

Use portable vibrators and hand spading to consolidate the concrete to form a smooth, dense surface free of air or water blisters.

If unstable foundation conditions are encountered, the Contractor may alter concrete foundation construction to secure a stable foundation, as approved by the Engineer. If obstructions such as solid rock are encountered that prevent concrete foundation construction as planned, the Contractor may adjust the foundation dimensions as required by the contract, or directed by the Engineer, to provide a stable foundation.

Form the exposed concrete above the adjacent ground line, sidewalk, or paved area to present a neat appearance.

F.2 Anchor Rods

Place the anchor rods in pole foundations in a rigid cage to maintain alignment while pouring the concrete as approved by the Engineer. Provide anchor rod cages designed without welding or tack welding on the anchor rods or as shown on the standard plate. The Engineer will reject anchor rods with welding or tack welding. Provide a rigid metal template for the anchor rod projections, conduit, and ground rod alignment. Leave the template in place until the concrete is cured. Do not begin work on the concrete foundation until the Engineer approves the anchor rods. The Engineer will reject foundations if anchor rods, conduits, and ground rod electrodes are improperly aligned after the concrete cures. Do not enlarge bolt holes in transformer base plates to allow for shifted anchorages or alter the transformer base plate openings to accommodate misaligned conduits and ground rod electrodes.

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F.3 Equipment Pads

Construct concrete equipment pads at the location staked by the Engineer and as detailed in the Plans.
Install the equipment pad for the Department provided traffic control signal cabinet and control equipment as part of the equipment pad concrete foundation using Department provided anchor rods, nuts, and washers to mount the cabinet.
Install the equipment pad for the signal service cabinet type SSB as part of the equipment pad concrete foundation using anchor rods, nuts, and washers supplied by the SSB cabinet manufacturer.
The anchor rods must project above the pad to accommodate the 1/2 in (13 mm) thick gasket.

G Loop Detectors

G.1 General

Provide preformed rigid PVC or saw-cut inductive loop detectors as required by the contract. Install complete loop detectors with the following:

(1) An electrical conductor embedded loop or group of loops installed in the roadway as required by the contract, and
(2) A loop detector lead-in cable to the traffic control signal cabinet or other cabinet.

G.2 Installation

Splice the loop detector roadway conductor to the loop detector lead-in cable in accordance with Standard Plates 8130 or 8132 and as follows:

(1) Cut the drain wire off the loop detector lead-in cable at the point where it exits the cable jacket at the end of the cable assembly that will be installed in the loop detector splice kit,
(2) Ensure the loop detector lead-in cable jacket is encased in the loop detector splice encapsulation material forming a water tight seal, and
(3) Terminate the loop detector lead-in cable assembly located in the traffic control signal cabinet in the appropriate terminals as shown on the cabinet print.

G.2.a Preformed Rigid PVC Loop Detector

Provide loop detectors encased in rigid PVC conduit in accordance with Standard Plate 8132.

G.2.b. Saw-Cut Loop Detectors

Provide saw-cut loop detectors in accordance with Standard Plate 8130.

The Engineer may make minor adjustments to the size or shape of the loop detector in the field at no additional cost to the Department.

Make an individual saw cut from each loop detector to the conduit leading to the handhole.

G.3 Loop Detector Test Report

Submit three copies of a signed and dated loop detector test report to the Engineer. Include the following information in the report for each loop detector and lead-in cable system provided and installed as required by the contract:

(1) Project numbers, intersection, and location identification,
(2) Loop detector number shown on the Plans,
(3) Width and length dimensions of the loop detector, in inches, as installed,
(4) Number of turns of wire in loop detector as installed,
(5) Meet the following continuity test results for each detector circuit as tested at two locations:
  (5.1) Less than 0.5 Ω, from lead to lead for loop detectors, as measured at the handhole or junction box before splicing the loop detector lead-in cable,
  (5.2) Less than 5 Ω for loop detector and lead-in cable systems at the intersection traffic control signal cabinet after splicing the handhole or junction box, and
  (5.3) An ohm reading at the intersection traffic control signal cabinet greater than the ohm reading measured at the loop detector adjacent handhole or junction box.
(6) Inductance test results from 50μH to 900μH for each loop detector and lead-in cable system, and
(7) Insulation resistance test results of at least 100 MΩ as performed at 500 VDC between one loop detector lead-in cable conductor and the "Equipment Ground Bus" in the cabinet.

Perform the continuity test, inductance test, and insulation resistance test at the intersection traffic control signal cabinet before terminating the loop detector lead-in cable conductors on the terminal facilities. Perform loop detector tests in the Engineer's presence at no additional cost to the Department.

The Engineer will distribute the three final loop detector test reports for the intersection as follows:

(1) The original to the official project file,
(2) One copy to the traffic control signal cabinet, and
(3) One copy to the Department's Electrical Services Unit or maintaining agency.

Provide the electrical instruments, apparatus, tools, and labor to perform the required loop detector tests on each loop detector and lead-in cable system. Electrical instruments, apparatus, and tools remain the Contractor's property after the tests are completed.

If a loop detector or lead-in cable system fails any of the loop detector tests, replace parts or the entire loop detector and lead-in cable system at no additional cost to the Department as directed by the Engineer. Repeat and record the loop detector tests for the "revised" loop detector and lead-in cable system.

Each loop detector and lead-in cable system must pass the loop detector tests and must be operational as approved by the Engineer. Regardless of the test results, the Department may test each loop detector and lead-in cable system with their own test equipment.

H Bonding and Grounding

Provide bonding, grounding, grounding electrodes, grounding electrode conductors, equipment grounding conductors, and grounding connections in accordance with NEC.

Use NRTL- listed stainless steel, copper, tin plated copper, brass, or bronze connectors for bonding and grounding unless otherwise specified in contract documents.

H.1 Grounding Electrodes

Provide grounding electrodes in accordance with 3818.

H.2 Bonding and Grounding

Form a continuous bonded and grounded system using the following mechanically and electrically secure components:

(1) Metal conduit,
(2) Metal traffic control signal pedestals,
(3) Mast arm pole standards,
(4) Light poles,
(5) Service equipment,
(6) Metal junction boxes,
(7) Down guys,
(8) Span wire,
(9) Microwave and sonic detector units,
(10) Cabinets, and
(11) Pedestrian Push Button Stations

Provide conductors for bonding jumpers and equipment grounding. Provide grounding of the system and neutral at the service point, as required by the NEC.

Furnish a minimum No. 6 AWG, stranded copper, insulated green grounding electrode conductor.

H.3 Pole Base Bonding and Grounding

Use a brass, bronze, or stainless steel bolt a minimum of $^{3}/_{16}$ in [5 mm] in diameter installed in the lower part of the shaft or base to attach the grounding and bonding jumper to metal traffic control signal pedestals, mast arm pole standards, and light poles.

Do not use a solder or sheet metal strap connection.

Use an NRTL-listed, reusable screw-type, active clamping ground lug with a tang that connects to the $^{5}/_{16}$ in [8 mm] signal pole base grounding stud to attach the No. 6 AWG stranded, insulated green grounding conductor to metal traffic control signal pedestals and mast arm pole standards to the signal pole base.

Terminate the No. 6 AWG stranded, insulated green conductor on the "Equipment Ground Bus." Ground the "Equipment Ground Bus" to the signal service ground rod electrode with at least No. 6 AWG stranded, insulated green grounding electrode conductor.

Provide and connect a No.6 stranded, insulated green equipment grounding conductor from the "Equipment Ground Bus" in the traffic control signal cabinet or other type cabinet to the ground bus of the service cabinet and to each incoming conduit insulated grounding bushing lug or each incoming No. 6 AWG stranded, insulated green conductor

When connecting the daisy chain #6 AWG stranded insulated green grounding conductor that runs from the adjacent signal poles ground rod electrode to the next signal pole's ground rod electrode, exothermically weld it to the ground rod electrode with a T type connector utilizing a 3 or 4 wiretap connection. Use a 2 wiretap connection at the end of the daisy chain run.

Bond the #6 AWG stranded, insulated green grounding conductor to the signal pole base 5/16" grounding stud using a NRTL listed re-usable screw type active clamping ground lug with a tang.

H.4 Exothermic Welding

Bond all ground rod electrodes to the #6 AWG stranded, insulated green conductor coming from the traffic control signal cabinet and running to the signal pole base using exothermic welding.

The exothermic welding is achieved by:

(1) Stripping off enough insulating material from the #6 AWG stranded green insulated grounding wire to ensure the insulation does not burn or melt during the welding process.

(2) Use a manufacturer's specific sized mold for exothermic welding of a #6 AWG stranded copper wire being welded to a non-threaded 5/8 inch copper clad ground rod electrode. Use a T type configuration with a 4 wiretap, 3 wiretap or 2 wiretap for the mold as specified in the Plans.

(3) Strict adherence to the weld manufactures instructions for material preparation, when welding and testing of the exothermic weld.

H.5 Ground Rod Electrode Installation

Drive ground rod electrodes at service points and locations required by the contract. Install ground rod electrodes and grounding connections in accordance with the NEC. Place the ground rod electrode for PA85, PA90, PA100, and BA series signal poles in the nearest hand hole adjacent to the signal pole foundation as required by the contract. Provide pedestal foundations with a ground rod electrode placed inside the pedestal foundation slightly off center in the pedestal foundation as required by the contract before casting the concrete foundation. Ground the signal poles by bonding together the No. 6 AWG, stranded, insulated green grounding conductor that runs from the traffic control signal cabinet to the ground rod electrode and through to the pole base. Install the ground rod electrode in the handhole with the top of the ground rod 3 in [75 mm] below the bottom of the handhole cover as required by the contract.

When ground rod electrodes are required to be installed outside of the foundation and rock is encountered preventing the ground rods from being installed vertically, follow the installation requirements for rod electrodes in accordance with the NEC. If it is not possible to install ground rods according to the installation requirements of the NEC, install plate electrodes in accordance with 3818 as directed by the Engineer.

If installing the ground rod electrode in concrete foundations, install the top of the ground rod electrode from 2 in [50 mm] to 3 in [75 mm] above the foundation. Bond the service equipment to the ground rod electrode.

Use exothermic welding to bond ground rod electrodes to the No. 6 AWG stranded, insulated green grounding conductor from the traffic control signal cabinet to the signal pole base.

Use a No. 6 AWG standard green insulated grounding electrode conductor to bond metal poles, pedestals, cabinets, and other structures requiring a grounding conductor to the ground rod electrode as required by the contract. Attach one end of the bonding jumper to the lower part of the pole, pedestal, cabinet, or structure shaft or base. Use an exothermic weld to attach the other end of the bonding jumper to the ground rod electrode as specified in the contract.

If installing non-metallic conduit for future use, the Contractor may omit the equipment grounding conductor.

H.6 Replacement RSC Conduit Threaded Insulated Grounding Bushings

In addition to the required bonding and grounding jumper and required threaded insulated grounding bushings with lay in ground lugs on open ends of new RSC conduit, provide and install new bonding and grounding jumpers and new threaded grounding conduit bushings on open ends of in-place RSC conduit at the in-place locations as directed by the Engineer.

H.7 Oxide Inhibiting Agent

Apply an oxide inhibiting agent to all bonding and grounding connections after assembly and final connection.

I (Blank)

J Wiring

J.1 General

Install electrical cables, conductors, and electrical wiring in accordance with the NEC.

Use insulated spade lugs or pole base connectors for terminal connections of conductors.

Tape the ends of un-terminated spare electrical conductors to exclude moisture.

Leave 3 ft [1 m] of slack cable in each handhole through which a run of cable passes.

Leave 24 in [600 mm] of slack cable or conductors in each mast arm pole base, light pole base, and traffic control signal pedestal base.

Install unmetered service conductors in a separate conduit system from all other conductors. Run conductors of a branch circuit in a single conduit.

Continuously run electrical cables and conductors without splices from the terminal appliances in the traffic control signal cabinet to the pole base connectors, terminal blocks, or other terminal appliances.

Continuously install loop detector lead-in cable without splices or terminals from the loop detector conductor and lead-in cable splice to the traffic control signal cabinet or other type cabinet.

Continuously install interconnect cable between cabinets without splices. Run the cable in straight lines with a minimum number of bends in the cable run.

Provide the size and quantity of conductors in each cable and the number of cables in a given conduit run as shown on the Plans.

Wire the electrical system in accordance with the field wiring diagram shown in the Plans. Identify cables as shown on the field wiring diagram in all handholes, junction boxes, traffic control signal pedestal bases, mast arm pole bases, light pole bases, and cabinets. Except for the individual conductors terminated at the cabinet fuse panels, wrap white vinyl adhesive tape around the cable to identify cables and conductors. Handwrite labels with a black permanent marker as approved by the Engineer or use a label maker with labels suitable for use in wet locations. Wrap the labels from a label maker around the cable in one complete revolution with minimum $^{1}/_{10}$ in overlap.

Place machine printed labels, embossed plastic labels, vinyl adhesive pre-printed labels, or sleeve type labels around each conductor to identify the individual conductors terminated at the cabinet fuse panels. Place labels on each cable terminated at the terminal appliances located inside the traffic control signal cabinet (i.e. RED 2-1, YEL 2-1, GRN 2-1, RLTA 5-1, YLTA 5-1, GLTA 5-1, RRTA 4-1, YRTA 4-1, GRTA 4-1, DWK P6-1, WLK P6-1, etc., or the like, indicating the signal indication and the signal head number). Apply the label within 3 in [75 mm] of the terminal point. Provide an identification strip for terminal blocks in traffic control signal pedestal bases and pole bases as part of the terminal block. Each conductor shall be identified in a similar manner as above to label the signal indication it serves.

Using a black permanent marker, label both sides of pole base connectors with signal head number.

J.2 Underground Wiring

To avoid damaging the cable and conductor insulation, hand pull electrical cables and conductors through rigid steel conduit. Clean the conduit at the time of installation. Tape the ends of electrical cables and conductors to exclude moisture until spliced or terminated.

Hand pull cables and conductors through rigid PVC conduit without splitting or damaging the rigid PVC conduit due to "pull rope abrasion". Replace the damaged portion of the rigid PVC conduit as approved by the Engineer.

Use the trenching method or a vibratory plow to direct bury interconnect cable not placed in conduit to a depth of at least 36 in [915 mm], except where required to enter a handhole. If the contract requires the interconnect cable to enter a handhole, install the cable in the side of the handhole from 6 in to 8 in [150 mm to 200 mm] above the bottom of the handhole. Maintain the a depth of at least 36 in [915 mm] within 2 ft to 3 ft [600 mm to 915 mm] of the handhole.

If plowing direct buried interconnect cable, provide a vibratory plow with a feed blade that is capable of performing the following:

(1) Breaks the ground,
(2) Places the cable to a predetermined depth,
(3) Guides the cable into the bottom of the break through the guide blade chute so that little or no stress is placed on the cable during installation to avoid damage,
(4) Does not pull the cable in place,
(5) Places a warning tape 18 in (460mm) above the cable, and
(6) Closes the break in the ground.

Submit the plowing method to the Engineer for approval before installing the cable.

Place plastic warning tape meeting the following characteristics at least 18 in [460 mm] above the interconnect cable or conduit containing the interconnect cable and at least 12 in [300 mm] below the surface:

(1) 3 in [75 mm] wide,
(2) Permanent orange,
(3) Stretchable,
(4) Non-biodegradable, and
(5) Imprinted with the inscription, "CAUTION – MnDOT COMMUNICATION CABLE BELOW"

Place any direct buried cable that enters or exits handholes in an electrical conduit sleeve at least 3 ft [915 mm] long.

J.3 Cabinet Field Lead Wiring

Do not cut a field lead entering a cabinet shorter than the farthest terminal in the cabinet. After completing field connections to the cabinet terminal, dress and band together the field leads to provide an orderly arrangement within the cabinet.

J.4 Splices

Do not splice unless required by the contract or approved by the Engineer. If required by the contract or approved by the Engineer, only splice in handholes, control cabinets, junction boxes, or in bases of poles. Do not splice underground cable unless specifically required by the contract. Use an approved epoxy splice kit for underground cable splices as required by the contract.

Provide electrical splices for conductors and cables as required by the contract. Electrically and mechanically secure splices without solder, except loop detector splices. Use connector types with splices as specified in the contract.

(1) Do not use pressure spring type connectors.
(2) Splice loop detectors as specified in the contract.

J.5 Aboveground Wiring

For electrical cables and conductors installed above ground, except where run on overhead span wire, use one of the following methods:

(1) Conduit attached to wood poles, metal poles, cabinets, or other structures; or
(2) Inside metal poles, pedestals, cabinets, or other structures.

Provide slack of 5 percent of the span length when installing overhead span wire.

When installing electrical cables and conductors on span wire, using straps with spacing less than 18 in [450 mm] for lacing. Provide weather-resistant, black nylon, non-metallic straps with a loop tensile strength of at least 250 lb [113.4 kg]. Submit the non-metallic straps to the Engineer for approval before installation.

J.6 Pole Base Connectors

Provide Department-approved pole base connectors for terminating signal conductors in mast arm pole bases, traffic control signal pedestal bases, and other bases with vehicle and pedestrian signal indications or pedestrian signal indications.

Assemble pole base connectors in accordance with manufacturer's instructions.

Use a Department-approved hand crimp tool to install pole base connectors as specified in the contract.

J.7 Signal and Pedestrian Head Terminal Block Wiring

For horizontally mounted terminal blocks in the signal head, terminate the forks of the spade lugs facing down on the terminal block for the signal control cable running from the pole base into signal head. Form a loop with the conductors at least 3 inches above the terminal block and then loop the conductors back down to exit the head for termination in the pole base.

For vertically mounted terminal blocks, terminate the spade lugs for the signal control cable running from the pole base into signal head and loop the conductors to extend up from the terminal block at least 3 inches above the terminal block and then loop the conductors back down to exit the head for termination in the pole base.

After the conductors have been properly terminated, spray the spade lugs and the entire terminal block with an approved pole base terminal block coating. The coating of the terminal block includes spraying the terminal connections and the exposed wire ends where crimped to the spade connector.

Only use Department-approved pole base terminal block coatings listed on MnDOT's Approved/Qualified Products List under "Signals."

J.8 Terminal Blocks

Where required by the Contract for retrofit projects with in place terminal blocks, or temporary wood pole traffic control signal systems, provide each mast arm pole base, traffic signal pedestal base, and other bases or poles with vehicle and pedestrian signal indications or pedestrian signal indications with a NRTL listed terminal block for terminating field conductors and traffic signal conductors.

The terminal blocks, screws, and spade lugs in each base shall be covered with an approved electrical insulating coating. Provide Pole Base Terminal Block Coatings listed on the Approved/Qualified Products List under "Signals."

Remove the white plastic marking strip from the terminal block before applying the approved electrical insulating coating. After coating the terminal block, reinstall the white plastic marking strip.

Install terminal blocks in bases so that the terminal block screws face the door opening and are accessible.

K Service Equipment Installation

Install service equipment in accordance with the NEC and local laws and ordinances governing service equipment installations.

Refer to the Plans for the approximate location of service points. The Engineer or the electric utility company will determine the exact location of service points.

Install signal service cabinets Type SSB as specified in the contract.

Install roadway lighting service cabinets as specified in the contract.

Install the Department provided rubber gasket sections between the bottom of each cabinet base and the concrete foundation. Leave one ½ inch [13 mm] gap in the gasket to ensure proper water drainage.
Position the photocontrol to face north. The photocontrol may face east or west only if facing it north is not an option due to service cabinet orientation.

When installing service equipment on a wood pole, install the meter socket directly above the service disconnect. Terminate risers near the top of the wood pole or structure. Cap risers with a weatherhead to prevent the entrance of water. Extend power conductors beyond the weatherhead with an additional 4 ft (1.22 m) length for a drip loop, to allow the electric utility company to connect to the power conductors from the source of power. The electric utility company will perform connections at no additional cost to the Contractor, unless otherwise specified in the contract.

For installation on a mounting bracket assembly, locate the meter socket and disconnecting means as specified in the contract.

Provide lugs for terminating conductors sized for the associated conductors. Do no trim strands of conductors to fit into undersized lugs.

Arrange for the power connection with the electric utility company.

L Vehicle and Pedestrian Signal Head Installation

L.1 Pedestal Mounted (With Signal Bracketing)

Mount vehicle and pedestrian signal heads on top of traffic control signal pedestals as required by the contract. Install symmetrically arranged and securely assembled pedestal mounted assemblies plumb and level. Provide for internal wiring within the pedestal shaft signal brackets and pipe fittings.

Place a pedestal mounted vehicle signal head directly above the pedestal slipfitter collar. Attach with a bracket to the top of the vehicle signal head and to the pedestal shaft.

L.2 Vertical Pole Shaft Mounted (With Signal Bracketing)

Mount vehicle and pedestrian signal heads on a vertical pole shaft if shown on the Plans. Provide threaded 1½-inch [38 mm] half-couplings capable of receiving threaded 1½-inch [38 mm] signal brackets and provide for internal wiring within the vertical pole shaft. Weld the half-couplings into the vertical pole shaft 10 ft [3 m] above the pole foundation. Position threaded couplings on the vertical pole shaft as specified in the contract.

Mount vehicle and pedestrian signal heads as shown on the Plans. Provide plumb, securely assembled pole mounted assemblies that allow for internal wiring within the vertical pole shaft, signal brackets, and pipe fittings.

L.3 Vertical Pole Mounted (With Angle Mount Plumbizer)

Use angle mount plumbizers to plumb the vehicle and pedestrian signal heads mounted on vertical pole shafts.
Assemble the signal and pedestrian heads and angle mount plumbizers in accordance with manufacturer installation instructions.
Attach two vehicle signal sections below the mount. Attach the remaining vehicle signal sections above the mount. Attach the signal head and the angle mount plumbizer assembly to the pole as specified in the contract.

Mount the pedestrian head below the signal head mount as specified in the contract.

Install an angle and straight mount cap on the unused upper side of the angle mount when installing pedestrian signal indications.

Use extended threaded pole adaptors if attaching a cluster head (dog house) style signal head assembly at the mount.

Use signal head mounting spacers if attaching four sections or five sections at the mount.

L.4 Pedestal Mounted (With Two Vehicle Straight Mount Plumbizers)

Use a straight mount plumbizer to mount vehicle and pedestrian signal heads plumb on pedestal shafts.
Attach two separate signal sections below the mount attach the remaining vehicle signal sections above the mount. Attach the signal head and the straight mount plumbizer assembly to the pole as specified in the contract.

Use a universal hub to attach the straight mount plumbizer to the pedestal shaft. Using the manufacturer's specific installation tool for captive fastener installation, attach the universal hub to the pedestal shaft in accordance to the manufacturer's instructions. Install a PVC wireway between the universal hub and the entrance of the straight mount plumbizer.

Mount the pedestrian head on the bottom of the straight mount plumbizer as specified in the contract. Use a universal hub to attach the straight mount plumbizer to the pedestal shaft. Using the manufacturer's specific installation tool for captive fastener installation, attach the universal hub to the pedestal shaft in accordance with the manufacturer's instructions. Install a PVC wire way between the universal hub and the entrance of the straight mount plumbizer.

Mount the pedestrian head below the signal head mount as specified in the contract.

Install an angle and straight mount cap on the unused upper side of the angle mount when installing pedestrian signal indications.

Use signal head mounting spacers if attaching four signal sections or five signal sections at the mount.

L.5 Mast Arm Mounted (With Straight and Angle Mount Plumbizer)

Use angle mount plumbizers to mount vehicle signal heads on traffic control signal mast arms at the extended end of the mast arm. Use straight mount plumbizers to mount vehicle signal heads at the mid arm position of the mast arm. Mount two signal sections below the mount and the remaining signal sections above the mount.

Mount two signal sections below the mount and the remaining vehicle signal sections above the mount. Attach the signal head and the straight mount or angle mount plumbizer assembly to the pole as specified in the contract.

Use signal head mounting spacers if attaching four signal sections or five signal sections at the mount.

Provide vertical clearance from the bottom of the signal heads, including the background shields, to the pavement from 17 ft [5.18 m] to 19 ft [5.79 m].

L.6 Signal and Pedestrian Indication Labeling

Label the indications with the installation date as follows:

Place a date of installation on the back of the indication.

Provide labels for the date of installation on the back of the indication meeting the following requirements:

(1) Record the installation date on white self-adhering label,
(2) Use machine printed numbers,
(3) Black text ½ inch (12.7 mm) tall,
(4) Month/Year numeric format,
(5) Suitable for placement in wet locations,
(6) Paper based labels are not acceptable, and
(7) Place inside on the back of the indication.

L.7 Bagging

Use "gunnysacks" or other material approved by the Engineer to bag vehicle and pedestrian signal heads after installation and until traffic control signal activation to indicate that the traffic control signal is not in operation. Maintain bagging as approved by the Engineer.

L.8 Anti-Seize Lubricant

Brush an anti-seize lubricant meeting the requirements of MIL-PRF-907E onto the threaded portions of signal bracketing, pipe fittings, mounting hardware, angle and straight mount plumbizer threaded nipples, and any threaded metallic fittings before installation.

L.8 Signal and Pedestrian Indication Documentation

For each signal and pedestrian indication, submit to the Engineer, for approval, four copies of all warranty information indicating the required 5-year warranty period (from date of installation), product invoice, and documentation indicating name of manufacturer, model number, and serial number.

M LED Luminaire Installation

Provide LED luminaires as shown on the Plan. Wire luminaires continuously, without splices, from the source of power to the luminaire as required by the contract.

Provide a MnDOT approved wire holder that supports the luminaire cable/conductors within the end of the luminaire slipfitter near the connection point of the luminaire.

Label each luminaire in accordance with 2545.3P.2.c

If a photocontrol unit is required orient the unit to face north.

After the luminaire shaft extension (davit pole) and the luminaire have been installed on the mast arm pole, place a level on the area provided on the top of the luminaire, and level the luminaire from side-to-side and front-to-back.

N Wood Pole Installation

Place wood poles in the ground to a depth equal to 20 percent of the pole length. Excavate 8 in [200 mm] larger than the diameter of the base of the pole and keep free from loose material. Hoist the pole into place without damage. Plumb and rake as directed by the Engineer. Provide backfill utilizing Selected Material as specified in 2451, "Structure Excavations and Backfills," and place in 8 inch (200 mm) or less lifts. Moisten and compact each lift. Place the wood pole so that a void area does not display between the wood pole and backfill at the ground plane when placed under load.

O Blank

P Traffic Control Signal Pedestal Installation

Use U-shaped, galvanized, metal shims in accordance with Standard Plate 8129 to plumb traffic control signal pedestals as approved by the Engineer. Bolt traffic control signal pedestals to the cast-in-place anchor rods of the concrete foundations. Place the pedestal access door 180 degrees from the roadway centerline.

Q Mast Arm Pole Standard Installation

Hoist mast arm pole standards into position without damage. Use two nuts and washers on each anchor rod to plumb the mast arm pole standards and to vertically position the pole surface opposite the arm. Do not enlarge or alter holes in the base plate to accommodate misaligned anchorages.

Use the following procedure to install mast arm pole standards on anchor rods:

(1) Place the transformer base access door 180 degrees from the mast arm.

(1.1) Attach no appurtenances (such as pedestrian push buttons, signs, etc.) to the transformer base that requires the drilling of holes in the transformer base.

(1.2) Place 100% clear silicone sealant between the pole base plate where it meets the transformer base top to ensure a moisture proof seal between the pole and the transformer base.

(2) Assemble and tighten the transformer base and pole in accordance with pole manufacturer instructions and AASHTO "Structural Supports for Highway Signs, Luminaires, and Traffic Signals" Sixth Edition 2013 or the most current version, Section "5.17.5.2-Anchor Bolt Pretensioning" and as follows:

(2.1) Clean exposed part of anchor rods with a wire brush or equivalent.

(2.2) Ensure clean anchor rods and that nuts spin freely along the entire length of all anchor rods.

(2.3) Lubricate anchor rod threads with brush-on anti-seize compound meeting the requirements of MIL-PRF-907E.

(2.4) Install and level heavy hex leveling nuts.

(2.4.1) Ensure the clearance between the bottom of the leveling nuts and the top of the foundation is less than one bolt diameter.

(2.5) Install first set of washers, place base or pole to anchor rod cluster, install second set of washers.

(2.6) Install and hand tighten heavy hex top nuts.

(2.7) Using "full force" and a standard 12 inch long wrench, or a few impacts of an impact wrench, tighten top nuts.

(2.8) Using "full force" and a standard 12 inch long wrench, tighten leveling nuts.

(2.9) Mark positions of top nuts in relation to its adjacent bolt. Tighten top nuts as follows:

For PA85, 90, 100 and BA foundations;
For anchor rods ≤ 1 ½ inches in diameter turn the nut one-third turn beyond tightening achieved in Steps 2.7 and 2.8.
For anchor rods > 1 ½ inches in diameter turn the nut one-sixth turn beyond tightening achieved in Steps 2.7 and 2.8.

For Pedestal foundations;
For anchor rods ≤ 1 ½ inches in diameter turn the nut one-sixth turn beyond tightening achieved in Steps 2.7 and 2.8.
For anchor rods > 1 ½ inches in diameter turn the nut one-twelfth turn beyond tightening achieved in Steps 2.7 and 2.8.

(2.10) After 48 h, with the entire mast arm pole standard completely assembled and installed, check the tightness of the nuts. Follow step 2.7, step 2.8, and step 2. 9 for additional tightening.

(2.11) Ensure the end of the anchor rod extends beyond the outside surface of the top nut allowing for full nut engagement to the anchor rod. When the end of the anchor rod is inside the top nut, it is considered incomplete nut engagement and not acceptable.

(3) Provide and Install Stainless Steel Woven Wire Cloth in accordance with 3836 and as follows:

(3.1) Insert and wind around the transformer base opening to prevent rodent entry.

(3.2) Cut even and smooth and secure flush with self-tapping screws to the upper edge of the transformer base opening.
(3.3) Connect at the overlap with either a small stainless steel or brass bolt and nut assembly.
(3.4) Ensure that the woven wire cloth bottom edge is smooth, flush with the transformer base, concrete foundation. Ensure ends overlap at least two (2) inches, and secured, in a manner, that does not allow movement.
(3.5) Ground the entire woven mesh assembly as required by the National Electrical Code (NEC).
(3.6) Fill voids between the stainless steel woven wire cloth and the pole base bottom opening with clear 100% silicone sealant.

Install mast arms, brackets, and other attachments to the vertical pole shaft without damage.

Ensure a moisture-free seal between access openings and covers use a clear, 100 percent silicone sealant to seal the access opening covers on the mast arm pole.

Repair and restore damaged areas to original condition as specified in the contract or as approved by the Engineer.

Repair damage to galvanized finish in accordance with ASTM A780 Annex A2. Only use zinc rich paints found on MnDOT's Approved/Qualified Products List for "Signals".

R Pedestrian Push Button Installation

Provide and install pedestrian push button stations as detailed in the Plans.

R.1 APS Push Button Bases

Install APS push button bases and shafts at locations indicated in the Plans and in accordance with the following:

1. Install 1 inch (25.4 mm) Rigid PVC Conduit with end bell 2 ± ½ inches (63.5 mm) above the sidewalk.

2. Support the 1 inch (25.4 mm) Rigid PVC Conduit with a minimum ½ inch (12.7 mm) rebar prior to concrete pouring.

   (2.1) Drive support rebar into the ground below a sufficient depth to adequately support the conduit during concrete pouring operations.
   (2.2) Remove the support rebar after the concrete has been poured during concrete finishing operations.

After the concrete has cured:

3. Drill four (4) 3/4 inch (19 mm) holes six (6) inches (152 mm) deep into the concrete as detailed in the Plans.

4. Install 5/8 inch (UNC) stainless steel threaded rods.

5. Use APS push button base adhesive anchoring systems to secure the stainless steel threaded rods into the drilled holes.

   (5.1) Follow all manufacturers' installation instructions including cleaning and insertion of the anchor with adhesive.

6. Allow the epoxy adhesive to cure a minimum of 24 h prior to installing the pedestrian push button pedestal base.

   (6.1) Follow epoxy manufacturers required cure time prior to installing the pedestrian push button pedestal base.
   (6.2) Do not exceed manufacturers maximum torque values when tightening nuts holding the pedestal base.

7. Apply anti seize compound to all the exposed threads on the anchor rods, access door cover, set screws, and 4 inch aluminum shaft prior to assembly.

8. Install stainless steel washers and nuts.

9. Plumb pedestal shaft and APS push button base with leveling shims in accordance with Standard Plate 8129.

10. Install a continuous 6 AWG green insulated grounding conductor from the pedestrian pedestal base grounding lug to the nearest hand hole.

    (10.1) Exothermic weld 6 AWG green insulated grounding conductor to the ground rod installed in the hand hole.

R.2 APS Pole Mounting Adaptor

Install APS pole mounting adaptors at locations indicated in the Plans and in accordance with the following:

1. Do not install the APS pole adaptor on the pole above the transformer base access cover,
2. Do not install the APS pole adaptor on the transformer base,
3. Installation of the APS Pole mounting adaptor will require four (4) ¼-20 stainless steel bolts 1 inch long, flat washers, and lock washers,

   (3.1) Drill and tap Four (4) ¼ 20 holes in the signal pole for APS pole adaptor mounting,
   (3.2) Drill a ½ inch hole for a wire way access behind either the upper or lower horizontal tube for APS button connection wire,
   (3.3) Paint the freshly drilled holes with zinc rich paint found on the MnDOT APL for Signals,
   (3.4) Provide a rubber grommet in the ½ inch hole to protect the 2C #14 (Loop Lead-in),
   (3.5) Apply brush-on anti-seize lubricant meeting MIL-PRF-907E to all mounting bolts prior to assembly,
   (3.6) Place 100% clear silicone sealant between the pole and the mounting flange before assembly, and

4. Follow the APS button manufacturer's installation instructions.

R.3 APS Pushbutton Mounting Spacers

Install APS pushbutton mounting spacers at locations indicated in the Plans and in accordance with the following:

1. Install APS pushbutton mounting spacers behind the APS pushbutton between the pedestal and the APS pushbutton.

2. Installation of the APS Pushbutton will require 2 or 3 of the mounting spacers depending on the APS pushbutton manufacturer used.

(2.1) When 3 spacers are required one will be used as a wire way for the low voltage communications cable.

3. Where the APS communications cable enters the aluminum pedestrian shaft a nonconductive sleeve is required to prevent abrasion to the cable assembly.

R.4 APS Push Button Units

Install accessible pedestrian push button units at the locations as indicated on the Plans.

Each push button unit contains three (3) custom components:

1. Sign with Braille.
2. Push button with direction arrow.
3. Custom voice message.

Pay careful attention to button placement to ensure the button is placed in the correct location. Mount the button facing the pedestrian landing and parallel to the crossing.

Apply an approved electrical insulating coating to the APS wire termination blocks, after wire installation.

Provide electrical insulating coatings listed on MnDOT's Approved/Qualified Products List under "Signals".

Apply a bead of 100% clear silicone sealant around the top of the push button station housing where the push button comes in contact with the pole shaft.

S Crosswalk Pavement Markings (Preformed Pavement Marking Tape)

Provide Preformed Pavement Marking Tape for Permanent Traffic Lane Delineation and Legends (PREF TAPE) in accordance with 2582.2A.

Install crosswalk block markings in accordance with 2582 and as follows:

(1) Groove the block markings into the pavement surface to protect the marking from snow and ice removal operations.
(2) Mobile retroreflectometer measurements (MRM) are not required for crosswalk block markings.

T Sign Installation

T.1 Pedestal or Pole Shaft Mounted

Provide each pedestal or pole shaft mounted sign with two standard sign mounting bracket assemblies using a stainless steel band at least ¾ in [19 mm] wide. Mount on the pedestal or pole shaft at the height as directed by the Engineer. Drill and tap

shaft and mount signs as directed and as approved by the Engineer. Mount pedestal and pole shaft signs with a clearance of at least 7 ft [2.13 m] from the bottom of the sign to the finished walking surface or ground surface at the base of the pole.

T.2 Mast Arm Mounted

Provide each mast arm mounted sign with mast arm mounting bracket assemblies in accordance with the mast arm sign mounting details in the Standard Signs Manual, Detail 105A, and mounted at the specified location on the mast arm as approved by the Engineer.

T3 Sign Post Mounted

Use U-channel sign posts to mount sign post mounted sign panels in accordance with the contract.

T.4 Sign Panel Warning Stickers

Install Department furnished warning stickers on new sign panels in accordance with MnDOT 2564.3H.

U Traffic Control Signal Cabinet Installation

Securely bolt pad mounted cabinets to the concrete as approved by the Engineer.

Install rubber gasket sections, Department or Contractor provided, between the bottom of the aluminum cabinet base and the concrete foundation. Leave a ½ in [13 mm] gap in the gasket for water drainage.

V Fiber Optic Cable Installation

Install fiber optic cable in accordance with 2550.3A.

W Emergency Vehicle Preemption (EVP) Installation

W.1 Installation

Install EVP detectors and EVP confirmatory indicator light atop traffic control signal mast arms and, if required by the contract, atop traffic control signal pedestal shafts in accordance with the following:

(1) Install the detector, confirmatory indicator light, wiring, and connections in accordance with manufacturer's instructions.
(2) Inform the Engineer of obstructions in line with the detector before installation.
(3) Attach the detector and confirmatory indicator light to the traffic control signal mast arm or traffic control signal pedestal shaft to the satisfaction of the Engineer.
(4) Provide any extension hardware with the same outside diameter as the traffic control signal bracketing framework, and use a reducer conduit fitting to attach the detector and indicator light assembly to the traffic control signal mast arm.
(5) Paint extension hardware the same color as the traffic control signal mast arm. Do not paint the detector and confirmatory indicator light assembly.
(6) Securely tighten hardware.
(7) Install and mount the detector and confirmatory indicator to ensure the watertight integrity of the assembly.
(8) Provide a 6 in [150 mm] vertical separation between the detector and confirmatory indicator light combination.
(9) Install the detector shield tube with the drain hole at the bottom.
(10) Do not splice detector cables from the EVP detector on the mast arm to the traffic control signal cabinet.
(11) Mark the detector cable in the traffic control signal cabinet with its street and direction association.
(12) Make one-way or two-way EVP detectors and one-way or two-way EVP indicator lights operational when the signal system is initially turned on.
(13) Ensure each approach of the intersection detects an approaching Emergency Vehicle at a minimum distance of 1800 feet [548.6 m].

W.2 EVP Confirmation Lamp Holder Modification

Disassemble the rubber washer and stainless steel holding clip on the lamp side of the MnDOT approved lamp holder. Remove the fiber washer from behind the rubber washer. Reinstall the rubber washer and stainless steel holding clip.

Install LED EVP confirmation indications in each confirmation lamp holder. Apply manufacturer supplied dielectric grease to the indication base threads and pin at the time of installation.

X Painting

Paint metal structures and metal components of traffic control signal systems with finish coat paint if required by the contract and in accordance with 2478, "Organic Zinc-Rich Paint System," and the following:

(1) Apply exterior, dark green meeting the requirements of 3532, "Exterior Polyurethane Paint," on the traffic control signal pedestal bases and mast arm pole standard transformer bases.
(2) Apply sign yellow baking and Air Dry meeting the requirements of 3532, "Exterior Polyurethane Paint," on cast aluminum vehicle and pedestrian signal indication housings, mast arm pole standard vertical pole shafts, traffic control signal pedestal shafts, pedestal slipfitter collars, pedestal reinforcing collars (wind collars), all signal brackets and pipe fittings, and pedestrian push button stations.

(3) For the first two coats, apply aluminum paint meeting the requirements of 3533, "Aluminum Polyurethane Paint," to steel cabinets, traffic control signal mast arms, luminaire vertical pole shaft extensions, and luminaire mast arms.

(4) Apply dull non-reflective black on aluminum visors, aluminum directional louvers, aluminum background shields, and aluminum vehicle and inside and outside pedestrian signal indication housing doors.

As an alternative to field painting, the Contractor may use equivalent manufacturer's shop coat paint and field touch-up any damaged finish as approved by the Engineer. If a manufacturer's shop coat paint is accepted or specified in the contract, make every effort during installation to protect the factory applied finish. Repair and restore damage to the finish as approved by the Engineer.

Provide mast arm pole standards painted at the manufacturer. Remove any protective wrap provided by the manufacturer during shipping immediately after receipt of the shipment on the project. Protect the factory applied finish when erecting the painted mast arm pole. Provide a collar for handling the pole made of a material that will protect the painted finish of the pole. Except for touch-up painting, do not field paint the mast arm pole standards. Use touch up paint provided by the manufacturer to repair and restore nicks, scratches, paint chips, or other damage to the finish as approved by the Engineer.

Do not field paint unpainted aluminum components of a signal system.

Y Existing Materials and Electrical Equipment

Y.1 Removing and Salvaging

Remove and salvage electrical systems in accordance with 2104, "Removing Pavement and Miscellaneous Structures," and as specified in the contract at locations required by the contract or directed by the Engineer. Do not damage the removed and salvaged materials and electrical equipment during removal.

Take ownership of materials and electrical equipment of an existing electrical system required to be removed but not salvaged and dispose of the materials and equipment outside the right-of-way, subject to 2104.3.D.3, "Disposal outside Right of Way," and as specified in the contract.

Y.2 Reinstalling

Where installing salvaged materials and electrical equipment at new locations provide and install materials required to complete the new installation.

If the Engineer determines that existing materials and electrical equipment are unsatisfactory for reuse, replace the unsatisfactory material with new materials and electrical equipment. If the salvaged material was not damaged by removal the cost of the new material and equipment will be paid for as extra work in accordance with 1402, "Contract Revisions."

Y.3 Stockpiling

The Contractor may stockpile materials and electrical equipment of an existing electrical system required to be removed and not reused on the project until its removal outside the right-of-way. Stockpile as approved by the Engineer.

Z Field Testing

Before completing the work, perform a functional test demonstrating to the Engineer that the traffic control signal components as fully functional. Do not activate the traffic control signal until completion of all field tests and the Engineer approves the results.

Before final acceptance, provide the Engineer manufacturers' warranties, instructions, and wiring diagrams of the materials and electrical equipment provided to the project.

AA Activating Signals

Before activating traffic control signal systems, aim vehicle and pedestrian signal heads as directed by the Engineer. Notify the Engineer at least 48 h before the scheduled traffic control signal activation.

Department personnel will activate the traffic control signal system unless otherwise directed by the Engineer. Provide assistance at the time of the turn on to ensure the traffic control signal system is operating correctly and safely. Provide parts and labor to correct malfunctioning components of the traffic control signal system. This requirement does not include Department-provided material and components, except if damaged by the Contractor. Do not activate the signal system before the Engineer approves the operational signal system and its components, including the emergency vehicle preemption and the traffic control interconnection.

Do not turn the signal system ON, OFF, or in flashing mode unless approved by and in the presence of the Engineer.

BB Restoration and Cleanup

Replace or repair sidewalks, curbs, gutters, pavements, base materials, sod, or plants damaged or removed during the Contractor's operations as approved by the Engineer. Maintain reconstruction work as approved by the Engineer until final acceptance.

CC Available Fault Current Calculations

Provide available fault current calculations as required by Article 110.24 of the NEC and as follows:

(1) Provide calculations for the available fault current at the line side of the meter socket for each electrical service.

(2) Provide and install labels for the calculation results meeting the following requirements:

(2.1) Self-adhering label.
(2.2) Machine printed numbers and letters.
(2.3) Suitable for placement in damp locations
(2.4) Paper based labels are not acceptable.
(2.5) Placed in the inside of the service cabinet on the dead front door so it is visible when the dead front door is closed.
(2.6) Containing the following information:

Transformer Size in KVA
Available fault current in amps at the terminations of the utility transformer
Available fault current in amps at the line side of the meter socket.
The date the calculations were made.

2565.4 METHOD OF MEASUREMENT

The Engineer will measure the new *Traffic Control Signal System* as an integral unit complete in place and operating. The complete installation at one intersection is considered as one unit.

The contract unit price for an *APS Push Button Station* includes the cost of the complete push button station assembly. The Complete assembly is comprised of the base, aluminum shaft, aluminum dome cap, mounting of hardware and components, anchor adhesive, wiring, connections, the APS push button, and other miscellaneous items required for a complete installation of the APS push button station with APS push button.

The contract unit price for an *APS Push Button and Sign* is the cost of the complete push button unit including sign with Braille message, mounting, mounting hardware, wiring, connections, mounting of the APS push button, and other miscellaneous items required for a complete installation of the APS push button and sign.

The contract unit price for an *APS Cabinet Control Unit* is the cost of the complete APS cabinet control unit including interface boards and required wiring harnesses, mounting hardware, wiring, connections, mounting and installation of the APS cabinet control unit and other miscellaneous items required for a complete installation of the APS cabinet control unit.

The contract unit price for an *APS Pole Mounting Adaptor* is the cost of the APS pole mounting adaptor, mounting, mounting hardware, wiring, connections, mounting of the APS push button and sign, and other miscellaneous items required for a complete installation of the APS push button and sign mounted on an APS push button mounting spacer.

The contract unit price for an *APS Push Button Mounting Spacers* is the cost of the three (3) three APS push button pole mounting spacers, mounting, mounting hardware, wiring, connections, mounting of the APS push button and sign, and other miscellaneous items required for a complete installation of the APS push button and sign mounted on a set of APS push button mounting spacers.

The contract unit price for an *Emergency Vehicle Preemption System* is the cost of providing and installing the complete emergency vehicle preemption (EVP) system as specified herein and is measured as an integral unit complete in place and operating.

The contract unit price for an *Traffic Control Interconnect* is the cost of providing and installing the complete traffic control interconnect system as specified herein and is measured as an integral unit complete in place and operating.

2565.5 BASIS OF PAYMENT

The Department will pay for new traffic control signal systems on the basis of the following schedule:

Item No:	Item:	Unit
2565.511	Traffic Control Signal System	signal system
2565.512	APS Push Button Station	each
2565.512	APS Push Button and Sign	each
2565.512	APS Cabinet Control Unit	each
2565.512	APS Pole Mounting Adaptor	each
2565.512	APS Push Button Mounting Spacers	each
2565.513	Emergency Vehicle Preemption System	lump sum
2565.514	Traffic Control Interconnect	lump sum

2571 PLANT INSTALLATION AND ESTABLISHMENT

2571.1 DESCRIPTION

This work consists of providing, planting, and establishing trees, shrubs, vines, and perennials of the species, variety, grade, size, or age, and root category specified for the locations shown on the plans, including planting or transplanting plants provided by the Department.

Perform this work in accordance with the current edition of the Inspection and Contract Administration Manual for MnDOT Landscape Projects (ICAMMLP).

2571.2 MATERIALS

A Nursery Plant Stock.....3861

Provide plants of the species shown on the plans in the variety, grade, and size, or age indicated.

A.1 Investigations and Supply of Planting Stock and Materials

By submitting a proposal and accepting award of the contract in accordance with 1205, "Examination of Proposal Package and Site of Work," the Contractor assures familiarity with the project site and contract documents, commitments from suppliers, and delivery of the plant stock and materials required to complete the contract.

A.2 Plant Stock and Materials Documentation

Provide the following plant stock and materials documentation:

(1) At or before the preconstruction conference, provide the Engineer with a MnDOT-preliminary *Certificate of Compliance for Plant Stock, Landscape Materials, and Equipment* (copy of form provided in the current edition of ICAMMLP).

(2) At least one week before plant stock delivery to the project, provide the Engineer with the following:

- (2.1) A copy of a valid nursery stock, dealer or grower certificate, registered with the Minnesota Department of Agriculture (MDA), a current nursery certificate or license from a state or provincial Department of Agriculture for each plant stock supplier, or both;
- (2.2) Documentation certifying that plant material shipped from out-of-state nursery vendors subject to state and federal quarantines, is free of currently regulated pests, including Emerald Ash Borers, and Gypsy Moths. To determine if Minnesota vendors are subject to quarantines, call the MDA Supervisor of Nursery Inspection and Export Certification at (651) 201-6388; and
- (2.3) An updated *Certificate of Compliance*, signed by the Contractor's authorized representative.

(3) Upon delivery of plant stock and materials to the project, provide the Engineer with the following:

- (3.1) Bills of lading or shipping documents for plant stock and landscape materials delivered to the project, and
- (3.2) An updated and signed *Certificate of Compliance*, if necessary, to reflect deviations from the original *Certificate of Compliance* documentation submitted at or before the preconstruction conference.

(4) As a condition for authorization of payments, provide the Engineer with vendor invoices or billing statements for plant stock and materials used on the project.

The Engineer will consider work performed with plant stock, materials, or equipment that was misrepresented in the documentation, as unauthorized work.

If the Contractor does not provide the documentation required by this section, the Engineer may consider subsequent work unauthorized and the Department may assess a daily charge of $200.00, on a calendar day basis, until the Contractor achieves compliance.

A.3 Substitutions

The Engineer may allow substitutions in accordance with 1605, "Substitute Materials." Before requesting substitutions, provide written documentation that plants shown on the plans are not available in quantities to fulfill the contract requirements from the individual suppliers on the *Partial List of Nursery Dealers and Growers* in the most current edition of the ICAMMLP. The Engineer, in consultation with the project designer, may authorize specific substitute plants or may extend the contract time to ensure availability of the plants shown on the plans. Provide substitutions equal to or better than the initially specified materials.

B Department Furnished Stock and Transplant Stock

Obtain Department provided stock and transplant stock from sources shown on the plans or specified by the special provisions.

C Incidental Materials and Work

The Department considers incidental materials and work, specified, non-specified, replacement, or miscellaneous, to include materials and work that are incidental to payment for the individual plant installation contract items and for which the Department does not make direct payment.

C.1 Specified Incidental Materials and Work

Supply, install, and maintain incidental materials as required for plant installation and establishment in accordance with the special provisions, plans, and standard planting details.

C.2 Non-specified Incidental Materials and Work

Supply, install, and maintain non-specified incidental materials for plant installation and establishment success in accordance with product labeling, manufacturer's instructions, and applicable laws, regulations and ordinances.

C.3 Replacement Materials and Work

Provide materials and work to replace unacceptable or missing plants, materials, and incidental items in accordance with the special provisions, plans, and standard planting details. Provide replacement materials and work that is equal to or better than the initially specified materials and work.

C.4 Miscellaneous Incidental Materials, Equipment and Work

Miscellaneous incidental materials, equipment, and work include the following:

(1) Mobilization,
(2) Traffic control,
(3) Protection and restoration of vegetation and property,
(4) Layout and staking,
(5) Soil cultivation,
(6) Compost,
(7) Mulch,
(8) Rodent protection,
(9) Staking and guying,
(10) Seedling shelters,
(11) Temporary erosion control,
(12) Mowing,
(13) Application of herbicides, insecticides, fungicides, and water and
(14) Other materials, equipment, and work necessary to install, maintain, and establish plants as shown on the plans and in a healthy, vigorous, and weed-free condition.

2571.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Landscape Specialist

Provide a Landscape Specialist, certified by the Department, to perform or supervise plant installation and establishment work. Provide documentation of the Certified Landscape Specialist at or before the preconstruction conference. Landscape specialists may obtain certification by completing the one-day Department Landscape Project Inspection and Administration Training Class and passing a test administered by the Department's Environmental Planning and Design and Roadside Vegetation Management Units. Full certification is valid for 3 years. Landscape Specialists may obtain provisional certification for 1 year by passing a test without completing the training class.

A.2 Notices by Contractor

Notify the Engineer at least 3 calendar days before planned deliveries of initial and replacement planting stock to the project to allow for inspection scheduling. Notify the Engineer at least 24 hours before beginning or changing distinct operations. Include the following in the notice:

(1) The project number,
(2) Engineer's name,
(3) Notification date,
(4) Intended dates and times for the operations, and
(5) The planned locations of work.

Provide notifications in writing, using confirmable e-mail, or facsimile transmissions.

A.3 Unauthorized Work and Penalties for Non-compliant Operations

The Engineer will consider work performed as follows to be unauthorized work:

(1) Without required and acceptable documentation and notifications,
(2) Without supervision by a certified landscape specialist,
(3) Without conducting required and acceptable competency tests, or
(4) In conflict with the working hours of the contract.

In the case of non-compliant operations, the Department may assess a daily charge of $200.00, on a calendar day basis, until the Contractor achieves compliance.

A.4 Required Equipment

Provide equipment meeting the requirements of 1805, "Methods and Equipment," and with the following available on the project at all times:

(1) At least one portable compaction tester capable of measuring compaction in the soil to at least 18 in [450 mm] deep,
(2) At least one soil recovery probe for assessment of soil moisture conditions, and
(3) At least one tree caliper with measurement readings in inches.

B Preconstruction Work

Preconstruction work includes:

(1) Attending a preconstruction conference,
(2) Submitting preconstruction documentation,
(3) Mobilizing equipment and supplies to the project,
(4) Protecting existing vegetation, resources, and property in accordance with the plans, special provisions, and 1712, "Protection and Restoration of Property," 2031, "Field Office and Laboratory," 2557, "Fencing," and 2572, "Protection and Restoration of Vegetation."

C Staking Planting Holes and Beds

Stake the exact locations and layouts for the Engineer's approval.

To remedy unanticipated, localized problems and seasonal conditions that may hinder plant establishment, the Contractor may request the Engineer's approval to perform the following in accordance with the standard planting details and options shown on the plans:

(1) Relocate plantings,
(2) Make plant substitutions, or
(3) Modify soil or drainage characteristics.

Locate plantings to provide the following:

(1) A clear sight distance in front of traffic signs.
(2) Clear zones and safety sight corners and lines shown on the plans free of plants with ultimate growth diameter of 4" [10 cm] or greater.

D Preparing Planting Holes and Planting Beds

To prevent site compaction and damage, do not work in planting holes and bed areas if the soil moisture is greater than field capacity.

D.1 Utilities

Before cultivating soil or excavating holes on the project, meet the requirements of 1507, "Utility Property and Service."

The Contractor may request the Engineer's approval to relocate plantings to avoid unanticipated conflicts with utilities.

D.2 Weed Control and Soil Cultivation

Apply herbicide to actively growing vegetation beginning in spring or fall. Before cultivating individual planting holes and bed areas, kill turf and weed growth within the limits of planting areas that will receive mulch in accordance with the following:

(1) Mow existing vegetation to at least 3 in [75 mm] at least one week before spraying herbicide. Remove the cuttings. Allow the vegetation to re-grow to a height from 4 in to 8 in [100 mm to 200 mm] before applying the herbicide.
(2) At least three days before applying herbicide, submit to the Engineer, labels of the intended herbicides and a copy of a valid MN Pesticide Applicator License, including Category A and Category J.
(3) Spray and kill turf and weeds, including the top growth and roots, only within designated areas using a non-selective, non-residual post emergent herbicide containing 41 percent glyphosate as the active ingredient. Ensure personnel, licensed by the MDA and experienced in the use of chemical pesticides perform the work in accordance with the manufacturer's instructions and recommendations. Apply the herbicide to dry foliage on actively growing vegetation. Apply the herbicide in August or early September before the fall or spring Plant Installation Period (PIP) as required by the contract. If an August or September application is not possible for the spring PIP, apply the herbicide in late April or early May. If precipitation occurs within 6 hours after applying herbicide, reapply herbicide as needed to achieve 100 percent kill.
(4) Before beginning soil cultivation work, schedule and perform a Competency Test to the satisfaction of the Engineer. The Engineer considers a satisfactory Competency Test one that demonstrates acceptable soil cultivation, incorporation of soil additives, compaction levels, and soil drainage in one planting bed area and one individual tree planting area.

(5) Before placing soil additives as shown on the plans, use a spading machine to deep cultivate the planting hole and bed areas by loosening the soil to at least 12 in [300 mm] deep and a compaction level of no more than 200 psi [1,400 kPa] to this depth, as measured from the finished grade elevation of the soil. The Engineer may approve other equipment to address site constraints, if requested by the Contractor. For hydraulic spade-type, machine-moved tree-transplanting, the Engineer will not require planting hole cultivation, other than loosening the soil outside the soil-ball perimeter in accordance with the standard planting details shown on the plans.

(6) Unless otherwise shown on the plans, add 4 in [100 mm] of Grade 2 compost, in accordance with 3890, "Compost" and other soil additives shown on the plans or as requested by the Contractor and approved by the Engineer, over the cultivated planting hole and bed areas and use a spading machine to incorporate it to a depth of at least 12 in [300 mm], as measured from the finished grade elevation of the soil.

(7) Use a compaction tester to ensure compaction in the planting hole and bed areas does not exceed 200 psi [1,400 kPa] to a depth of at least 16 in [400 mm]. If Contractor-operations result in zones of hardpan or excessively compacted soil, repeat deep cultivation or de-compact the subsoil in accordance with 2105.3.H, "Finishing Operations," specifically the requirements for turf establishment areas, at no additional cost to the Department.

(8) Ensure drainage in the planting hole and bed areas. For suspected drainage problems, perform a percolation test by filling a 16 in [400 mm] deep planting hole with water and measuring the time it takes the water to drain from the hole. The Engineer considers adequate drainage equal to or greater than a percolation rate of ½ in/h [12 mm/h]. If drainage does not meet these requirements, request approval from the Engineer to relocate or delete affected planting locations or proceed with Extra Work using one or a combination of the planting details for poorly drained soils, as shown on the plans.

(9) Apply temporary erosion control measures in accordance with the NPDES permit, SWPPP notes, and 2573, "Storm Water Management." The Contractor may use Type 6 wood chip mulch at a depth no more than 1 in [25 mm] for temporary erosion control in prepared planting bed areas.

D.3 Wet Soils, Rock, and Debris

If the Contractor encounters excessively wet soils, bedrock, or excessive quantities of boulders and construction debris, the Contractor may request the Engineer's approval to relocate or delete plantings, or modify soil or drainage characteristics in accordance with the alternative options in the standard planting details shown on the plans.

E Delivery and Storage of Plants

Before installation, the Engineer will provide for inspection and acceptance of plant stock delivered to the project in accordance with the current edition of the ICAMMLP and 3861, "Plant Stock."

Install plant stock on the day of delivery to the project unless using temporary storage methods. Before installation, keep the roots of plants completely covered with a moisture-holding material consisting of wood chips, straw, sawdust, moss, or soil. Keep the moisture-holding material continuously moist and protect it from drying winds, direct sunlight, excessive heat, freezing, low humidity, inadequate ventilation, and animal or human harm. The Engineer will consider plants with damage that occurred or was discovered during temporary storage, unacceptable. Do not store plants from one planting season to the next.

E.1 Pruning — Top Growth and Roots

Immediately before planting, prune the roots of bare-root plants, except seedlings, and the top growth of deciduous plants. Cut-back broken or badly bruised roots and dry root tips to sound, healthy tissue. Prune to remove dead, rubbing, damaged, diseased, and suckering branches, and to improve plant symmetry, structure, and vigor. Prune coniferous trees and shrubs only to remove damaged growth or a competing leader.

Prune in accordance with the horticultural practices specified in the current edition of the ICAMMLP and the standard planting details on the plans.

Do not prune oak trees during the oak wilt season from April through July, to prevent the spread of oak wilt disease. Immediately treat accidental cuts or wounds to oaks with a wound dressing in accordance with the standard planting details shown on the plans. Keep wound-dressing material on the project during the oak wilt season.

E.2 Buried Root Flares

The Engineer will consider container-grown and balled and burlapped plant stock unacceptable if provided with more than 4 in [100 mm] of soil depth above the root flare. The Engineer may accept plants provided with no more than 4 in [100 mm] excess soil above the root flare if the excess soil can be removed without damaging the root system of the plants.

E.3 Excessive Roots

Reject containerized or balled and burlapped plants with roots extending at least 4 in [100 mm] beyond the container or burlap.

F Installation of Plants

F1 General

Before proceeding with plant installation work, schedule and perform a competency test demonstrating acceptable plant installation methods to the Engineer's satisfaction and in accordance with the plans and standard planting details, for each plant pay

item and root category on the project. The Engineer considers a satisfactory competency test to be one that demonstrates acceptable handling of plants, digging of holes and beds, and installation of plants, initial watering, installation of protection materials and mulching.

Before digging planting holes, rake temporary erosion control wood chip mulch off prepared planting areas to prevent wood chip contamination of the planting soil in the holes.

The Contractor may re-spread wood chip mulch formerly used as temporary erosion control around plants to a depth no greater than 1 in [25 mm] following plant installation, if newly provided and acceptable Type 6 mulch is applied over the top to the depth shown on the standard planting details in the plans.

Dig planting holes to the configuration and minimum dimensions shown in the standard planting details on the plans. If the soil moisture is greater than field capacity, do not work in planting holes and beds.

Ensure drainage in the planting hole and bed areas. For a suspected drainage problem, perform a percolation test by filling a 16 in [400 mm] deep planting hole with water and measuring the time it takes the water to drain from the hole. The Engineer considers adequate drainage equal to or greater than a percolation rate of ½ in/h [12 mm/h]. If drainage does not meet these requirements, request approval from the Engineer to relocate or delete affected planting locations or proceed with extra work using one or a combination of the planting details for poorly drained soils as shown on the plans.

F.2 Individual Plant Stock Types and Installation Requirements

Install plants in accordance with the steps and requirements in the standard planting details shown on the plans and specific to each plant stock type.

G Watering

Provide watering equipment and forces on the project capable of completely watering plants as often as necessary to maintain soil moisture in the root zones.

Within 2 hours of installation, saturate the backfill soil of each plant with water. After settling, provide additional backfill to fill in the voids.

H Mulch

Before placing mulch, fine grade and level the planting bed soils with hand tools. Place mulch material in accordance with the standard planting detail shown on the plans no more than seven days after plant installation. The Engineer will consider placement of mulch, contaminated with soil or other materials and not complying with the requirements of 3882, "Mulch Materials," unacceptable. Remove unacceptable mulch from the project.

I Protection of Installed Trees

Use protective materials to ensure the healthy growth and survival of installed trees.

I.1 Staking and Guying

Unless staking and guying is shown on the plans, only stake and guy trees if necessary to maintain the trees in a plumb condition. The following circumstances may warrant staking and guying:

(1) Excessive soil moisture,
(2) Light-textured soil,
(3) Steep slopes,
(4) Exposure to excessive wind, and
(5) The likelihood of vandalism.

Install staking and guying in accordance with the standard planting details shown on the plans.

Remove staking and guying within 1 year of initial installation.

I.2 Rodent Protection

Place rodent protection around deciduous, pine, and larch trees in accordance with the standard planting details shown on the plans.

I.3 Tree Painting

Paint trees in accordance with the standard planting details shown on the plans.

I.4 Seedling Tree Shelters

Install seedling tree shelters in accordance with the standard planting details shown on the plans.

J Cleanup and Restoration Work

Perform the following cleanup and restoration work on an ongoing basis and as the final step of the initial planting operations:

(1) Remove excess materials, rocks and debris from the project;
(2) Repair turf in disturbed areas with seed mixes as shown on the plans or to match in-place turf;
  (2.1) immediately before sowing seed or laying sod, prepare soil as specified in 2574.3 "Construction Requirements;"
  (2.2) Uniformly broadcast a Type 4 natural base fertilizer, as specified by 3881.2.B.4, "Type 4 — Natural Based Fertilizer," that provides nitrogen at an application rate of 43 lb/acre;
  (2.3) Lay sod, or uniformly broadcast seed at 1.5 times the rate specified in Table 3876-1, "Seed Mixes." Provide seed in accordance with the requirements of 3876, "Seed" and perform seeding in accordance with 2575-1, "Season of Planting."
  (2.4) Rake and firm seeded areas to ensure seed contact with the soil;
  (2.5) Broadcast or disc anchor Type 1 mulch in all seeded areas;
(3) Install erosion control measures to prevent erosion.

K Plant Establishment Period

K.1 Establishment Period

A Plant Establishment Period (PEP) of at least 2 calendar years begins on the date that initial planting operations on the project are completed and continues until final acceptance of the project, unless otherwise shown on the plans.

K.2 Establishment Work

Keep plants in a healthy growing condition in accordance with the current edition of the ICAMMLP throughout the establishment period and submit MnDOT *Landscape Contractor Scouting Reports* in accordance with item 1 of 2571.3.K.2.a, "All Plants." Perform plant establishment work throughout the growing seasons from April through October and as necessary during the dormant seasons from November through March. The Engineer may perform random inspections throughout the PEP to verify compliance. The Engineer will consider the Contractor non-compliant if the Contractor does not maintain plants throughout the PEP and does not submit scouting reports.

The Department may assess a daily charge of $200.00 for non-compliance, on a calendar day basis, until the Contractor achieves compliance.

K.2.a All Plants

In plant establishment work, perform the following:

(1) Scout to assess the condition of the plants and the planting site and factors that may influence plant health, vigor, and establishment success. Scout these conditions at least every two weeks during the growing season and at least every month during the dormant season;
(2) Submit a written scouting report to the Engineer via e-mail by the 1st and 15th of each month during the growing season from April to October and by the 1st of each month during the dormant season from November to March. The Engineer will use the report-frequency and content to assess plant establishment compliance. The report may include scanned copies of the plan sheets with the Contractor notes, copies of the report form found in the current edition of the ICAMMLP, or both. Include the following in the report:
  (2.1) The project number;
  (2.2) Engineer's name;
  (2.3) Name of Contractor's responsible scout or representative;
  (2.4) Dates work was performed;
  (2.5) Work locations;
  (2.6) Work completed;
  (2.7) Prevailing weather conditions;
  (2.8) Soil moisture assessments;
  (2.9) Insect, animal, vehicular, weather, or other damage;
  (2.10) Disease problems;
  (2.11) Treatment recommendations; and
  (2.12) Assessment of overall plant conditions including weed competition and control.
(3) Maintain soil moisture in accordance with the watering guidelines of the standard planting details shown on the plans;
(4) Repair, adjust, or replace staking and guying, mulch material, planting soil, rodent protection, seedling tree shelters, tree paint, and other incidental items in accordance with the plans;
(5) Maintain healthy, vigorous plants. free of harmful insects, fungus, and disease;
(6) Remove dead, dying, and unsightly plants. Provide and install replacement plants in accordance with 2571.2.K.2.b, "Replacement Requirements;"
(7) Maintain plants in a plumb condition at the planting depth shown on the planting details in the plans;
(8) Maintain planting areas in a weed-free condition as follows:
  (8.1) Remove weeds, top growth and roots, within the mulch limits by hand pulling. Pre-water mulched areas to ensure weed top growth and roots are entirely removed. Ensure weeding operations do not contaminate the mulch or project with weed seed, weed-laden soil or propagating weed parts. Remove State and County regulated noxious weeds to at least 5 ft [1524 mm] beyond the mulch

limits. Remove weed parts or weed-laden material from the project to avoid the spread of weed infestations;

(8.2) Do not spray chemicals for weed control in mulched planting areas during the PEP. The Contractor may apply a non-selective, non-residual post-emergent herbicide containing 41 percent glyphosate, as the active ingredient with a surfactant on a spot treatment basis with a brush or wick applicator. The Contractor may also apply a broad-spectrum dichlobenil based granular, pre-emergent herbicide in accordance with product labeling and manufacturer's recommendations;

(8.3) Do not weed whip or weed clip as weed control;

(8.4) Mow turf bands around the mulch limits at least 5 ft [1524 mm] beyond the limits and at least 4 in [100 mm] high if the turf height exceeds 9 in [230 mm] adjacent to mulched planting areas;

(8.5) Mow turf areas installed as part of the project when the growth exceeds 18 in [500 mm] high. Mow turf from 6 in [150 mm] to 12 in [300 mm] high. Control State and County-listed noxious weeds;

(9) Prune to remove dead, rubbing, damaged or diseased branches, unwanted suckers, and to improve plant form and structure;

(10) Prevent or repair rutting and other damage that may lead to soil erosion and weed infestation;

(11) Perform plant establishment operations consistent with plant care and horticultural practices detailed in the current edition of the ICAMMLP; and

(12) Remove excess material, obsolete temporary erosion control devices, rocks, and debris from the project.

K.2.b Replacement Requirements

Within the first year of the 2-year PEP, determine which plants need replacing. Replace dead, defective, or missing plants and incidental materials in accordance with initial installation requirements, including plants lost due to accidents, vandalism, theft, rodent damage, damage caused by the Contractor, or if ordered by the Engineer, at no additional cost to the Department. Conduct plant replacement operations during the month of May or September, based on the start of the PEP. At least one week before plant replacement, submit a summary report of proposed plant replacements to the Engineer. Include by attachment, copies of plan sheets with the proposed replacement quantities and locations identified and a MnDOT *Certificate of Compliance for Plant Stock, Landscape Material, and Equipment*, in the report. Using brightly colored paint, mark on site plants requiring replacement.

Provide replacement plants and incidental materials that are equal to or better than the initial material required by the contract.

If less than a full year remains in the PEP, do not replace plants unless the PEP is extended by a supplemental agreement or change order to provide at least one full year of establishment care.

L Acceptance of Work

For acceptance at full payment, ensure each plant meets the *Criteria For Accepting Plant Size* shown in the current edition of the ICAMMLP.

L.1 Acceptance of Preconstruction Work

The Engineer will accept the preconstruction work after the Contractor secures commitments for required materials, submits a MnDOT *Certificate of Compliance for Plant Stock, Landscape Materials, and Equipment*, participates in a preconstruction conference, obtains the Engineer's approval for the progress schedule, moves equipment and supplies to the project, and provides protection for existing plants.

L.2 Acceptance of Preparation of Planting Holes and Beds

For the Engineer's acceptance of preparation of planting holes and beds, complete a competency test, other specified staking, initial weed control, soil cultivation including incorporation of additives, and temporary erosion control work.

L.3 Acceptance of Initial Planting Operation

The Engineer will provisionally accept initial planting operations based on the following:

(1) Plant stock acceptance,

(2) Completion of a competency test,

(3) Installation of individual plants, and

(4) All incidental material and work items shown in the initial planting operations chapter of the current edition of the ICAMMLP, including initial but not limited to watering, tree protection materials, mulching, proper drainage, pruning, staking and guying, tree painting, fertilizing, erosion control, seeding and clean up.

L.4 Final Acceptance

As a condition for terminating the PEP and conducting the final inspection, the Engineer may require the Contractor to bring the plant establishment work into compliance.

On or about the date of termination of the PEP, the Engineer will perform a final inspection of the project.

The Engineer will determine which plants to accept for payment at the contract unit price, at a reduced payment, or with no payment.

Upon final acceptance, the Engineer will not require further Contractor-care of plantings.

The Engineer will make final acceptance at the completion of the two-year PEP and based on a final inspection of the completed project.

2571.4 METHOD OF MEASUREMENT

The Engineer will measure plants separately by the number of acceptable plants for each contract item in accordance with 2571.5.G, "Payment Schedule."

2571.5 BASIS OF PAYMENT

The Department will make payment for plant installation and establishment at a percentage of the contract unit price per item unit of measure for all costs relating to furnishing, installing, and maintaining, the required plants and associated incidental materials as specified and shown on the plans.

The Engineer may require additional materials and work beyond that specified or shown in the contract. The Department will make payment for the additional materials and work as extra work.

The Department may make full payment, reduced payment or no payment of no more than the maximum eligible partial payment percentage at any payment phase (initial, interim, final) based on the performance of the Contractor (see Payment Checklist in the current edition of the ICAMMLP).

A Full Payment

The Department will make full payment of 100 percent of the contract unit price for each plant the Engineer considers acceptable, upon inspection, if the Contractor fully achieves all Payment Criteria as defined in the Payment Checklist in the current edition of the ICAMMLP.

B Reduced or No Payments

The Department will make a reduced payment or no payment of the contract unit prices for each plant if the Contractor does not achieve all Payment Criteria, as defined in the Payment Checklist in the current edition of the ICAMMLP.

C Initial Payment

The Department will make partial payment up to 70 percent of the contract unit price for each plant for completion of the following work:

C.1 Preconstruction Work

The Department will pay no more than 10 percent of the contract unit price for each plant with the completion and acceptance of preconstruction work as defined in the *Preconstruction Work Checklist* in the current edition of the ICAMMLP.

C.2 Preparation of Planting Holes and Beds

The Department will pay no more than 15 percent of the contract unit price for each plant with the completion and acceptance of preparation of planting holes and beds work as defined in the *Preparation of Planting Holes and Beds Checklist* in the current edition of the ICAMMLP.

C.3 Initial Planting Operations

The Department will pay no more than 45 percent of the contract unit price for each plant with the completion and acceptance of initial planting operations work as defined in the *Initial Planting Operations Checklist* in the current edition of the ICAMMLP.

D Interim Payment

At the end of the first calendar year of the PEP, and after completion and acceptance of the Contractor's work and continuous compliance with the plant establishment requirements as defined by the *Plant Establishment-Year One Checklist* in the current edition of the ICAMMLP, the Engineer may authorize no more than 15 percent of the contract unit price for each plant.

E Final Payment

The Department will make final payment after final inspection and acceptance of the completed project at the end of the PEP. The Engineer may authorize no more than 15 percent of the contract unit price for each plant as defined by the *Plant Establishment Year 2 Checklist* in the current edition of the ICAMMLP. The total final payment includes the Plant Establishment Year 2 payment, assessments and reduced payments, if any, and bonus payment, if eligible.

The Department will not pay for replacement plants, unless authorized by the Engineer.

The Department may continue to withhold any percentage of initial and interim payments from the final payment.

The Department will not reimburse any assessments charged during the contract period at the final payment. If the final voucher shows that the total of initial and interim payments made exceeds the total amount due the Contractor, promptly refund the Department for the overpayment.

F Bonus Payment

When 90 percent or more of all plants installed within the initial plant installation period (PIP) and related contract operations have been continuously acceptable throughout the contract period, the Department will make a bonus payment of 10 percent of the total final contract unit price for plant installation and establishment.

The Department considers replacement plants, replaced during the initial PIP, to be initially installed plants. Replacement plants made during the PEP are not eligible for bonuses.

G Payment Schedule

The Department will pay for plant installation and establishment on the basis of the following schedule:

Item No.	Item	Unit
2571.501	Coniferous tree (size & root category)	tree
2571.502	Deciduous tree (size & root category)	tree
2571.503	Ornamental tree (size & root category)	tree
2571.504	Coniferous shrub (size & root category)	shrub
2571.505	Deciduous shrub (size & root category)	shrub
2571.506	Vine (age or size & root category)	vine
5271.507	Perennial (age or size & root category)	plant
2571.541	Transplant tree (spade size*)	tree
2571.544	Transplant shrub	shrub
2571.546	Transplant vine	vine
2571.547	Transplant perennial	plant

NOTE: State Root Category: Seedling, Bare Root, Machine Moved, Container Grown, Balled and Burlapped

* Spade size: 42 in [1.1 m], 60 in [1.5 m], 78 in [1.9 m], 85 in [2.1 m], 90 in [2.3 m].

2572 PROTECTION AND RESTORATION OF VEGETATION

2572.1 DESCRIPTION

This work consists of protecting and preserving vegetation from damage and restoring vegetation damaged by the Contractor's operations.

2572.2 MATERIALS

A Plant Materials ..... 2571 and 2575

B Temporary Fence

Provide temporary fence meeting the following characteristics and requirements:

(1) At least 4 ft [1.2 m] high,
(2) Conspicuous in color (see Standard Detail Sheet for Protection and Restoration of Vegetation), and
(3) Commercially available snow fence or other fencing material approved by the Engineer.

C Water..... 2571.2.C.4

D Rooting Topsoil Borrow..... 3877

E Tree Growth Retardant (TGR)

Provide the TGR paclobutrazol or an equal approved by the Engineer.

2572.3 CONSTRUCTION REQUIREMENTS

A Protecting and Preserving

Protect and preserve the following:

(1) Specimen trees,
(2) Threatened and endangered plants listed on the Federal and state threatened and endangered species list,
(3) Vegetation as required by the contract,
(4) Trees, brush, and natural scenic elements within the right-of-way and outside the limits of clearing and grubbing in accordance with 2101.3, "Clearing and Grubbing, Construction Requirements," and
(5) Other vegetation as directed by the Engineer.

Do not place temporary structures, store material, or conduct unnecessary construction activities within 25¼ ft [8 m] outside of the dripline of trees designated for preservation, unless otherwise approved by the Engineer.

Do not place temporary structures or store material, including common borrow and topsoil, outside of the construction limits in areas designated for preservation, as required by the contract or as approved by the Engineer.

Do not place or leave waste material on the project, including bituminous and concrete waste that would interfere with performing the requirements of 2105.3.C, "Preparation of Embankment Foundation," or 2575, "Establishing Turf and Controlling Erosion." The Department defines concrete waste as excess material not used on the project, including material created from grinding rumble strips. Dispose of excess material in accordance with 2104.3.D, "Disposal of Material and Debris."

A.1 Temporary Fence

Place temporary fences to protect vegetation before starting construction. Place temporary fence at the construction limits and at other locations adjacent to vegetation designated for preservation as required by the contract or as approved by the Engineer. The Department will provide tree protection signs. Place tree protection signs in accordance with the following:

(1) Along the temporary fence at 50 ft [15.25 m] intervals,
(2) At least two signs per fence, or
(3) As directed by the Engineer.

Do not remove the fence until all work is completed or until approved by the Engineer.

Ensure the fence prevents traffic movement and the placement of temporary facilities, equipment, stockpiles, and supplies from harming the vegetation.

A.2 Clean Root Cutting

Cleanly cut tree roots at the construction limits as required by the contract or as directed by the Engineer.

Immediately and cleanly cut damaged and exposed roots. Cut back damaged roots of trees designated for protection to sound healthy tissue and immediately place topsoil over the exposed roots. Immediately cover root ends exposed by excavation activities with 6 in [150 mm] of topsoil as measured outward from the cut root ends. Immediately (within 5 minutes) treat cut oak roots with a wound dressing material consisting of latex paint or shellac. Limit cutting to a minimum depth necessary for construction. Use a vibratory plow, or other approved root cutter in accordance with the Standard Detail Sheet for Protection and Restoration of Vegetation, before excavation.

A.3 Watering

Water root-damaged trees during the growing season that root damage occurs, and water specified trees if required by the contract or directed by the Engineer. Maintain adequate but not excessive soil moisture by saturating the soil within the undisturbed portion of the dripline of impacted or identified trees to a depth of 20 in [500 mm]. Use a soil recovery probe to check the soil moisture to a depth of 20 in [500 mm], and adjust the intervals and frequency of watering in accordance with prevailing moisture and weather conditions.

A.4 Rooting Topsoil Borrow

Place Rooting Topsoil Borrow instead of common borrow fill within the dripline of specimen trees as required by the contract or as directed by the Engineer.

Place the topsoil to avoid over-compaction as approved by the Engineer. Establish turf consistent with the adjacent areas as approved by the Engineer.

A.5 Utility Construction

Bore under roots of trees designated for preservation for utility installations within the tree protection zone in accordance with the following:

Table 2572-1
Tree Protection Zone

Tree diameter at 4.5 ft [1.4 m] above ground, *in [mm]*	Minimum distance from face of tree trunk, *ft [m]*	Minimum depth of tunnel, *ft [m]*
<2 [50]	2 [0.6]	2 [0.6]
2–4 [51–100]	4 [1.2]	2.5 [0.75]
>4–9 [101–225]	6 [1.8]	2.5 [0.75]
>9–14 [226–350]	10 [3.0]	3 [0.9]
>14–19 [351–480]	12 [3.6]	3.25 [1.0]
>19 [480]	15 [4.8]	4 [1.2]

Do not perform open trenching within the tree protection zone.

A.6 Blank

A.7 Pruning

Provide an arborist certified by the International Society of Arboriculture to prune trees as required by the contract or as directed by the Engineer in accordance with 2571.3.E.1, "Pruning – Top Growth and Roots." Ensure the arborist removes dead, broken, rubbing branches, and limbs that may interfere with the existing and proposed structures.

A.8 Destroyed or Disfigured Vegetation

Restore vegetation designated on the plans for preservation that is damaged or disfigured by the Contractor's operations at no additional cost to the Department. Restore the damaged vegetation to a condition equal to what existed before the damage. The Engineer may assess damages against the Contractor for damage to vegetation not restored to the previous condition. The Engineer will assess the value of damages to trees and landscaping at not less than the appraisal damages as specified in the Council of Tree and Landscape Appraisers *Guide for Plant Appraisal*. The Engineer will determine and assess damages of other vegetation.

A.9 Oak Trees

Avoid wounding of oak trees during April, May, June, and July to prevent the spread of oak wilt. If the Engineer determines that work must take place near oak trees during those months, immediately treat resulting wounds with a wound dressing material consisting of latex paint or shellac. Blend paint colors with the bark color. Maintain a supply of approved wound dressing on the project at all times during this period.

A.10 Tree Growth Retardant (TGR)

Provide an arborist certified by the International Society of Arboriculture to treat trees with the TGR as required by the contract or as directed by the Engineer. Ensure the arborist applies the TGR paclobutrazol as a basal drench or soil injection and in accordance with the label directions. Provide the Engineer with the product label and material safety data sheet for the product used.

A.11 (Blank)

A.12 Other Vegetation Protection Measures

Provide other vegetation protection measures including root system bridging, compaction reduction, aeration, irrigation systems, J-barriers for specimen tree protection, and retaining walls as required by the contract or as directed by the Engineer.

B Ash Trees (Emerald Ash Borer Compliance) 2101.3.D.4

C Plant Installation 2571

D Disposal of Material and Debris 2104.3.D

2572.4 METHOD OF MEASUREMENT

A Temporary Fence

The Engineer will measure temporary fence placed, maintained, and removed by length along the bottom of the fence between end posts.

B Clean Root Cutting

The Engineer will measure clean root cutting by length along the plow line. The Engineer will determine the beginning and ending points for clean root cutting as the intersection of the construction limit and the dripline of the tree or brush or in accordance with lines shown on the plans.

C Water

The Engineer will measure water by volume used to protect and restore vegetation. The Engineer will not measure water otherwise used in performing the work, such as for maintenance of sod.

D Rooting Topsoil Borrow

The Engineer will measure Rooting Topsoil Borrow by loose volume as required by the contract.

E Pruning

The Engineer will measure pruning by the hours of actual pruning work.

F Tree Growth Retardant (TGR)

The Engineer will measure TGR by volume of material applied for the size of the tree treated. The Engineer will determine the volume of TGR required by the diameter at breast height (DBH) of each tree treated. DBH is defined as 4.5 ft [1.4 m] above ground level. The Engineer will use a diameter tape measure to measure DBH.

2572.5 BASIS OF PAYMENT

The Department will include the cost of the following with other relevant contract items:

(1) Boring under roots in the tree protection zone, dressing of wounds, and disposal of material and debris, and
(2) Pruning made necessary to allow for the Contractor's operations or to remedy damage caused by the Contractor's operations.

The Department will pay for protection and restoration of vegetation based on the following unit prices, in the absence of contract unit prices:

Table 2572-2
Protection and Restoration of Vegetation Items

Item	Unit Price
Temporary fence	$2.50 per ft [$8.00 per m]
Clean root cutting	$3.50 per ft [$11.50 per m]
Water	$3.00 per 100 gal [$8.00 per L]
Prune trees	$75.00 per h
Tree growth retardant	$8.00 per diameter in [$3.15 per diameter cm]

The Department will pay for protection and restoration of vegetation on the basis of the following schedule:

Item No.:	Item:	Unit:
2572.501	Temporary Fence	linear foot [meter]
2572.502	Clean Root Cutting	linear foot [meter]
2572.503	Water	gallon [liter]
2572.505	Prune Trees	hour
2572.506	Tree Growth Retardant	gallon [liter]

The Department will pay for Rooting Topsoil Borrow (3877) on the basis of the schedule in 2574.5B.

2573 STORM WATER MANAGEMENT

2573.1 DESCRIPTION

This work consists of managing storm water runoff and project related water discharges to minimize sediment pollution and managing the discharges associated with dewatering and basin draining activities.

2573.2 MATERIALS

A (Blank)

B Water Treatment 3875

C Mulch 3882

D Silt Fence 3886

E Flotation Silt Curtain 3887

F Temporary Slope Drain 3892

G Sandbags 3893

H Sediment Control Log 3897

I Flocculants 3898

J Filter Berm 3874

2573.3 CONSTRUCTION REQUIREMENTS

A General

Schedule, construct, maintain, or install temporary sediment control and storm water management measures as required by the contract and in accordance with the permits required for the project.

Adjust the installation location of temporary storm water management and sediment control devices as shown on the plans to better accommodate the actual field conditions and increase the effectiveness of a device.

A.1 Erosion Control Supervisor

Provide an Erosion Control Supervisor with a valid Minnesota Erosion and Stormwater Construction Site Management certification, authorized to represent the Contractor regarding meeting contractual requirements for Erosion and Stormwater Management and work in public waters. The certification is obtained from a MnDOT approved provider.

The Erosion Control Supervisor shall be available to the work site within 24 hours of initial disturbance and at the site daily when work is taking place until final stabilization. The following list describes the duties of the Erosion Control Supervisor:

(1) Implements the quality control program,
(2) Ensures proper installation, functionality, and maintenance, clean-up, and removal of all erosion and sediment control Best Management Practices BMPs and in accordance with manufacturer's recommendations,
(3) Implements the erosion and sediment control schedule,
(4) Coordinates the work of subcontractors and ensures the full execution of erosion and sediment control measures for each operation and stage of work,
(5) Oversees the work of subcontractors and ensures the subcontractors undertake erosion and sediment preventive measures at each stage of the work,
(6) Prepares the required weekly erosion control schedule and inspections with the dates and times,
(7) Attends construction meetings to discuss the erosion control schedule and inspections,
(8) Prepares the erosion and sediment control Site Management Plans as required by the contract or as directed by the Engineer,
(9) Provides for erosion and sediment control methods for temporary work not shown on the plans,
(10) Ensures effective preventative BMPs are in place, recommends changes to the SWPPP for the Engineer's approval, and amends the SWPPP to document changes,
(11) Ensures acquisition of and compliance with applicable permits for borrow pits, dewatering, and temporary work in rivers, lakes and streams,
(12) Ensures the full installation of erosion and sediment control work before suspension of the work,
(13) Coordinates with federal, state, and local regulatory agencies on resolution of erosion and sediment control issues resulting from the work,
(14) Ensures that proper cleanup occurs from vehicle tracking on paved surfaces locations where sediment leaves the right-of-way,
(15) Ensures daily compliance with environmental laws, permits, and SWPPP requirements, and
(16) Ensures that installers of erosion and sediment control have proper certifications. certification of installers for operations in accordance with 2573.2.A.2, "Certified Installers."

The Erosion Control Supervisor is authorized to install, fix, or repair erosion or sediment control practices when a certified installer is unavailable.

A.2 Certified Installers

Provide a certified installer to install or to direct installations of erosion or sediment control practices and for the following:

(1) Seeding,
(2) Sodding,
(3) Mulching,
(4) Silt fence or other perimeter sediment control device installations,
(5) Rolled Erosion Control Products (RECP) installation,
(6) Hydraulic Erosion Control Product installation,
(7) Silt curtain installation,
(8) Ditch check installation, and
(9) Compost installation.

Provide at least one installer with a valid Minnesota Erosion and Stormwater Construction Installer Certification at the time of installation. The certification is obtained from a MnDOT approved provider.

A.3 Areas of Environmental Sensitivity

Schedule and phase construction in and around Areas of Environmental Sensitivity (AES), as shown on the plans to minimize the potential of sediment entering into these areas. Use measures such as hand clearing and grubbing, limiting bare soil exposure time, expediting construction activities, and immediately establishing final vegetation to minimize sediment loss potential.

A.4 Construction of Temporary Sediment Basins and Traps

Construct temporary sediment basins concurrently with the start of soil disturbing activities. Direct storm water run off from localized watershed to the basins. Mulch and seed the exposed side slopes of the basins.

A.5 Temporary Perimeter Sediment Control Measures

Install sediment control measures down gradient before, or in conjunction, with soil disturbing activities.

Recover sediment, restore property to the pre-existing conditions for loss of sediment off the project, or both at no additional cost to the Department

A.6 Dewatering and Pumping

Provide a water treatment plan for turbid or sediment laden water. Submit the water treatment plan to the Engineer before pumping. Do not begin work until the Engineer accepts the water treatment plan including any contractor required permits. Include in the water treatment plan the use of sediment traps, vegetative filter strips, flocculants, or other water treatments in accordance with 3875, "Water Treatments".

Protect the discharge location of the dewatering process from erosion. Unless otherwise required by the contract, provide and install the BMPs to control erosion and suspended sediment during the dewatering or pumping operation.

A.7 Suspension of Grading

Shape exposed soil and incorporate temporary and permanent erosion control measures as approved by the Engineer before suspending grading operations.

A.8 Related Work

Control drainage and erosion on the work related to the Project including: haul roads, temporary construction, waste disposal sites, plant and storage locations, and borrow pits other than commercially operated sources. Maintain the area, shape the area, install temporary BMPs, replace topsoil, and establish vegetative cover on areas where the potential for pollution has been increased due to the Contractor's operations. Waste disposal sites, borrow pit areas or other related work located outside of the Right-of-Way may require separate permits.

B Installation of Silt Fence

B.1 Type PA Preassembled

Install preassembled silt fence with attached wooden stakes in small areas less than ¼ acre [0.6 ha]. Pound stakes at least 1.5 ft [0.5 m] into the ground. Install the geotextile with the salveged edge on top. Place the bottom edge of the geotextile into a trench 6 in [150 mm] deep and 6 in [150 mm] wide. Backfill and tamp the trench for compaction.

B.2 Type MS Machine Sliced

Mechanically install the geotextile with the salveged edge on top. Place the geotextile directly behind the soil-slicing blade as it works to achieve consistent placement and depth. Do not plow soil if using the slicing method. Roll the wheels of a tractor or skid steer on each side of the geotextile at least 2 times to compact the soil immediately next to the geotextile

Install posts adjacent to the back face of the geotextile with the studs facing away from the geotextile fabric. Secure each post by inserting three plastic zip ties through the geotextile.

B.3 Type HI Hand Installed

Install the geotextile by hand with the selvaged edge on top in areas inaccessible by a machine. Install the bottom 8 in [200 mm] to 12 in [300 mm] of the geotextile in accordance with one of the following methods:

(1) Place the geotextile into a trench 6 in [150 mm] deep and 6 in [150 mm] wide with the bottom edge of the geotextile wrapping back up to the soil surface. Backfill and tamp the trench for compaction, or

(2) In areas where soils prohibit hand trenching, place the geotextile on the ground on the front face and covered with crushed rock or p-gravel at least 12 in [300 mm] wide and 6 in [150 mm] high to provide for as a filter.

Install posts adjacent to the back face of the geotextile with the studs facing away from the geotextile fabric. Insert three plastic zip ties to secure it to each post.

B.4 Type SD Super Duty

Place the bottom edge of the geotextile from 4 in [100 mm] to 6 in [150 mm] underneath the face of the median barrier exposed to direct storm water runoff. Place the median barriers end to end to minimize the gap between each barrier. Attach the geotextile to the face of the barrier with wire or plastic zip ties and tie to each eyelet on the barrier.

B.5 Type TB Turbidity Barrier

Use turbidity barriers to isolate the work zone from the watercourse. Install the turbidity barrier as close to the work area as possible but at no point in expected water depths greater than 3 ft [0.9 m] deep (includes wave heights). Do not trench the geotextile into the watercourse. Anchor at least a 1 ft [0.3 m] flap folded upgradient with sandbags in accordance with 3893,

"Sandbags," to seal the bottom edge. In the top edge, insert a steel support cable into a 2 in [50 mm] double stitch sleeve and fastened to steel fence posts in accordance with 3403, "Hot-Rolled Steel Fence Posts."

Install posts adjacent to the back face of the geotextile with the studs facing away from the geotextile fabric. Secure each post by inserting three plastic zip ties through the geotextile.

Before removing the turbidity barrier, remove and dispose of material not originally in the isolation zone in a location approved by the Engineer.

C Installation of Bale Barriers

Trench bales into the ground 4 in [100 mm] and stake with two wood stakes per bale. Provide the stakes in a length that allows the placement of the stake so the top of the stakes remains flush with the top of the bale when embedded into the ground at least 10 in [250 mm].

D Sandbag Barrier Installation

Install sandbags on a level contour. Sandbags installed a minimum of 6 ft [2 m] back from the toe of the slope to allow ponding, and to provide room for sediment storage. Stack sandbags at least three bags high. Butt ends of bags tightly together and overlap butt joints of rows beneath with each successive row. Stack bags in trapezoidal shape with respect to the side profile.

E Filter Berm Installation

E.1 Type 1, Type 2 (Compost, Slash Mulch)

For slope breaks and perimeter control, install filter berms along the contour of the slope and perpendicular to sheet flow. Install the filter berms so the beginning and end of the installation points slightly up the slope to create a "J" shape at each end to contain runoff from above and prevent it from flowing around the ends of the berm. For slopes that receive runoff from above, place a filter berm at the top of the slope to control the velocity of the flow running onto the slope, and to spread the runoff out into sheet flow.

For ditch checks, install perpendicular to the ditch gradient such that the top of the berm in the middle of the ditch is lower in elevation than the bottom of the terminating points on the ditch side slopes.

Upon formation, immediately seed compost filter berms.

E.2 Type 3 (Rock Weeper)

Line the bottom of the rock weeper with a Type IV geotextile in accordance with 3733, "Geotextiles." Provide a rock weeper that forms a trapezoidal-shaped berm. Install coarse filter aggregate in accordance with 3149, "Granular Material," on the front half of the berm. Install Class I riprap in accordance with 3601, "Riprap Material," on the back half of the berm.

For ditch checks, install perpendicular to the ditch gradient. Construct the center section of the rock weeper 6 in [150 mm] lower than the end points of the weeper at the ditch side slopes to form a weir.

For permanent ditch checks, reduce the height to 16 in (40 cm) and modify the side slopes to 1:6 (V:H).

E.3 Type 4 (Topsoil)

For perimeter control, construct a topsoil berm using topsoil salvaged from the project. Immediately following formation, stabilize the berm with seed and mulch or an equivalent approved by the Engineer.

E.4 Type 5 (Rock)

Install Class II riprap on top of a Type IV geotextile liner in accordance with 3733, "Geotextiles." Configure riprap in a trapezoidal-shaped berm.

For ditch checks, install perpendicular to the ditch gradient. Construct the center section of the rock berm 6 in [150 mm] lower than the end points of the rock berm at the ditch side slopes to form a weir.

F Sediment Control Log Installation

F.1 Straw, Wood Fiber, and Coir

Prepare a shallow trench for the sediment control log to be placed. Backfill and compact the upgradient side of the sediment control log with soil. Stake logs through the back half of the log at a 45 degree angle with the top of the stake pointed upstream. Stakes shall be spaced every 2 ft. (0.6 m). If using more than one sediment control log for length, overlap the ends 6 in [150 mm] and stake both ends.

For ditch checks, place log perpendicular to flow and in a crescent shape with ends facing upstream. Use logs with a center section of the ditch check one log diameter lower than the ends. Space stakes every 1 ft. (.3 m).

F.2 Wood Chip, Compost, and Rock

Place logs on smooth, prepped soils with no gaps between log and soil. Install logs along contours with ends turned up slope in a J-hook manner.

F.3 Wood Fiber and Blanket System

For Ditch checks install Category 3B Erosion Control Blanket (ECB) in accordance with 3885, "Rolled Erosion Control Products," on bare soils and perpendicular to the ditch flow with the leading edge exposed to flow buried in a trench 4 in [100 mm] deep and 4 in [100 mm] wide. Backfill and compact the trench. Staple the ECB at spacing no greater than 1 ft [0.3 m] on center.

Install a Wood Fiber Sediment Control Log in accordance with 2573.F.1, without the trench, on top of the ECB.

Drive the stakes through the back half of the log at a 45 degree angle. Point the top of the stake upstream. If using more than one sediment control log for length, overlap the ends 6 in [150 mm] and stake both ends.

G (Blank)

H (Blank)

I Flotation Silt Curtain Installation

Provide a flotation silt curtain meeting the following requirements and characteristics:

(1) Contains connecting devices at each end so that sections can be joined together,
(2) Contains connecting devices designed to prevent silt from permeating through the connection and at the specified strength to prevent ripping out, and
(3) Installation shall reach the bottom of the water body.

I.1 Still Water

Secure both ends of a Light Duty Floating Silt Curtain in accordance with 3887, "Flotation Silt Curtain," to land with steel fence posts in accordance with 3403, "Hot-Rolled Steel Fence Posts," and extend the curtain at a 45 degree angle from both ends. Anchor the curtain in the waterway with at least 40 lb [18 kg] anchors at intervals no greater than 100 ft [30 m] along the length of the curtain. Mark each anchor with a buoy in navigable waters. Keep the curtain as tight to the work area or shoreline as possible not to exceed one-fourth of a stream width.

I.2 Moving Water

Secure both ends of a Heavy Duty Floating Silt Curtain in accordance with 3887, "Flotation Silt Curtain," to land with steel fence posts in accordance with 3403, "Hot-Rolled Steel Fence Posts," and extend the curtain at a 45 degree angle from both ends. Anchor the curtain in the waterway with at least 150 lb [68 kg] anchors at intervals no greater than 50 ft [14.2 m] along the length of the curtain. Mark each anchor with a buoy in navigable waters. Keep the curtain as tight to the work area or shoreline as possible not to exceed one-fourth of a stream width.

J (Blank)

K Construction Exit Controls

Select Exit controls from the following list of stabilized construction exits:

-Slash mulch,
-Crushed Rock,
-Temporary paving,
-Reinforced geotextile,
-Sheet pads,
-Floating road,
-Timber pad,
-Rumble pad.

Provide a wheel wash off system in addition to stabilized exit controls when project site conditions warrant.

Use construction exit control BMPs at exit locations to minimize vehicle tracking of sediment from the project onto paved surfaces. Install BMPs during the initial phase of the project.

Select construction exit BMP based on project site conditions, soil type, vehicle size, time of year, and duration of use. Used materials generated by the project as construction exit controls whenever possible. Maintain exit controls during the project.

Clean paved streets at the end of each working day, or more frequently as necessary to provide safety to the traveling public.

L Culvert End Controls

Provide culvert inlet end controls consisting of the BMPs and devices for temporary impoundment and treatment of construction stormwater upstream. Culvert inlet end controls apply to median culverts, centerline culverts, box culverts, and entrance culverts.

Protect culvert inlet ends with sediment capture devices before soil disturbing activities that would result in sediment laden storm water runoff entering the culvert. Protect culvert outlet ends with energy dissipation devices, transition devices, or both to reduce erosion and sediment loss while reducing the velocity of water exiting culvert. Leave installed devices in place for as long as the culvert is functioning. Maintain devices until the Contract is completed.

Clean out devices regularly and provide an emergency overflow features to reduce the flooding potential. Place devices in a manner that does not create driving hazards or obstructions. Remove sediment deposited in, or plugging the drainage systems.

M Storm Drain Inlet Protection

Implement BMPs and devices to protect all inlets throughout the Work to prevent passage of sediments into and through underground drainage systems.

Protect storm drain inlets, including manholes, catch basins, curb inlets, and other drop type inlets constructed for the ingress of surface water runoff into underground drainage systems.

Install storm drain inlets with sediment capture devices before soil disturbing activities. Provide effective storm drain inlet protection until the completion of paving or final stabilization of soils.

Prevent or minimize the potential for unsafe flooding or siltation problems. Clean out devices regularly and provide devices with an emergency overflow to reduce the flooding potential. Place devices without creating driving hazards or obstructions.

N Flocculants

Do not apply flocculants directly to public waters (i.e. lakes, wetlands, streams). Apply flocculants in a contained area and assure thorough mixing into the water. Before applying a flocculant, test the pH and temperature of the storm water. Apply flocculant within the manufacturer's specified ranges. Allow from 15 min to 20 min retention time for the chemical reaction for clay size particles to settle, ensuring that the discharge of the treated water is visually the same as the receiving water.

N.1 Liquid Flocculant

Hydraulically apply liquid flocculant over the surface of the water to be treated. Dilute the liquid flocculant concentrate to form a stock solution. Apply the stock solution at the manufacturer recommended rate to yield 1 ppm in the final treated water volume.

N.2 Flocculant Sock

Securely anchor the flocculant sock in an area where the water to be treated will flow over the sock. Do not leave flocculant socks in standing, stagnant water.

N.3 Granular Flocculant

Mix granular based flocculant with water in a tank to form a stock solution. Hydraulically apply the stock solution at the manufacturer's recommended rate to yield 1 ppm in the final treated water volume.

O (Blank)

P Maintenance

P.1 General

Keep all devices functioning properly and maintained in accordance with the Contract. Repair or replace plugged, torn, displaced, damaged, or nonfunctioning devices within 24 h of discovery or as soon as practicable as approved by the Engineer.

P.2 Temporary Sediment Control Devices

Remove sediment from devices such as bale barriers, silt fences, ditch checks, sediment control logs, and perimeter controls when the sediment reaches one-third of the height of the device. Replace non-functional devices and devices damaged by sediment removal. Perform sediment removal within 24 h of discovery or as soon as field conditions allow access.

P.3 Filter Berms

Remove accumulated sediment or install a new berm when sediment reaches one-third of the berm height. Expand, enlarge, or augment the filter berm with additional erosion and sediment control practices if concentrated flows bypass or breach the berm. Add filter material to maintain the dimensions of the berm.

P.4 Sediment Basins and Traps

Drain the basin and remove the sediment when the depth of sediment collected in the basin reaches 50 percent of the height of the riser or 50 percent of the storage volume. Complete drainage and removal within 72 h of discovery or as soon as field conditions allow access. Remove sediment to the original designed or excavated grade or as necessary to restore the function of the device.

Clean out and shape temporary sedimentation basins intended for use as permanent water quality management basins as shown on the plans.

P.5 Storm Drain Inlet Protection Devices

Clean, remove sediment, or replace storm drain inlet protection devices on a routine basis to ensure the full functionality of the devices for the next rainstorm event.

P.6 Culvert End Control Devices

Clean, remove sediment, or replace culvert end control devices on a routine basis to ensure the full functionality of the devices for the next rainstorm event.

Q Removal of Temporary Devices

Remove temporary sediment control devices after completing the work unless otherwise required by the contract or directed by the Engineer. All removed materials become the property of the Contractor.

Spread accumulated sediment to form a suitable surface for turf establishment or dispose of the sediment. Shape the area to permit natural drainage as approved by the Engineer.

Remove the silt curtain upon completion of work. Do not allow re-suspension of sediment or loss of trash and oil into the water during the silt curtain removal.

R Workmanship Rework Schedule

To qualify for payment, correct unacceptable workmanship when the quality falls below the threshold level in accordance with Table 2573-1, "Temporary Sediment Control: Corrective Action" and prevent reoccurrences of unacceptable work.

Table 2573-1
Temporary Sediment Control: Corrective Actions

Item	Corrective Action Required
Silt fence	Improper geotextile used
	Insufficient geotextile embedment
	Insufficient compaction of soil
	Soil turned over, loosened, or both due to inadequate equipment for sliced type
	Inadequate fastenings
	Incorrect post spacing
Bale barriers	Not notched in
	Not properly staked into the ground
Filter berms	Damaged or compacted by equipment
	Berm breached or bypassed
Floating silt curtain	Curtain not anchored on land
	Curtain not weighted sufficiently in water
Ditch checks	Sediment control logs not properly trenched, staked, or both
	Not stapled properly for blanket and sediment control log system
	Water flows around the end rather than over the middle
	Incorrect spacing of checks
	No geotextile used for rock weeper system or rock checks
Perimeter controls	Incorrect BMP for location
	Not properly J-hooked at termination points
	Not placed along contours
Storm drain inlet protection	Inlet opening unprotected.
	Emergency overflow not provided where required
	Device not cleaned out
Sediment control logs	Not staked properly resulting in undermining or movement of logs
	Log ends not overlapped when more than one is needed in a line

2573.4 METHOD OF MEASUREMENT

A Bale Barriers

The Engineer will measure the bale barriers by the length installed.

B Silt Fence

The Engineer will measure silt fence along the base of the fence from outside to outside of the end posts for each section of fence.

C Sandbag Barriers

The Engineer will measure sandbag barriers by surface area based on actual measurement taken along the length of the barrier times its height. If the Contractor installed more than one thickness of sandbags the Engineer will measure the surface area of each layer of thickness and add it to the quantity.

D Flotation Silt Curtain

The Engineer will measure flotation silt curtain by length installed.

E Sediment Traps

The Engineer will measure sediment trap quantities by volume for basin excavation and construction. The Engineer will measure excavation by volume of the material in its original position. The Engineer will measure overflow devices separately. Maintenance if sediment traps including removal and spreading of sediments is incidental.

F Temporary Slope Drains

The Engineer will measure temporary slope drains by length installed. The diversion mound is incidental to the measured length of pipe installed. The Engineer will measure materials used to provide an outlet separately.

G Blank

H Sediment Control Logs

The Engineer will measure types; straw, wood fiber, coir, wood chip, compost, and rock by the effective length installed. The Engineer will not include overlaps in the measurement.

The Engineer will measure types; Wood Fiber and Blanket System by length installed. The Engineer will not include overlaps in the measurement.

I (Blank)

J Culvert End Controls

J.1 Each

The Engineer will measure culvert inlet end controls by measuring the number of individual culvert ends protected throughout the work regardless of the type or number of devices used at each culvert end.

J.2 Lump sum

The Engineer will measure culvert inlet end controls as lump sum. Lump sum shall include all materials and labor necessary to provide proper culvert end controls thru the life of the contract regardless of quantities and types required.

K Storm Drain Inlet Protection

K.1 Each Storm Drain inlet

The Engineer will measure storm drain inlet protection by the number of individual inlets protected over the life of the contract regardless of the types of number of devices used at each storm drain inlet.

K.2 Lump Sum

The engineer will measure storm drain inlet protection as Lump sum. Lump sum shall include all materials and labor necessary to provide proper inlet protection thru the life of the contract regardless of quantities and types required.

L Flocculants

The Engineer will measure liquid flocculant by the volume of liquid flocculant concentrate used. The Engineer will not include the water used to dilute the concentrate in the measurement for liquid flocculant.

The Engineer will measure flocculant sock by each sock provided.

The Engineer will measure granular flocculant by the weight used and placed. The Engineer will not include the water used to dissolve and dilute the granular flocculant in the measurement for granular flocculant.

M Filter Berm

The Engineer will measure by length installed based upon following the installation methods and materials dimensions.

N Construction Exit Controls

The Engineer will measure construction exit controls by the lump sum including the cost of protecting each exit over the life of the contract regardless of types or quantities. Wheel wash of systems will be measured separately.

2573.5 BASIS OF PAYMENT

The contract unit prices for storm water management items will include the material, maintenance, and removal as required by the contract to complete the work. For items of work not included in the schedule of Contract Pay Items, the Department will pay unit prices for the relevant items of work.

The Department may provide partial payment of temporary sediment control devices no greater than 50 percent of the contract unit price for each relevant pay item unless otherwise required by the contract. The Department will pay the remaining partial payment after proper maintenance and removal of the device.

The Department will withhold from monies owed to the Contractor for each improperly installed or maintained device where the Contractor failed to remove sediments, and the Engineer has ordered this corrective action.

A Filter Berms

The contract unit price for Topsoil filter berm includes seed and mulch.

B Storm Drain Inlet Protection

The contract unit price for the inlet protection devices contract item includes the cost of removing and disposing of trapped sediment in inlet protection devices or sediment deposited in or plugging drainage systems protected by the devices.

C Culvert End Controls

The contract unit price for the culvert protection controls contract item includes the cost of removing and disposing of trapped sediment in culvert end controls or sediment deposited in or plugging drainage systems protected by these controls.

D Silt Fence

The contract unit price for the silt fence includes the cost of maintaining and removing the devise. Removal and disposal of trapped sediment is incidental.

D.1 Reductions

The Department will withhold from monies owed to the Contractor for each section of silt fence not maintained at discharge points or where damaged by the public or the Contractor, and the Engineer has ordered this corrective action.

E Water Treatments

The lump sum price for *Water Treatments* includes the cost of labor, development of water treatment plan, equipment, materials, monitoring, outfall scour protection, treatment, supervision complete in-place, pumping, setting up tanks, maintenance, protection of trees, repair and replacement of damaged sections, removal of sediment deposits, and removal of erosion protection and sediment control systems after final stabilization.

F Construction Exit Controls

he lump sum price for construction exit controls includes the installation, maintenance, and removal upon successful completion of the project. Wheel wash of systems will be paid for separately for each system.

G Sediment Traps

The Department will pay for each sediment trap constructed and maintained. Sediment removal and spreading or disposal is incidental.

H Erosion Control Supervisor

The Department will provide partial payment no greater than 50 percent of the contract lump sum price for *Erosion Control Supervisor* upon satisfactory completion of either half the allowable project working days or half the anticipated project duration time as approved by the Engineer. If providing partial payment, the Department will pay the remaining percentage upon performance of duties as approved by the Engineer and completion of the work.

In the absence of a Contract bid item for Erosion Control Supervisor and when required in the plans, the Erosion Control Supervisor will be considered incidental for all work and duties for which no direct payment will be made.

H.1 Reductions

The Department will withhold from monies owed to the Contractor for failure to provide a certified erosion control supervisor or failure to perform erosion control supervisor duties.

I Pay Items

The Department will pay for temporary sediment control items on the basis of the following schedule:

Item No.:	Item:	Unit:
2573.501	Bale Barrier	linear foot [meter]
2573.502	Silt Fence, Type ___	linear foot [meter]
2573.504	Sandbag Barrier	square foot [square meter]
2573.505	Floatation Silt Curtain, Type ___	linear foot [meter]
2573.506	Sediment Trap Excavation	cubic yard [cubic meter]
2573.507	Temporary Slope Drain	linear foot [meter]
2573.510	Water Treatment	lump sum
2573.511	Water Treatment Type ___	each
2573.515	Filter Berm Type ___	linear foot [meter]
2573.520	Sediment Removal, Backhoe	hours
2573.521	Sediment Removal, Vac Truck	hours
2573.530	Storm Drain Inlet Protection	Each
2573.531	Storm Drain Inlet Protection	lump sum
2573.533	Sediment Control Log Type ___	linear foot [meter]
2573.535	Stabilized Construction Exit	lump sum
2573.536	Wheel Wash Off	each
2573.541	Liquid Flocculant	gallon [cubic meter]
2573.542	Flocculant Sock	each
2573.543	Granular Flocculant	pound [kilogram]
2573.550	Erosion Control Supervisor	lump sum
2573.560	Culvert End Controls	each
2573.561	Culvert End Controls	lump sum

2574 SOIL PREPARATION

2574.1 DESCRIPTION

This work consists of providing temporary shaping and grading, and preparing the soil for permanent turf establishment to reduce the risk of soil erosion. Temporary shaping and grading includes directing water flow and smooth rough grading to install temporary erosion control materials. Preparing the soil for permanent turf includes soil tilling and soil additives.

2574.2 MATERIALS

A Lime.....3879

B Topsoil Borrow.....3877

C Fertilizer 3881

D Compost.....3890

E Soil and Root Additives.....3896

2574.3 CONSTRUCTION REQUIREMENTS

A General

Prepare the soil to minimize soil erosion and to provide a media for plant and root establishment. Perform soil preparation operations for permanent seed and sod and for temporary conditions.

A.1 Erodible Surface

Erodible surface potential starts when construction activities disturb the natural vegetation or topsoil. Erodible surface potential ends at completion of finishing and turf establishment. In order to expedite this process the Department will withhold $3000 per acre[$7413 per ha] from the Contractor for areas open to erosion The Engineer will determine the areas open to erosion before approving each partial payment. Areas open to erosion will not include the roadway embankment area.

A.2 Temporary Grading

Perform temporary grading when installing temporary erosion control materials in locations where the final topsoil grade has not been established and soils will be left idle for more than 1 week. Shape subsoil to remove clods of soil greater than 3 in [75 mm] in diameter and ruts, erosion rills, or washouts deeper than 3 in [75 mm].

A.3 Soil Tracking

After establishing final grade with topsoil placement and before turf establishment, perform soil tracking on slopes 1:2 (V:H) slopes. To perform soil tracking, create horizontal grooves on an exposed slope using a stair-stepping procedure or run tracked construction equipment up and down the slope to roughen the surface and to increase the relief of a bare soil surface. Perform the stair-stepping procedure parallel to the contour of the land.

A.4 Soil Bed Preparation

Prepare the soil surface to provide a smooth, moist, and evenly textured foundation before sowing seed or placing sod. Complete the tilling after applying soil amendments to the soil. Use cultivating equipment such as disks, harrows, field diggers, or tillers capable of loosening the soil to a depth of at least 3 in [75 mm] on all areas except for slopes steeper than 1:2 (V:H). Till the soil surface to remove track imprints from wheeled or tracked equipment. Operate cultivating equipment on slopes at right angles to the direction of surface drainage. Soil clods, lumps, and tillage ridges 3 in [75 mm] high may remain in place for seeding operations. Soil clods, lumps and tillage ridges 1.5 inch (40 mm) high may remain in place for sodding operations. Multiple passes of the equipment may be needed to meet these requirements.

A.5 Subsoiling

Perform subsoiling before placing topsoil on areas where topsoil placement is greater than 6 inches (150 mm) in depth otherwise after topsoil is placed and in the following areas:

- Where the subsoil has been compacted by equipment operations,
- Staging areas, old road beds to be vegetated,
- Where the plans show turf establishment, and
- Infiltration, Filtration or Bioretention areas.

Perform subsoiling in one direction on the contours perpendicular to the flow of water and slopes flatter than 1:2 (V:H). Use a multi-shanked, parallelogram implement to create channels. Do not use disc cultivators, chisel plows, or spring-loaded equipment to perform subsoiling. Space the grid channels from 12 in to 36 in [300 mm to 910 mm] apart except as shown on the plans. Create channels to provide a depth from 16 in [400 mm] to 20 in [500 mm] or as shown on the plans. Subsoil areas shall be loosened to less than 200 psi [1400 kPa]. For saturated soil, delay subsoiling operations until soil dries to at least field capacity.

Observe a minimum setback as directed by the Engineer for the following subsoiling exceptions:

- Areas within the dripline of existing trees,
- Over utilities within 30 in [750 mm] of the surface,
- Where trenching or drainage lines are installed,
- Where compaction is required by design (abutments, footings, or inslopes), and
- Inaccessible slopes.

B Infiltration, Filtration, and Bioretention Areas

Construct sites after stabilizing contributing drainage areas. Stabilize areas draining to infiltration sites. Prevent sediment laden runoff from entering infiltration site during construction. Use light tracked equipment to excavate, grade, shape, and place soil loosely as shown on the plans. Minimize tracking and compacting over the infiltration areas. Place excavated material to prevent the material from re-entering the basin during the work. Subsoil infiltration basins before placing topsoil borrow type G in accordance with 3877, "Topsoil Borrow."

C Topsoil

Place and shape topsoil to the depths as shown on the plans. Remove all rocks and debris exceeding 3 in [75 mm] in topsoil surface.

Salvaged topsoil shall be stockpiled on the project site or at a suitable location approved by the Engineer. Test stockpiled topsoil in accordance with the testing procedures for soil fertility in 3877, "Topsoil Borrow." Complete the testing at least 1 month before placement. Use these test results to determine pH adjustments and fertilizer, soil additives, and compost needs for plant establishment. The Engineer will determine adjustments to the existing topsoil for plant establishment based on the test results.

Topsoil Material sources must be approved by the Engineer prior to blending and delivery. Before blending individual components to create a topsoil borrow, verify that each component meets the specification requirements

D Applying Soil Amendments

Do not place commercial fertilizer, liming material, and soil additives on frozen ground or snow. Apply fertilizers after the runoff from spring snowmelt.

Use mechanical spreading devices to uniformly apply fertilizers, compost, liming materials, and additives at the rates required by the contract before placing seed or sod. Till the soil at least once within 24 hours of placing fertilizer, compost, lime, or soil additives. Apply seed within 48 hours of fertilizing.

The Department based the lime application rates on 1,000 lb Effective Neutralizing Power (ENP) per ton [500 kg ENP per tonne] of agricultural liming material. Adjust the actual lime application rate to meet the above rate.

The Contractor may use Grade 1 compost instead of commercial fertilizer, as approved by the Engineer. Apply the compost at an equivalent nutrient application rate to the rate for commercial fertilizer shown on the plans.

E Acceptance of Work

Notify the Engineer at least 24 h before beginning and changing soil preparation operations. Till and mix soil amendments into the soil before seeding operations. The Engineer will reject soil preparation not verified by inspection as unauthorized work in accordance with 1512, "Unacceptable and Unauthorized Work."

The Engineer will accept an infiltration, filtration, or bioretention area after an infiltration test demonstrates an acceptable percolation rate in accordance with 3877, "Topsoil Borrow."

F Workmanship Rework Schedule

The Engineer may require corrective action for the conditions indicated in Table 2574-1 for the work to qualify for payment.

Table 2574-1
Required Corrective Action

Item	Corrective Action Required if	Corrective Action
Fertilizer and lime	Incorrect rate of application	Reapply at adjusted rate to meet require rate.
	Not uniform placement	Reapply on areas missed.
	Not incorporated properly	Re-till the soil.
Compost	Incorrect rate of application	Reapply at adjusted rate to meet require rate.
	Not uniform placement	Reapply on areas missed.
	Rutting of slopes with equipment	Re-till the soil.
Topsoil and topsoil borrow materials	Inadequate soil loosening or preparation	Re-till the soil.
	Failure of Double Ring infiltrometer test	Amend or replace soil to correct

Correct the quality of work for soil placement necessary for approval by the Engineer at no additional cost to the Department. Dispose of nonconforming materials in accordance with 1608, Unacceptable Materials."

2574.4 METHOD OF MEASUREMENT

A Fertilizer

The Engineer will measure fertilizer by the weight of each type applied. If the Contractor provides fertilizer with different type than as shown on the plans, the Engineer will adjust the application rate of the fertilizer provided to meet the equivalent type proportions of the fertilizer shown on the plans.

B Lime

The Engineer will measure agricultural lime by weight applied.

C Soil and Root Additives

The Engineer will measure soil and root additives by the weight or volume applied.

D Compost

The Engineer will measure Grade 1 compost by weight applied.

The Engineer will measure Grade 2 and Grade 3 compost by loose volume.

E Topsoil Borrow

The Engineer will measure topsoil borrow by loose volume as required by the contract.

F Subsoiling

The Engineer will measure subsoiling by area successfully loosened.

G Soil Tracking

The Engineer will measure soil tracking by area.

H Soil Bed Preparation

The Engineer will measure soil bed preparation by area.

2574.5 BASIS OF PAYMENT
A Erodible Acres Partial Payment

The Engineer may divide the project into separate control areas for release of the withholding.

The Department may make partial payments for erodible surface area based on withholding reductions approved by the Engineer and in accordance with Table 2575-5:

Table 2575-5
Partial Release

Control Area Surface Condition	Withholding Reduced
Possible erosion damage or water pollution exists	No release until fixed
Rough grading completed and permanent topsoil placed	50 percent
Permanent stabilization completed	25 percent
Vegetation established and accepted	Full release

B Payment Schedule

The Department will pay for soil preparation on the basis of the following schedule:

Item No.:	Item:	Unit:
2574.508	Fertilizer, Type ____	pound [kilogram]
2574.510	Iron Sulfate	pound [kilogram]
2574.512	Activated Charcoal	pound [kilogram]
2574.514	Plant Hormones	gallon [liter]
2574.515	Hydrophilic Polymers	pound [kilogram]
2574.516	Mycrorrhizal Inoculum	pound [kilogram]
2574.517	Rhisobium Inoculum	pound [kilogram]
2574.518	Compost Tea	gallon[liter]
2574.550	Compost, Grade 2	cubic yard [cubic meter]
2574.550	Compost, Grade 3	cubic yard [cubic meter]
2574.551	Compost, Grade 1	ton [metric ton]
2574.575	Subsoiling	acre [hectare]
2574.525	_____ Topsoil Borrow	cubic yard [cubic meter]
2574.576	Lime	ton [metric ton]
2574.578	Soil Bed Preparation	acre [hectare]
2574.579	Soil Tracking	acre [hectare]

2575 ESTABLISHING TURF AND CONTROLLING EROSION

2575.1 DESCRIPTION

This work consists of applying temporary soil covers and establishing a perennial ground cover to reduce the risk of soil erosion.

Temporary soil covers include mulch, establishment of an annual vegetative cover, erosion control blanket and hydraulic soil stabilizers. Establishment of a perennial vegetative cover includes seeding, sodding, mulching, and any other specified work.

2575.2 MATERIALS

A Seed.....3876

B (Blank)

C Sod 3878

D Riprap Material.....3601

E (Blank)

F Mulch 3882

G Rolled Erosion Control Products 3885

H (Blank)

I Hydraulic Erosion Control Products 3884

2575.3 CONSTRUCTION REQUIREMENTS

A General

Minimize soil erosion and prevent damage from sedimentation by using the Best Management Practices (BMP) to cover bare soils in temporary and permanent conditions. Use temporary erosion control BMP's, including limiting the amount of exposed erodible soils and providing for proper exposed soil stabilization for slopes, ditches, storm drain and culvert outlets, and storm water discharge points from erosion. Use permanent erosion control BMP's to provide the final stabilization of exposed slopes. Properly prepare soils in accordance to 2574, "Soil Preparation."

A.1 Exposed Soil Stabilization

Use rapid stabilization methods to temporarily stabilize disturbed areas within 200 ft [61 m] of surface water and in Areas of Environmental Sensitivity (AES). Use temporary seed mixtures and/or mulch or hydraulic erosion control products to stabilize other disturbed areas. Schedule, construct, or install stabilization measures on exposed soil areas as shown on the plans or as required by the permit.

A.2 Growing Seasons

Schedule and install temporary and permanent seed or sod in areas at the optimum growing time for proper turf establishment

A.2.a Seeding Dates

Plant seed mixtures during the seasons of planting for the various seed mixtures in accordance with Table 2575-1:

Table 2575-1
Season of Planting

Seed Mixture Number	Spring	Fall
21-112	—	Aug. 1 – Oct. 1
21-111	May 1 – Aug. 1	—
22-111, 22-112*	April 1 – July 20.	July 20 – Oct. 20
25-121, 25-131, 25-141, 25-151*	April 1 – June 1	July 20 – Sept. 20
25-142*	April 1 – Sept. 1	—
Any mix beginning with a 3	April 15 – July 20	Sept. 20 – Oct. 20

* For the portion of Minnesota north of, and including T.H. 2, plant seed mixtures 22-111 to 25-142 from April 15 to September 20.

Provide temporary stabilization when outside the season of planting dates of the specified permanent seed mixture

Request to adjust dates in writing by no more than 10 calendar days to shorten or extend the exclusion dates when conditions warrant. The engineer may approve the request or direct the contractor to seed outside the seeding dates.

A.2b Sodding Dates

Sod growing days are any calendar day exclusive of the days from November 1 to April 15. Sodding shall be avoided during June 10 to August 10 for Bluegrass dominated sod. Sodding shall be avoided during June 10 to October 31 for Fescue dominated sod.

The engineer may adjust these dates by no more than 15 calendar days, to shorten the excluded periods when conditions are favorable to active growth, or to lengthen the excluded period when conditions for establishment are unfavorable.

Provide temporary stabilization when outside the sodding dates.

A.3 Winter Season

During the winter season, perform erosion control operations to protect the site through the end of the spring snowmelt season. Such practices include dormant seeding and sodding, snow seeding and mulching, and frozen ground mulching. Both dormant seeding and sodding are performed during the early winter season. Early winter season is the period when soil temperatures will not allow seeds to germinate and when normal plant rooting will not occur.

A.4 Substitutions

The Engineer may allow substitutions in accordance with 1605, "Substitute Materials" for the following products; Mulch, Erosion Control Blankets, Turf Reinforcement Mats, and Hydraulic Erosion Control Products. The Engineer, in consultation with Office of Environmental Stewardship Erosion Control and Storm Water Management Unit, may authorize requested substitutions. Provide substitutions equal to or better than initially specified material.

B Placing Seed

Store the seed from time of purchase until installation at 50° F (10 °C) and 50 percent humidity. Protect the seed from moisture until sowing. Do not use wet or moldy seed. Apply seed within 48 hours of fertilizer application.

Sow the seed uniformly at the adjusted bulk rate of application for each mixture. Adjust the bulk seeding rate needed to achieve the required PLS rate for the mixture in accordance with 3876, "Seed" and the following formulas:

(1) Bulk Application, lb [kg] = $\frac{PLS, lb[kg]}{\%PLS}$

(2) % PLS = % germination × % purity

Immediately after seeding firm the seedbed with a cultipacker to provide seed to soil contact. Do not broadcast seed with wind velocities greater than 15 mph [25 km/h].

B.1 Temporary Seeding

Perform temporary seeding in addition to temporary mulching on graded areas with topsoil and unable to receive permanent seeding or slopes and topsoil berms left idle for longer than 21 days. Use cover crop and mid-term stabilization seed mixtures as shown in 3876, "Seed", Table 3876-1 for temporary seeding.

Prepare the soil in accordance with 2574.3.A and 2574.3.B, except for stockpile and berms where no soil preparation is needed.

B.2 Seeding Turf Mixes

Mechanically sow or hydraulically apply seed mixture numbers from 21-111 to 25-151 adjusted bulk application rate of each mixture Only use hand operated mechanical spreaders on areas too small for or inaccessible by the specified equipment.

If using an agricultural type seed drill, operate the drill in a general direction at right angles to the direction of surface drainage and sow the seed shall to a depth no greater than ⅜ in [10 mm].

B.3 Seeding Native Mixes

Seed native mixes (any mix beginning with a number 3) with a native seed drill, a drop type seeder, or a hydro seeder at the adjusted bulk application rate of each mixture. Use a drill capable of accurately metering the types of seed planted and capable of maintaining a uniform mixture of seeds during drilling. Use a drill with disk furrow openers and a packer assembly to compact the soil directly over the drill row. Seed native mixes in rows spaced no greater than 8 in [200 mm] apart. Place seeds to a final planting depth from ⅛ in [3 mm] to ⅜ in [10 mm]. Perform drill seeding at a right angle to surface drainage. A drop type seeder equipped with a separate seed box for the fluffy seed and a soil packer assembly may be used in lieu of a drill with disc openers Use a cyclone or spinner type seeder on areas no greater than 1 acre [0.4 ha] or on areas inaccessible to other equipment, as approved by the Engineer.

B.4 Hydro-seeding

Use a hydro-seeder capable of continuous agitation action to uniformly distribute the seed over the area. Add a 50 lb [22.5 kg] 3884.2.C, "Type Hydraulic Mulch", as a tracer for each 500 gal [1.9 cu. m] of water in the hydro-seeder tank. Use flood type nozzles and Manufactures' recommended water volume. Once the seed has been added to the tank mixture a one hour time limit is set for spreading the mixture on the soil. Once the one hour is passed the excess mixture must be discarded. Perform hydro-seeding separate from placing Hydraulic Erosion Control Products (hydro-mulching).

B.5 Interseeding

Perform interseeding if seeding into temporarily mulched areas or if drilling additional seed into previously seeded areas. Use an interseeding drill containing trash rippers and at least one box fine seed and at least one box for larger seeds or fluffy seeds. Operate the drill to slice through the vegetative mat and make a furrow 1 in [25 mm] wide and from ⅜ in [10 mm] to 1 in [25 mm] deep in the underlying soil. Place seeds in the furrows through the drill seed disk openings. Drop the seed onto the ground surface from the fine seed box. Place the large or fluffy seed to a final planting depth from ¼ in [6 mm] to ⅜ in [10 mm].

B.6 Permanent Seeding into Temporarily Mulched/Blanketed Areas

Permanently seed areas previously temporarily mulched. Without performing additional tillage or site prep work, the Contractor may use an interseeding drill to drill seed directly into temporarily mulched or temporarily seeded areas. In lieu of using an interseeding drill, the Contractor may lightly disc the mulched areas before seeding. Apply fertilizer within 24 h before interseeding or light disking. Leave the existing cover in place as serve as mulch.

Permanently seed into areas temporary blanketed using the hydroseeding application as mentioned above. Hydroseed into the installed blanket with the nozzle 6 feet [2m] from blanket, forcing the seed and water through the blanket.

B.7 Winter Seeding

Dormant seed after October 20 and when soil temperatures 1 in [25 mm] below surface are no greater than 40 °F [4 °C].

Perform snow seeding over the top of snow allowing the seed to melt through the snow to the soil and germinate upon warm up in the spring.

C Applying Mulch

Mechanically spread mulch to provide a uniform distribution over all exposed soil at the application rate to provide 90 percent uniform soil coverage. If non-uniform distribution occurs, re-mulch areas or remove the excess coverage.

Do not operate mulch-blowing equipment on slopes steeper than 1:2.5 (V:H) or on slopes that will rut the soil surface. Use blower attachments to apply the mulch without traversing the slopes. Do not mulch with wind velocities greater than 15 mph [25 km/h].

Areas within 10 ft [3 m] of the shoulder immediately mulch, and anchor the mulch in a continuous operation after seeding. If traffic or wind dislodges the seed or mulch due to delays in the continuous operation, reseed and remulch the affected areas.

Areas outside 10 ft [3 m] of the shoulder shall be mulched within 24 hr after seeding.

C.1 Temporary Mulching

Perform temporary mulching on contiguous areas of 2.0 acres [0.8 Ha] and greater to protect the site from erosion when left idle for more than one week and during non-seeding periods and when outside the seeding and sodding dates. For areas less than two acres, mulch in accordance with 2575.3.M, "Rapid Stabilization."

C.2 Type 1, Type 3, Type 7, and Type 8 Mulch

Use blower equipment to place Type 1, Type 3, Type 7, and Type 8 mulch at a target application rate of 2 ton per acre [4.5 tonne per ha]. Apply the mulch at an actual rate as directed by the Engineer to match varying material or project conditions. Apply the mulch to ensure 90 percent coverage of the soil surface.

C.3 Type 4 Mulch

Apply Type 4 mulch as a dual operation with the Type 1 mulch blown on the soil surface at 1 ½ tons per acre (3.4 metric tons per hectare) and immediately over-spray with 3884, Stabilized Fiber Matrix at 750 pounds per acre (840 kg/ha).

C.4 Type 5 Mulch

Apply Type 5 mulch at a rate of 80 cu. yd per acre [150 cu. m per ha] as specified in the plans as an erosion control material.

C.5 Type 6 Mulch

Apply Type 6 mulch at the rate shown on the plans or special provisions.

C.6 Type 9 Mulch

Apply Type 9 mulch at a rate required by the contract. Before placing mulch, uniformly compact and smooth the foundation, cover the foundation with 6 mil [150 µm] plastic sheeting, and uniformly spread the aggregate mulch to the thickness shown on the plans without harming the foundation. Level the finished aggregate surface flush with adjacent areas.

C.7 Winter Mulching

Perform frozen ground mulching on bare frozen soils. Place 3882, Type 5, Type 6, and Type 9 mulch materials with no modifications to meet the requirements of frozen ground mulching. Place 3882, Type 1, Type 3, or Type 8 mulch materials with the following modifications to meet frozen ground mulching:

At temperatures above 20 °F (-6 °C) use 3884, Type Natural or Synthetic Tackifier, in lieu of disc anchoring

At temperatures below 20 °F (-6 °C) delay mulching until ground is snow covered and perform snow mulching.

Perform snow mulching at any time over the top of snow. No disc anchoring is required. Apply Snow mulching prior to or during a snowfall event.

D Disk Anchoring

Anchor Type 1, Type 3, and Type 8 mulches with a disk anchoring tool as required by the contract immediately after placement unless otherwise approved by the Engineer.

Punch the mulch into the soil to a depth from 2 in [50 mm] to 3 in [75 mm]. Space the blades and discs on the anchoring tool no greater than 8 in [200 mm] apart. Use Hydraulic Erosion Control Products to anchor the mulch in lieu of disc anchoring, in areas inaccessible by disc equipment.

E Placing Hydraulic Erosion Control Products

Protect public and private investments and properties from overspray by suitable means and methods including appropriate shields, covers and avoidance measures. Accidental overspray must be cleaned up at the time of installation (occurrence). Perform separate from hydro-seeding.

E.1 Tackifiers

Use natural tackifiers alone, as an additive to other soil stabilizers, or as an overspray on mulched areas.

E.1.a Type Natural Tackifier

Use the manufacturer's recommended rate of application and mix ratios based on use, site conditions, and time of year. Allow from 9 to 12 hours of dry time before subject to rain. Uniformly distribute the tackifier over the target area.

E.1.b Type Synthetic Tackifier

Dilute synthetic tackifier at a rate of 10 parts water to 1 part polymer and apply to the soil at a rate of 1,200 gal per acre [220 kg per ha].

E.1.c Type Polyacrylamide (PAM)

Do not use polyacrylamide (PAM) on pure sand or gravel without fine silts or clays. Do not apply PAM over snow cover or to slopes that flow directly into a wetland or state waters. Apply PAM as recommended by the manufacturer.

Provide certification of the following:

(1) Percent of pure PAM present by weight,
(2) Percent activity,
(3) Average molecular weight, and
(4) Charge density of the PAM.

Provide a material safety data sheet for prepackaged PAM. The Contractor may include PAM as a part of a polymer stabilized fiber matrix. Apply PAM in its pure form on slopes and channels at a rate no greater than 200 lb per acre [224 kg per ha] and no later than 4 hours prior to rain.

E.2 Matrixes

E.2.a Type Compost

Apply hydraulic compost matrix with hydraulic spray equipment in a water-slurry mixture. The tank must have jet or mechanical agitation for mixing. The dry material targeted application rate is 3,000 lb per acre [3,363 kg per ha]. Use the water to bale ratio as recommended by the manufacturer

E.2.b Type Mulch

Apply hydraulic mulch with hydraulic spray equipment in a water-slurry mixture. The dry material targeted application rate is2500 lb per acre [2800 kg per ha]. Use the water to bale ratio as recommended by the manufacturer. Increase the application rate and percent tackifier to roughened soils for complete coverage. The Engineer may inspect the tank loading and spray application, to verify that the applied materials meet the manufacturer recommendations and the soil is 100 percent covered.

E.2.c Type Stabilized Fiber Matrix

Do not field mix additives or components for stabilized fiber matrix, as this mulch is a pre-manufactured matrix. Apply stabilized fiber matrix at the targeted dry weight rate of 3000 lb per acre [3363 kg per Ha] and no later than 48 hours prior to rain. Adjustments made in the field based on site characteristics, soil conditions, and manufacturer recommendations.

E.2.d Type Bonded Fiber Matrix (BFM)

Apply BFM with hydraulic spray equipment by a manufacturer's certified applicator. The Contractor may apply seed and BFM in a single operation in small or inaccessible areas as approved by the Engineer. Apply BFM at the targeted dry weight rate of 3500 lbs per acre [3923 kg per ha] . Adjustments are made in the field based on site characteristics, soil conditions, and manufacturer recommendations. Use the water to bale ratio recommended by the manufacturer. Apply the BFM from at least two opposing directions and obtain continuous ground coverage. Apply the BFM in two stages using one half of the material in each stage. Allow the first stage application to dewater before applying the second stage. Do not use BFM in water bearing soils or by itself in ditch bottoms carrying concentrated flows.

E.2.e Type Reinforced Fiber Matrix (RFM)

Apply FRM with hydraulic spray equipment by a manufacturer's certified applicator. Apply RFM at the targeted dry weight rate of 3,900 lb per acre [4372 kg/ha]. Adjustments made in the field based on site characteristics, soil conditions, and manufacturer recommendations. Use the water to bale ratio recommended by the manufacturer.

F Placing Sod

Before delivering sod to the work site, prepare the soil in accordance with 2574.3.A, "Soil Preparation, Construction Requirements, General," to avoid delays in placing the sod. Before placing the sod pre-wet the soil to a damp condition.

Use straw or hydro mulch to stabilize exposed areas until installation of sod is within the specified sodding dates.

Reseed or remulch damaged areas adjacent to the sod within 5 working days after completing the sod placement and rolling or tamping operations.

F.1 Slopes

Place sod strips starting at the bottom of the slope and progressing upward with long edges parallel to the contour. Stagger joints alternately without space between. Secure the sod to the slope with wire staples or another anchor system approved by the Engineer as per Table 3885-5 spaced no greater than 2 ft [0.61 m] apart. At the tops of slopes steeper than 1:4 (V:H), trench the sod 3 in [75 mm] into the topsoil.

Shingle sod on slopes 1:2 (V:H) and steeper and at culvert ends, overlap the upper piece by at least 3 in [75 mm]. Use wire staples to secure sod on the slope at 16 in [406 mm] intervals. Trench 3 in [75 mm] of sod into the topsoil on the uppermost strip of sod.

F.2 Ditches

In ditch bottoms and other areas with expected concentrated water flow(i.e. flumes), place the sod parallel to the direction of water flow in the main channel. Shingle sod overlapping the ends by at least 4 in [100 mm] and the edges by at least 3 inches [75 mm]. Trench 3 in [75 mm] of sod into the topsoil on the uppermost strip of sod on side-slopes steeper than 1:4 (V:H).

In ditch bottoms with high flow velocities, overlay shingled sod with jute, a biodegradable netting, or chain link fence. Use stakes or staples to secure the jute, netting, or fence to the sod. The jute, biodegradable netting, or the chain link fence will not require removal after maintenance period.

F.3 Winter Sodding

Perform dormant sodding, on slopes, in ditches, and at least 10 ft [3 m] from the shoulder between November 1 and soil freeze-up meeting the following conditions:

(1) The Engineer authorizes dormant sodding,
(2) Provide Soil Preparation for sod,
(3) Stake or staple the sod on slopes and in ditches,
(4) Water the sod to saturation immediately after placement, and
(5) Water the sod a second time unless the sod receives 1 in [25 mm] of rain or 6 inches [150 mm] of snow from 7 calendar days to 10 calendar days after placement.

Do not dormant sod in areas shown with Salt Tolerant Sod (3878) or within 10 ft [3 m] from the shoulder, including areas next to boulevards and areas receiving salt encrusted snow and ice from winter deicing operations. Temporary stabilize these areas with mulch or Erosion Control Blanket.

G Placing Rolled Erosion Control Products

G.1 Blank

G.2 Erosion Control Blankets

Place the blankets within 24 h after sowing of the seed on that area. Roll out or lay the blankets with netting on top. If using blankets with netting on two sides, place the side of the blanket with the majority of thread stitching on the bottom. Roll out blankets flat and parallel or perpendicular to the direction of water flow. Evenly spread the blankets without stretching, allowing the fibers to come in direct contact with the soil over the entire area. Shingle and overlap the edges parallel to water flow by at least 4 in [102 mm]. Shingle and overlap the edges perpendicular to water flow by at least 7 in [178 mm]. Staple overlaps on slopes at 1½ ft [0.5 m] intervals, see Table 3885-5.

At the tops of slopes and at the beginning of each blanket in ditch bottoms, bury the upgrade end of the blanket in a check slot 6 in [150 mm] deep. Insert the blanket end to the full depth of the check slot. Backfill and compact the check slot. For slopes longer than 100 ft [30 m], dig a second check slot perpendicular to the slope gradient one-third of the slope length measured from the bottom of the slope. Place the blanket to the full depth of the check slot. Backfill, and compact the check slot. Staple blankets with the number of staples in accordance with Table 2575-2 or in accordance with manufacturer recommendations:

Table 2575-2
Stapling of Blankets

Slope (V:H)	Minimum Number of Staples per 100 *sq. yd [84 sq. m]*
Flatter than 1:2	120 *[100]*
1:2 – 1:1	170 *[140]*
Channel or ditch applications	350 *[290]*

G.3 Placing Turf Reinforcement Mats

Shape and prepare the site by in accordance to 2574 Provide turf reinforcement mat meeting the requirements of the class as shown on the plans. Soil fill turf reinforcement mats.

Install the mat, half the seed, fertilizer, topsoil, and Category 3 erosion control blanket in one continuous operation. Roll out or lay the mat parallel to the direction of water flow. Evenly spread the mat without stretching, allowing the fibers to come in direct contact with the soil over the entire area. Bury and staple the beginning edge of each mat in a check slot 6 in [150 mm] wide by 6 in [150 mm] deep. Overlap adjacent strip edges by at least 4 in [102 mm]. Staple the mat at a uniform density of 3.5 staples per sq. yd [2.9 staples per sq. m].

Directly seed and fertilize with the amounts as shown on the plans. Soil fill with 3877, Sand Clay Loam Topsoil Borrow or as an alternative 3890.2.B, "Grade 2 Compost", to a depth from ½ in [12 mm] to 1 in [25 mm]. If equipment must operate on the mat use only rubber tired type. No tracked equipment or sharp turns are allowed on the mat. Smooth out soil to just expose the top netting of the matrix. Install Category 3 erosion control blanket in accordance with 2575.3.G.2, "Erosion Control Blankets" on top of the seeded topsoil.

G.4 Winter Blankets

Install 3885, erosion control blankets over frozen ground and use the appropriate anchors in as shown in Table 3885-5.

H Shoulder Mulch Overspray

Perform shoulder mulch overspray by spraying 3884, Tackifier over seeded and mulched areas on a strip 3 feet [0.9 m] wide immediately abutting a gravel or paved shoulder as shown on the plans. During placement, perform the following:

(1) Seed,
(2) Cultipack the seedbed,
(3) Place Type 1 mulch,
(4) Immediately disk anchor the mulch as required by the contract, and
(5) Uniformly overspray with Type natural Tackifier as a continuous operation.

Use a distributer spray bar to spray the 3884.2.A, "Tackifiers", at an application rate of 200 lbs per acre [225 kg/ha] that provides 90 percent ground coverage.

I Compost Blanket

Uniformly apply a 2 in [51 mm] deep layer of 3890.2.B, "Grade 2 Compost," as a compost blanket over the soil after preparing the soil in accordance with 2574. Distribute the compost by hand with a shovel, spreader unit, or pneumatic blower. Incorporate seed into the compost or broadcast the seed over the top after uniformly spreading the compost. When placing compost blanket adjacent other erosion control products or existing vegetation provide an overlap of at least 2 ft [60 cm]. When placing compost blanket on a 1:2 (V:H) slope, place and anchor open weave textile netting over the top.

J Weed Control

Control and prevent the spreading of state listed Prohibited Noxious Weed (PNW) and/ or invasive weeds as per contract or as directed by the Engineer. The current state listed PNW species is determined by the Minnesota Department of Agriculture. Identify, mark, map, and monitor weed infestation areas and apply treatments at the appropriate time in order to prevent seed production and spreading.

Minimize the spread of weed seed and other propagules from designated infested areas by minimizing disturbance and by cleaning vehicles and equipment. Cleaning shall remove soil and vegetation debris from vehicles and equipment before moving out of infested areas or moving into project limits. Stockpile of PNW infested soils shall be separate from non-infested stockpiles.

K Maintenance

K.1 Sod

Sod maintenance period is 30 calendar days. The maintenance period is suspended when soil temperature falls below 32 degrees Fahrenheit [0 degrees Centigrade] and resumes after snow melt and soil temperature is above 40 degrees Fahrenheit [4 degrees Centigrade]. Water within ½ hour after sod is laid on soil and provide 1 inch (2.5 cm) of water Supply water to sod daily for the first 10 calendar days to keep soil surface below sod moist. For the remainder of the 30 calendar days, water sod as needed to provide 1 inch (2.5 cm) per week. Apply water at a rate that prevents runoff to occur.

During the maintenance period, replace sod dried, dead, damaged, displaced, or weakened or sod infested with over 50 percent weeds. Maintain areas replaced with new sod for at least 20 calendar days after replacement.

After maintenance period has ended and as directed by the Engineer apply additional water to supplement rainfall not to exceed 1 inch (2.5 cm) per week until November 1.

K.2 Rolled Erosion Control Products

Maintain the erosion control blanket installation for 45 calendar days if required by the contract or if substituting erosion control blankets and seed for sod, as approved by the Engineer. Maintain turf reinforcement mats for 45 calendar days, if required

by the Contract. Water the blankets and mat systems immediately after placement at a rate of at least 3,000 gal per acre [28 cu. m per ha] and appropriately to establish vegetation. Control erosion and establish a permanent vegetative cover as approved by the Engineer until contract acceptance. Restore areas with seeding failure or erosion during the maintenance period at no additional cost to the Department.

K.3 Seed

Repair damage within the area caused by Contractor operations and within the Contractor's control at no expense to the Department. Reseed areas where the original seed has failed to grow, as directed by the Engineer.

K.4 Mulch

Remulch areas where the original mulch has eroded, washed away, or blown off, and reseed areas where the original seed has failed to grow, as directed by the Engineer. Use the seed mixture shown on the plans or other seed mixture approved by the Engineer to perform reseeding.

K.5 Mowing and Weed Spraying

Perform the work required to control the Department of Agriculture State listed Prohibited Noxious Weeds, either on the areas seeded or sodded under the Contract. The weed spray mixture to be furnished and used shall be as required for that weed control. The engineer shall approve all work and weed control material prior to the start of work. The equipment used shall not be so heavy that it causes soil slips or ruts on the slopes or in the ditches. Perform the work at such time and in such a manner that will avoid spray drift outside the areas designated for spraying

L Turf Establishment

Turf Establishment by a lump sum is for establishing permanent vegetation on small areas of 2 ½ acres [1 ha] or less per Contract. Such work shall include; soil bed preparation; fertilizer; sod or mulch, blanket, and seed.

Unless otherwise shown on the plans, establish vegetative cover by sodding or by seeding and mulching. Fertilize the areas with a Type 3, slow release fertilizer in accordance with 3881.2.B3 at a rate derived from a topsoil fertility test. If seeding, provide and place seed Mixture 25 141 as specified in 3876, "Seed", and provide 3882, Type 3 mulch with disc anchoring or Category 3 Erosion Control Blanket on slopes 1;3 and steeper. The Engineer will accept the area after the perennial seed germinates, vegetation is at least 6 inches in height, and cover is uniform. If the seeding fails to germinate, correct and reseed failed areas to establish turf. If using sod, place and maintain sod in accordance with 2575.3 F and K. The Engineer will accept sod in accordance with 2575.3N.

M Rapid Stabilization

Work consists of operations necessary to rapidly stabilize small contiguous exposed areas, each less than 2 acres, temporarily to prevent off site sedimentation in AES and near resource waters and keep in conformance to MPCA construction stormwater permits. Perform rapid stabilization at any time when work is stopped temporarily and there is a risk that sediment will enter the resource waters due to stormwater runoff. Provide the materials for the methods of rapid stabilization in accordance with Table 2575-3:

Table 2575-3
Rapid Stabilization

Method	Materials
1	Type 1 mulch placed at a rate of 2 ton per acre [4.5 tonne per ha] with disc anchoring.
2	Type 3 mulch placed at a rate of 1.5 ton per acre [3.4 tonne per ha]. 3884, Stabilized Fiber Matrix, placed at a rate of 750 lb/acre [835 kg/ha].
3	3884, Stabilized Fiber Matrix, placed at 330 lbs per 1000 gallons of slurry mixture [150 kg per 3.8 cubic meters of slurry mixture]. Seed mixture 22-111 placed at a rate of 10 lb per 1,000 gal [4.5 kg per 3.8 cu. m] of slurry mix. Type 3 Slow Release Fertilizer 10-10-10 placed at a rate of 50 lb per 1000 gal [22.7 kg per 3.8 cu. m] of slurry mix. Water placed at a rate of 875 gal per 1,000 gal [3.3 cu. m per 3.8 cu. m] of slurry mix. Apply mixture at a rate of 6 000 gal per acre [56 cu. m per ha].
4	Category 3 erosion control blanket. Seed mixture 22-111 placed at a rate of 2 lb per 100 sq yd [1.1 kg per 100 cu. m]. Type 3 Slow Release Fertilizer 10-10-10 placed at a rate of 8 lb per 100 sq yd [3.6 kg per 84 sq m].
5	Rip Rap Class II. Geotextile Type III.

M.1 Placement

M.1.a Method 1

Use Method 1 to place mulch on a coverage area from ½ acre to 2 acre [0.2 ha to 0.8 ha]. Loosen the soil surface before placement to allow anchoring the mulch. Place the mulch to obtain 90 percent ground coverage. Use blower equipment to

place mulch. In areas inaccessible to a blower, place mulch by hand. Immediately after placement, use a disc anchoring tool to anchor the mulch.

M.1.b Method 2

Use Method 2 to place mulch on a coverage area from ½ acre to 2 acre [0.2 ha to 0.8 ha]. Loosen the soil surface before placing the mulch. Place mulch to obtain 75 percent ground coverage. Use blower equipment to place mulch. In areas inaccessible to a blower, place mulch by hand. Immediately after placement, overspray the mulch with Type Hydraulic Mulch, at a rate of 750 lb per acre [840 kg per ha].

M.1.c Method 3

Use Method 3 to place slurry on a coverage area from ½ acre[0.2 ha] to 1.5 acres [0.6 ha]. Apply material in quantities to obtain 100 percent soil surface coverage. In inaccessible areas, the Contractor may pump the mix through a hose.

M.1.d Method 4

Use Method 4 to place fertilizer, seed, and erosion control blanket on a coverage area from 100 sq. yd [83.5 sq. m] to 800 sq. yd [668 sq. m]. Bury the upgrade end of each blanket strip at least 6 in [150 mm] in a vertical check slot. Place staples at seams and throughout the blanket spaced no greater than 2 ft [0.6 m] apart.

M.1.e Method 5

Use Method 5 to place class II riprap and geotextile to cover areas.

N Acceptance of Work

Notify the Engineer at least 24 h before beginning or changing turf establishment operations.

N.1 Seeding

The Engineer will accept permanent seeding in area increments after the placement of seed in accordance with the specifications2575.3B. For hydroseeding acceptance will be based on uniform soil coverage.

N.2 Mulching

Mulching will be accepted 2 calendar days after initial placement. Remulch areas where the mulch has blown off or washed away during the 2 calendar day period at no additional cost to the Department.

N.3 Sod

After expiration of the sod maintenance period, the Engineer will inspect the work and will accept living sod that is placed in accordance with 2575.3F.and when pulled does not lift from soil.

N.4 Erosion Control Blankets and Turf Reinforcement Mats

For contracts not requiring maintenance, the Engineer will accept blankets and mulch control netting and mats when installed in accordance to 2575.3

N.5 Hydraulic Erosion Control Products

The Engineer will accept hydraulic erosion control products providing 90 percent exposed soil coverage.. The Engineer will accept areas covered by BFM and Type RFM at100 percent exposed soil coverage.

O Restoration

After the Engineer accepts the turf establishment in an area, restore areas damaged by erosion and sedimentation beyond the Contractor's control as directed by the Engineer. Scarify, grade, shape, excavate, and till to restore eroded areas and clean up sedimentation as directed by the Engineer. Shape, fill, and compact depressions and washouts resulting from erosion with suitable topsoil borrow meeting 3877, "Topsoil Borrow," as approved by the Engineer. Remove deposited sedimentation as directed by the Engineer. Spread or dispose of sediment removed as approved by the Engineer.

Use seed, mulch, erosion blankets, and sod in the restoration as approved by the Engineer.

P Temporary Poly Coverings

Cover exposed soils with poly sheeting and secure it tightly in place using an anchoring system of sand bags, chain link fence, or other methods approved by the engineer. Trench the poly sheeting at the top of slope and secure adequately to maintain cover during reasonably expected conditions in the area. Provide a water diversion above the sheeting to direct water away from areas and prevent undermining. Provide toe protection to control drainage from areas covered by the sheeting so that the discharge does not cause erosion.

Q Workmanship Rework Schedule

Correct work, workmanship, and work processes not in compliance with the contract requirements in accordance with Table 2575-4, "Required Corrective Action" at no additional cost to the Department.

Table 2575-4 Required Corrective Action		
Item	**Corrective Action Required if:**	**Corrective action**
Seeding	Not uniformly placed	Re seed
	Not seeded with drill when required	
	Depth of seed incorrect	Reseed
	No cultipacking	Cultipack area
	Incorrect rate of seed application	Apply additional seed as necessary to achieve correct rate
	(Hydroseeding) Insufficient soil coverage	Reseed areas not covered properly
	Not mulched within 24 h	Reseed area
	Incorrect seed mixture	Reapply with correct mixture
Mulch material, hydraulic erosion control products	Incorrect rate of application	Remulch to provide proper coverage
	Not uniformly placed	Adjust placement of mulch to provide uniform placement
	Rutting on slopes from equipment	Fix ruts , remulch and reseed
Erosion control blankets and mats		
	Upgrade ends not embedded on slopes	Properly imbed blanket
	Improper overlaps and joints	Provide proper joints and overlaps
	Insufficient number of staples	Provide for the additional required staples
	Improper stapling pattern	Staple at proper patterns
	No embedment of joints in drainage ways	Embed joints properly
Turf establishment lump sum	Erosion not controlled	Fix erosion and reapply practices
	Insufficient established vegetative cover	Over seed area

2575.4 METHOD OF MEASUREMENT

A Seeding

Measure seeding by the area seeded, regardless of the seed mixture or quantity of seed used, and regardless of whether the seed was furnished by the Contractor or the Department. Areas reseeded by order of the Engineer, after the original seeding of the area was accepted, will be measured and added to the area originally seeded.

B Seed

The engineer will measure seed by the weight of pure live seed (PLS) by PLS mass of each mixture or species placed

C Mulch

The Engineer will measure mulch in accordance with the following:

(1) Type 1, Type 3, and Type 8 mulch by weight of each type provided and applied in accordance with 2575.3.C, "Applying Mulch,"
(2) Type 4 mulch by area covered with material provided and installed in accordance with 2575.3.C, "Applying Mulch,"
(3) Type 5 and Type 6 mulch material by volume (vehicular measure) of the material provided and installed in accordance with 2575.3.C, "Applying Mulch,"
(4) Type 9 (aggregate) mulch by volume, based on the area of aggregate provided and a placed in accordance with 2575.3.C, "Applying Mulch" to the thickness shown on the plans, and
(5) Additional mulch materials ordered and accepted by the Engineer in remulched areas.

D Water

Measure water used by volume for turf establishment of seeded or sodded areas when directed by the Engineer.

E Disk Anchoring

The Engineer will measure disk anchoring for Type 1, Type 3, and Type 8 mulch by the area of mulch disked in accordance with 2575.3.D, "Disk Anchoring."

F Sod

Measure sod by the surface area based at the time of installation. Include the overlapped portion of shingled sod in the measurement.

G Hydraulic Erosion Control Products

Measure Tackifiers by the area covered in accordance with 2575.3.E, "Hydraulic Erosion Control Products" . Measure all other hydraulic erosion control products by dry weight of each type. area covered

H Turf Establishment

Measure turf establishment by lump sum, no measurement will be made of any individual turf establishment item. Included are all materials and labor as necessary to accomplish the work regardless of quantities involved.

I Rolled Erosion Control Products

Measure separately blankets of each kind by the area covered. Overlapped portions in the area measured for erosion netting or blankets will not be included.

Measure Turf Reinforcement Mats by the area covered. Overlapped portions in the area measured will not be included. Measure separately the seed, fertilizer, topsoil, and erosion control blankets.

J Rapid Stabilization

The Engineer will measure Method 1 and Method 2 rapid stabilization are measured by the acre [hectare] acceptably installed. Minimum measure is ½ acre [0.2 ha] and in 1/6 acre [0.07 ha] increments per area measured.

The Engineer will measure Method 3 rapid stabilization will be measured by the metric gallons [cubic meter] of slurry furnished and acceptably placed. Minimum measure is ½ acre [0.2 ha] and in 1/6 acre [0.07 ha] increments per area measured.

The Engineer will measure Method 4 rapid stabilization will be measured by the square yard [square meter] of blanket acceptably installed. Minimum measure is 100 sq yd [83.5 sq m] and in 25 sq yd [20.9 sq m] increments per area measured.

The Engineer will measure Method 5 rapid stabilization will be measured by the ton [tonne] of rock provided and acceptably installed.

2575.5 BASIS OF PAYMENT

The contract unit prices for establishing turf and controlling erosion will include all labor, materials, equipment and other incidentals to compete the work as specified. .The contract unit price will include maintenance, replacement, and repair when required by contract.

For items of work not included in the schedule of Contract Pay Items, the Department will pay unit prices for the relevant items of work.

A Erosion Control Items

When the contract requires maintenance, the Department may pay for installation in a partial payment no greater than 50 percent of the contract unit price as approved by the Engineer. The will pay the remaining partial payment after final acceptance by the Engineer.

B Blank

C Seed

The Department will pay for seed by the PLS weight of each mixture or species measured.

D Hydroseeding

The Department will not pay for seed mixture or seed/fertilizer mixture that is unused and left in the hydroseeder for longer than 1 hour.

E Mulch

The contract unit price for *Mulch Material, Type 9* includes the cost of the plastic sheeting for the area covered. The contract unit price for mulch material type 4 includes Hydraulic Stabilized Fiber Matrix.

F Sod

The contact unit price for sod includes the shingle overlaps.

G Rapid Stabilization

The contract unit prices for rapid stabilization will include the cost of mobilization.

The contract acre [hectare] price of *Rapid Stabilization, Method 1 or Method 2* includes the cost of disc anchoring or hydraulic erosion control products.

The contract Mgallon [cubic meter] price for *Rapid Stabilization, Method 3* includes the cost of seed, fertilizer, and hydraulic erosion control products.

The contract square yard [square meter] price for *Rapid Stabilization, Method 4* includes the cost of seed and fertilizer.

The contract ton [metric ton] price for *Rapid Stabilization, Method 5* includes the cost of geotextile.

H Shoulder Mulch Overspray

The Department will pay for *Hydraulic Erosion Control Products, Type Tackifier* separately from Type 1 mulch and disk anchoring for Shoulder Mulch Overspray

I Compost Blanket

The contract unit price for compost blanket will include compost and all work to perform the task.

J Turf Establishment

The contract unit price includes all costs incurred to complete the work. The cost of restoring disturbed areas includes tilling, fertilizing, mulching, and establishment of vegetative cover.

K Mowing and Weed Control

Payment for mowing and weed spraying at the Contract prices per unit of measure will be compensation in full for all labor and equipment employed in the work, and for all materials used, except that separate payment will be made for the weed spray mixture furnished and applied in conjunction with the item of weed spraying.

L Payment Schedule

The Department will pay for establishing and maintaining turf and controlling erosion on the basis of the following schedule:

Item No.:	Item:	Unit:
2575.501	Seeding	acre [hectare]
2575.502	Seed, Mixture ___, or (Species)	pound [kilogram]
2575.505	Sod, Type ___	square yard [square meter]
2575.511	Mulch Material, Type ___	ton [metric ton]
2575.513	Mulch Material, Type ___	cubic yard [cubic meter]
2575.515	Mulch Material, Type 4	acre [hectare]
2575.518	Temporary Poly Covering	square yard [square meter]
2575.519	Disk Anchoring	acre [hectare]
2575.523	Erosion Control Blanket, Category ___*	square yard [square meter]
2575.525	Turf Reinforcement Mat, Category ___	square yard [square meter]
2575.526	Compost Blanket	square yard [square meter]
2575.527	Shoulder Mulch Overspray	pound [kilogram]
2575.535	Water	M gallons [cubic meter]
2575.541	Mowing	acre [hectare]
2575.545	Weed Spraying	acre [hectare]
2575.547	Weed Spray Mixture	gallon [liter]
2575.555	Turf Establishment	lump sum
2575.560	Hydraulic ___ Tackifier	pound [kilogram]
2575.560	Hydraulic ___ Matrix	pound [kilogram]
2575.561	Hydraulic ___ Tackifier	square yard [square meter]
2575.561	Hydraulic ___ Matrix	square yard [square meter]
2575.570	Rapid Stabilization Method 1	acre [hectare]
2575.570	Rapid Stabilization Method 2	acre [hectare]
2575.571	Rapid Stabilization Method 3	M gallons [cubic meter]
2575.572	Rapid Stabilization Method 4	square yard [square meter]
2575.573	Rapid Stabilization Method 5	ton [metric ton]

* If maintenance applies, the Department will place the subnote, "Includes Maintenance" on the pay item shown in the summary of quantities on the plans.

2577 SOIL BIOENGINEERED SYSTEMS

2577.1 DESCRIPTION

This work consists of installing vegetation with geosynthetic or natural materials to stabilize areas susceptible to erosion. The Contractor may use soil bioengineering as a permanent soil stabilization system in ditches, along stream banks, on shorelines, or on slopes. This work also consists of providing and installing a composite system on the project.

2577.2 MATERIALS

A Seed, mix as specified 3876

B Mulch, Type as specified.....3882

C Rolled Erosion Control products 3885

D (Blank)

E. Nursery plant stock 3861

F. Sediment Control Logs 3895

G. Riprap 3601

H. Concrete Armor Units 3608

2577.3 CONSTRUCTION REQUIREMENTS

A General

The installation locations and layouts shown on the plans are approximate. The Engineer will determine the exact locations and layouts of bioengineered systems.

Provide a qualified nurseryman, landscape specialist, or experienced crews working under the direct supervision of a qualified nurseryman or landscape specialist to harvest and install plant material.

Do not begin planting operations or deliver planting stock to the project until the Engineer determines that weather and soil conditions are suitable for planting and preparations for planting are complete.

During placement, install components until complete. Prevent overnight drying out of plant stock by storing in water. On slopes, begin installing material at the bottom of slope and proceed in horizontal layers upward. On shorelines and banks, begin installing material below the water line and proceed up the bank.

During the work, prevent siltation and turbidity of flowing or impounded waters of the State. If working in water, protect the work site with curtains, barriers, or other containment devices to prevent sediment and debris from entering the receiving water body.

B Harvesting Plant Stock

Obtain plant stock and cuttings from the regions, zones, or both shown on the plans.

At least three days before harvesting planting stock for the project, notify the Engineer of the harvest date to allow for inspection.

C Season of Placement

Refer to Table 2577-1 for the dates for seasonal placement. The Engineer may adjust a date specified in Table 2577-1 by no more than 20 calendar days, based on the prevailing weather conditions.

Provide plant material in a dormant stage; before buds burst open in the spring or after leaves change color and drop in the fall.

Table 2577-1
Approximate Season of Placement

System	Spring	Fall
Wattling	Before April 15	After Nov 1
Brush Layering	Before April 15	After Nov 1
Live Stake	Before April 15	After Nov 1
Root-Rap	April 15 – June 10	July 20 – Sept 20

D Wattling

Dig trenches along the contours of the slope, place bundles of dormant plant cuttings into the trenches, and tamp loose soil over the bundles. Before trenching, drive wooden stakes 16 in [0.4 m] on center along each trench location. Provide stakes with a diameter of 2 in [50 mm] and a length of 2 ft [½ m]. Drive the stakes to a firm hold with the tops 6 in [150 mm] above grade.

Dig trenches no more than 1 h before installing plant materials to minimize drying of soils. Leave the overall soil surface in a rough condition with clods, and ridges for maximum resistance to erosion. Immediately following trenching, place bundles of dormant plant cuttings into the trench. Lay cuttings in bundles together with the butt ends located at alternate ends of the bundle and tightly tied with binder twine at least three points along the bundle. Provide bundles consisting of dormant woody cuttings from ⅜ in to 2 in [9.5 mm to 50 mm] in diameter and from 3 ft to 8 ft [1 m to 2.4 m] long. Provide bundles from 6 in to 8 in [150 mm to 200 mm] in diameter. Overlap wattle ends in the trench. Drive additional stakes through bundles at a spacing no

greater than 2 ft [0.5 m] on center. During placement of the bundles, cover the bundles with loose soil, working it into the wattles leaving a uniform fringe of plant material, exposed to a height from 2 in to 3 in [50 mm to 80 mm].

E Brush Layering

Make trenches along the contour of the slope and embed dormant green plant cuttings into the slots and tamp loose soil over the cuttings. Make trenches 2 ft [0.61 m] deep, angled downward into the slope. Provide plant cuttings consisting of stems 3 ft [1 m] long, and from ½ in to 2 in [10 mm to 50 mm] in diameter. Transport cuttings in containers of water and keep cuttings in the containers until installation. As soon as possible after making the trenches, place the plant cuttings into the trenches with the butt end placed into the trench and at least 6 in [150 mm] of the cuttings protruding out of the trench. Place the stems randomly with some crisscrossing. While placing plant cuttings, immediately backfill the trench cuttings with soil and firm the backfill to meet the Engineer's approval.

F Live Stakes

Insert dormant live cuttings into the soil and tamp soil lightly around the cutting. Provide cuttings consisting of stems at least 3 ft [1 m] long and from 1 in to 2 in [25 mm to 50 mm] in diameter. Transport cut material in containers of water and keep material in water until installation. Insert the bottom end of the cuttings so the bottom-end is at right angles to the slope face for at least two-thirds to three-quarters of the cutting length and tamp. Do not split the ends or damage the bark of the cuttings. Place cuttings 2 ft [0.67 m] on center, using a triangular spacing. Place cuttings at a density of two to four stakes per square yard [square meter].

If rip rap is less than 2 ft [0.67 m] thick, stake the riprap (joint planting). Make a pilot hole by driving a tool, such as a pry bar or rebar, through the rip rap and filter layer, to reach the ground soil. Use a dead blow hammer to tamp the cuttings and avoid damaging the bark. Place the cuttings in a random configuration 2 ft [0.67 m] on center.

G Placing Coir log

Place biodegradable coir log for stabilizing shorelines. Before installing the coir log, drive wooden stakes with a diameter of 2 in [50 mm] and a length of 3 ft [1 m], 1 ft [0.3 m] on center along the planned alignment of the coir log. Ensure the stakes extend from 8 in to 10 in [200 mm to 250 mm] above the elevation of the water surface shown on the plans. After placing the stakes, install the coir log so the upper surface of the coir log is parallel to the water surface and 2 in [50 mm] protrude above the normal water level. Lace coir logs together end to end with woven nylon twine, ⅛ in [3 mm] in diameter to create a continuous length. Bury both ends of the coir rolls 5 ft [1½ m] laterally into the bank.

H Root-Rap

Place a gravel channel lining or riprap, and overseed or plant the completed channel in accordance with the details, typical sections, and elevation controls as shown on the plans. The Engineer will stake the actual alignment. During the work, continuously place the granular channel lining or riprap and shape the channel. Begin seeding or planting within 48 h of shaping the channel.

I Concrete Armor Units

Prepare grade to place Type IV geotextile in accordance with 3733, "Geotextiles." Place the geotextile so that it is completely in contact with the ground surface and is free of folds and wrinkles. Overlap adjacent strips of geotextiles by 3 ft [1 m] with the upstream strip overlapping the downstream strip. Place concrete armor units so not to tear the geotextile tightly interlocked matrix. Begin placement of the system at the toe termination trench and proceed up the slope.

J (Blank)

K Acceptance of Work

Upon satisfactory installation of the bioengineered systems, the Engineer will authorize partial payment not to exceed 80 percent of the contract unit prices. The remaining percentage shall not become due and payable until after the 30-day maintenance period.

2577.4 METHOD OF MEASUREMENT

A Wattling

The Engineer will measure wattling by the linear foot [meter] of each trench made and planted. If several trenches are made and planted, the Engineer will add each length of trench planted and accepted to the total.

B Brush layering

The Engineer will measure brush layering by the linear foot [meter] of each horizontal trench made and planted. If several trenches are made and planted, the Engineer will add each length of trench planted and accepted to the total.

C Coir log

The Engineer will measure coir log by the linear foot [meter] provided and installed including buried portions.

D Granular channel liner

The Engineer will measure granular channel liner by volume in cubic yard [cubic meter] placed in the final configuration.

E Concrete Armor Units

The Engineer will measure concrete armor units by surface area covered by each size provided, installed, and accepted by the Engineer, including the buried portions, using the outermost extremity of the units as required by the contract. On small projects, the Engineer will accept concrete armor units by the number of complete units assembled and installed as required by the contract.

2577.5 BASIS OF PAYMENT

If the contract does not include pay items for bioengineered systems, the Department will pay for bioengineered system items as extra work in accordance with 1402, "Contract Revisions."

A Wattles

The costs of plant cuttings, bundles, and stakes and rope to fasten logs are included in the contract unit price for wattling.

B Brush Layering

The costs of plant cuttings and stakes and rope to fasten logs are included in the contract unit price for brush layering.

C Coir Logs

The costs of stakes and rope to fasten logs are included in the contract unit price for coir logs.

D Pay Items

The Department will pay for bioengineered system items on the basis of the following schedule:

Item No:	Item:	Unit:
2577.501	Wattling	linear feet [meter]
2577.502	Brush Layering	linear feet [meter]
2577.504	Granular Channel Liner	cubic yard [cubic meter]
2577.505	Live Stakes	each
2577.506	Concrete Armor Units ____ (size)	each
2577.507	Concrete Armor Units ____ (size)	square yard [square meter]

2581 REMOVABLE PREFORMED PAVEMENT MARKING TAPE

2581.1 DESCRIPTION

This work consists of providing, placing, and removing temporary pavement marking material on pavement open to traffic and without permanent traffic markings.

2581.2 MATERIALS

Provide removable preformed pavement marking tape for traffic lane delineation and legends in accordance with 3355, "Removable Preformed Pavement Marking Tape for Traffic Lane Delineation and Legends."

2581.3 CONSTRUCTION REQUIREMENTS

Provide and place removable preformed pavement marking tape as shown on the plans or as directed by the Engineer immediately before modifying traffic flow. Place the marking tape on a clean and dry surface in accordance with the manufacturer's recommendations.

Removed marking material shall become property of the Contractor. Dispose of the removed marking material off the right-of-way in accordance with 1701, "Laws to be Observed."

The Department will base acceptance of pavement marking materials on the certification and quality control testing verified by the Materials Laboratory testing of verification samples and spot checks on samples obtained from contractor stock or from the project site in accordance with the Pavement Marking Qualification and Acceptance Program.

2581.4 METHOD OF MEASUREMENT

The Engineer will measure removable preformed pavement marking tape by the actual length of pavement marking provided, placed, and removed as required by the contract.

The Engineer will base the measurement of removable preformed pavement marking tape on equivalent lengths of 4 in [100 mm] wide marking, regardless of the color or type. The Engineer will adjust the measured length of removable preformed pavement marking tape with a width differing from the 4 in [100 mm] width by the ratio of the actual tape width to the 4 in [100 mm] width. The Engineer will measure broken or dotted line markings by the actual length of material placed. The Engineer will not measure gaps between the broken or dotted lines.

2581.5 BASIS OF PAYMENT

The contract linear foot [meter] price for *Removable Preformed Pavement Marking Tape* includes the cost of providing, placing, maintaining, replacing, removing, and disposing of the marking tape.

The Department will pay for removable preformed pavement marking tape on the basis of the following schedule:

Item No.:	Item:	Unit:
2581.501	Removable Preformed Pavement Marking Tape	linear foot [meter]

2582 PAVEMENT MARKINGS

2582.1 DESCRIPTION

This work consists of providing permanent and temporary pavement markings for roadways, including pavement messages, linear pavement markings, and crosswalks.

The Department defines pavement messages as word and symbol pavement markings installed in the roadway, including word and symbol messages that are not line segments or crosswalks.

The Department defines linear pavement markings as line segments of various widths installed in the roadway, including lane lines, center lines, no passing zone lines, edge lines, airplane markings, and stop lines. The Department does not consider crosswalks or pavement messages as linear pavement markings.

The Department defines crosswalks as blocks installed in the roadway parallel to the direction of travel in a pattern that is transverse to the direction of travel.

2582.2 MATERIALS

A Preformed Pavement Marking Tape for Permanent Traffic Lane Delineation and Legends (PREF TAPE).....3354

B Preformed Thermoplastic (PREF THERMO).....3356

C Epoxy Resin Pavement Markings (EPOXY).....3590

D High Solids Water-Based Traffic Paint (PAINT).....3591

E Drop-On Glass Beads.....3592

Provide and use pavement marking materials listed on the Approved/Qualified Products List. For Wet Reflective/Recoverable (WR) materials, use the Wet Reflective/Recoverable Marking Materials Approved/Qualified Products List.

Do not change the following unless approved by the Department:

(1) Product identification,
(2) Chemical composition as indicated by infrared spectrophotometry or chemical analysis, or
(3) Application requirements.

Submit proposed changes to the Materials Laboratory for further evaluation.

2582.3 CONSTRUCTION REQUIREMENTS

A Certification of Materials

The Department will base acceptance of pavement marking materials under the Pavement Marking Qualification and Acceptance Program on the product certification and quality control testing verified by Materials Laboratory testing of verification samples and spot checks on samples obtained from contractor stock or from project sites.

B Application

Apply on a clean, dry pavement surface, free of dirt and foreign matter, and as required by the contract. Apply all surface treatments prior to pavement marking installation.

B.1 Manufacturer's Specifications

Apply the pavement marking as recommended by the material manufacturer in regards to pavement type, environmental conditions, placement within a rumble, and other relevant factors in order to meet the requirements detailed in 2582.3.C "Acceptance".

B.2 Concrete Surface Preparation

Before applying EPOXY or PAINT markings, sandblast new portland cement concrete surfaces to remove surface treatments or laitance unless the marking is recessed per 2582.B.6.

B.3 Thickness Requirements

For EPOXY markings, apply the epoxy pavement resin with a wet-film thickness of at least 20 mil. Apply at a greater wet-film thickness as recommended by the material manufacturer based on pavement type, environmental conditions, placement within a rumble, and other relevant factors.

B.4 Manufacturer Installation Certification

For PREF TAPE or PREF THERMO, obtain manufacturer certification for installation. Certification is typically achieved by attending an application training seminar. The training shall address surface preparation and all application requirements and techniques necessary for successful marking tape applications. Upon completion of the seminar for these personnel, the manufacturer of the PREF TAPE or PREF THERMO shall provide written certification of approval to each person approved. Present a valid training certification card upon request of the Engineer or other state project personnel.

B.5 Assembly of Preformed Markings

For PREF TAPE or PREF THERMO Pavement Messages and Crosswalks, utilize precut messages, symbols and blocks meeting the requirements of the Minnesota Manual on Uniform Traffic Control Devices and the MnDOT Standards Signs Manual. Kits provided by the manufacturer are acceptable. Do not use line material to piece together individual letters, symbols or crosswalk blocks unless manufacturer specifications allow. Two strips of 18″ [455 mm] line material may be used to form crosswalk blocks of 36″ [910 mm] width.

Do not use narrower line material to piece together wider lines.

For PREF THERMO, taper the external edge of the marking to minimize risk of plow damage.

B.6 Recessing

Inlay PREF TAPE on bituminous pavements as recommended by the material manufacturer. Utilize a compaction roller lengthwise in the direction the PREF TAPE was laid with minimum speed and water and no vibration. Inlay when the mat temperature is between 150 degrees Fahrenheit and 120 degrees Fahrenheit. Verify the mat temperature with a thermometer. Do not use primers with inlay application. Do not install linear pavement markings on a bituminous seam. If markings cannot be inlaid in the bituminous, recess the markings utilizing the procedures for Ground In (GR IN) pavement markings.

For Ground In (GR IN) pavement markings, recess the pavement marking utilizing the following equipment and details:
Recessing Equipment

For PREF TAPE or PREF THERMO, the recessing shall be performed by a self-propelled machine equipped with gang stacked diamond cutting blades mounted on a floating head with controls capable of providing uniform depth and alignment. The cutting heads shall consist of stacked 1/8 inch to 3/8 inch [3 mm to 9 mm] wide diamond tipped cutting blades. The spacers between each blade must be such that the raise in the bottom of the finished recess between the blades is less than 25% of the recessed depth. The resulting bottom of the recess shall have a fine corduroy finish. If a coarse tooth pattern is present, increase the number of blades and/or decrease the thickness of the spacers on the cutting head.

For all other materials, the recessing shall be performed by either:

a self-propelled machine equipped with gang stacked diamond cutting blades mounted on a floating head with controls capable of providing uniform depth and alignment. The cutting heads shall consist of stacked 1/8 inch to 3/8 inch [3 mm to 9 mm] wide diamond tipped cutting blades. The spacers between each blade must be such that the raise in the bottom of the finished recess between the blades is less than 25% of the recessed depth. The resulting bottom of the recess shall have a fine corduroy finish. If a coarse tooth pattern is present, increase the number of blades and/or decrease the thickness of the spacers on the cutting head.

Or

a self-propelled machine equipped with carbide cutting blades with controls capable of providing uniform depth and alignment.

The equipment shall be capable of recessing the total width of the recess in one pass or be capable of recessing uniform depths with multiple passes. The maximum number of passes is detailed below. If multiple passes are used, the ridge between passes shall be mechanically removed prior to recess cleaning and pavement marking application.

The equipment shall be capable of recessing double lines simultaneously or parallel lines to a uniform depth with two passes.

The equipment shall be self-vacuuming and leave the cut recess ready for pavement marking installation. Dry cut recessing without a vacuum will only be allowed if markings run perpendicular to the roadway, such as Stop Bars. Use the equipment and method approved by the pavement marking manufacturer.

Recessing Details

The recessing shall be performed within the following tolerances. Failure to meet these tolerances will result in the suspension of work until the Contractor can demonstrate that these tolerances can be met to the satisfaction of the Engineer. The pavement marking system shall be applied so that it is centered within the recess.

RECESS WIDTH AND MAXIMUM NUMBER OF PASSES		
MARKING WIDTH	RECESS WIDTH	MAX NUMBER OF PASSES
4 inches [100 mm]	5" ± 1/8" [130 ± 3 mm]	1
6 inches [150 mm]	7" ± 1/8" [180 ± 3 mm]	1
8 inches [200 mm]	9" ± 1/8" [230 ± 3 mm]	1
12 inches [300 mm]	13" ± 1/8" [330 ± 3 mm]	2
24 inches [600 mm]	25" ± 1/8" [635 ± 3 mm]	3

FULL DEPTH RECESS LENGTHS	
Full Depth Recess Length (Broken Line)	10 feet ± 3 inches [3 m ± 75 mm]
Space Between Double Lines	4 inches ± 1/4 inch [100 mm ± 3 mm]

For PREF TAPE GR IN or PREF THERMO GR IN, provide a recess depth of 110 mil ± 10 mil.
For EPOXY GR IN or PAINT GR IN pavement markings, provide a recess depth of 40 mil ± 10 mil.
For EPOXY GR IN (WR) or PAINT GR IN (WR), provide a recess depth of 70 mil ± 10 mil.

Since pavements are irregular, the depth of recess across the width may vary. To compensate for this, the depth of the recess shall be measured from the bottom of the recess to a straight edge extended over the recess from the pavement surface opposite the pavement joint.

Place the recess 2 in ± 1 [50 mm ± 25 mm] in from the edge of joints or seams along edge or centerline, unless otherwise indicated in the Plan.

Recess alignment deviations from the control guide or existing lines specified by the Engineer shall not exceed 2 inches [50 mm].

Clean the recess completely prior to pavement marking application, using an air compressor with at least 185 CFM air flow and 120 PSI air pressure. The compressor must be equipped with a moisture and oil trap, and cannot have more than 50 feet of ¾ inch ID hose between the compressor and the air nozzle. The air nozzle must have an inside diameter of ½ inch or greater.

Place all pavement markings to be recessed in accordance with pavement marking or element manufacturer's instructions, except for recess depth. Do not construct a recess in new bituminous pavement within a minimum 10 days of the placement of the final course of pavement, unless otherwise directed by the Engineer.

Recessing operations are incidental to the pavement marking unit price.

If the pavement markings are to be installed in the same location where there are existing pavement markings, including interim or temporary, the removal of the existing pavement markings shall be incidental. The Contractor may cut the recess and remove the existing marking in a simultaneous operation.

B.7 Glass Beads

For PAINT linear markings, apply glass beads specified in 3592 "Drop-On Glass Beads" immediately after applying a PAINT line at a rate of at least 8 lb per gal. Apply beads at a greater rate if recommended by the manufacturer to achieve the minimum levels of retroreflectivity in accordance with Table 2582-1.

For EPOXY linear markings, apply glass beads specified in 3592 "Drop-On Glass Beads" at a rate of at least 25 lb per gal. Apply beads at a greater rate if recommended by the material manufacturer to meet the required minimum levels of retroreflectivity in accordance with Table 2582-1.

Evenly distribute glass beads on pavement markings.

C Acceptance

Pavement markings in Minnesota shall meet or exceed the standards defined in the MN MUTCD.

C.1 Alignment

Provide linear pavement marking in the width specified in the contract, varying by no greater than +¼ in per 10 ft [+6 mm per 3 m]. Provide broken line segments with lengths varying by no greater than 3 in [75 mm]. Provide alignment deviating from the control guide or existing lines specified by the Engineer by no greater than 2 in [50 mm]. Ensure the transverse position of linear markings varies by no greater than 1 in per 10 ft [25 mm per 3 m]. Do not apply pavement marking material over a longitudinal joint.

C.2 Color

Provide pavement markings in the color specified in 2582.2, "Materials," for the respective material.

C.3 Retroreflectivity

Initial pavement marking retroreflectivity is defined as the pavement marking retroreflectivity as measured between 14 days and 44 days after pavement marking installation. Provide pavement markings meeting the following minimum initial pavement marking retroreflectivity when tested using 30 m geometry in accordance with ASTM E 1710:

Table 2582-1
Minimum Initial Pavement Marking Retroreflectivity

	White	Yellow
PREF TAPE	600 mcd/sq. m/lux	500 mcd/sq. m/lux
PREF THERMO	400 mcd/sq. m/lux	250 mcd/sq. m/lux
PREF THERMO, ESR (Enhanced Skid Resistance)	250 mcd/sq. m/lux	150 mcd/sq. m/lux
EPOXY	300 mcd/sq. m/lux	200 mcd/sq. m/lux
PAINT	275 mcd/sq. m/lux	180 mcd/sq. m/lux

Remove and replace, or repair, pavement markings not meeting the minimum initial pavement marking retroreflectivity values in accordance with Table 2582-1, as approved by the Engineer at no additional cost the Department.

If the retroreflectivity deficiency is no greater than 20 percent per tenth mile segment, the Engineer may accept the work at a unit price reduced by the percent of retroreflectivity deficiency.

D Pavement Marking Warranty

For permanent pavement markings, transfer pavement marking warranties to the Department or other appropriate road authority after construction.

E Correction of Defects

Remove and replace, or repair, pavement markings not meeting the contract requirements as approved by the Engineer at no additional cost to the Department.

F Pavement Marking Installation Record

For permanent pavement markings, provide a record of the pavement marking installation. The Department will not pay for pavement markings unless the Contractor has submitted the installation record.

F.1 Striper Computerized Data Logging System for Liquid Markings (DLS)

For projects with a liquid pavement marking material (such as PAINT or EPOXY) and is at least 1 centerline mile in length, utilize a Striper Computerized Data Logging System for Liquid Markings. The pavement marking device shall have an onboard monitoring system for the purpose of managing the amount of striping materials being applied to the pavement surface. Collect data for any pavement marking application of 300 feet (drive length) or greater.

The following data shall be included in the documentation from the DLS:

1. State Project Number;
2. For every highway marked, the highway number with the beginning and ending reference points rounded to the nearest thousandths of a mile and the beginning and ending coordinates determined by a Global Positioning System receiver with 3 meter accuracy, including the direction of travel in terms of increasing or decreasing reference points;
3. Date, and beginning and ending time of application;
4. Vendor and product (binder and reflective material);
5. Lot number(s) of product used;
6. Striping contractor (striper code);
7. Designation of the marking being applied (LEL – Left Edgeline, REL – Right Edgeline, CL - Centerline, LL – Lane Line Broken or Dotted, 1LL – left most LL in multilane, 2LL – second to left most LL in multilane, etc);

8. Width of marking being applied;
9. Presence of groove or rumble strip (if pavement marking is being installed on top of, begin and end points of groove or rumble will be recorded by GPS);

The following data shall be reported as an average for each drive mile (or other Engineer approved segment) installed:
1. Application vehicle speed to the nearest 0.1 MPH;
2. Weight (LBS) and/or volume (GAL as measured through a positive displacement pump mechanism or flow meter) of liquid material(s) used by color;
3. Weight (LBS) of reflective material used;
4. Ratio of reflective material used (weight) per liquid material used (volume) reported as LBS/GAL;
5. Ambient air temperature (in degrees Fahrenheit);
6. Road surface temperature (in degrees Fahrenheit);
7. Humidity (%);
8. The system shall record the average material application rates and film thickness calculated over the section striped.

This system shall be capable of storing data and exporting to the Department's Pavement Marking Management Tool (PMMT). Submit the data to the email address: PMdata.dot@state.mn.us. The format of the required data file can be found at the following website: http://www.dot.state.mn.us/trafficeng/pavement/manual.html under the heading - Pavement Marking Management Tool. Provide a printed record of the data to the Engineer at the Engineer's discretion. The printed and electronic records shall be produced in their final form prior to the records being removed from the pavement marking equipment.

Provide to the Engineer the above records for all linear non-handwork lines installed.

The DLS equipment shall be operational, calibrated and in use during pavement marking operations. Pavement marking installation without the use of a DLS shall constitute unauthorized work under 1512.

Upon request, provide to the Engineer the DLS manufacturer's recommendations for equipment calibration frequency and provide certification that the equipment meets manufacturer's recommended calibration.

Verify that the physical and electronic measurement of distance travelled is consistent by travelling a 100 foot [30 m] distance prior to the start of pavement marking operations.

The Striper Computerized Data Logging System shall be incidental.

F.2 Construction Striper Operations Daily Log For projects with a liquid pavement marking material (such as PAINT or EPOXY) and is less than 1 centerline mile in length, utilize either a DLS from 2582.F.1 "Striper Computerized Data Logging System for Liquid Markings (DLS)" or complete the "Construction Striper Operations Daily Log" form after applying the pavement markings. This form can be found at the website http://www.dot.state.mn.us/products/pavementmarkings/pdf/construction-striper-operations-daily-log.pdf.

For non-liquid linear pavement markings (such as PREF TAPE), Pavement Messages of any material, and Crosswalks of any material, complete the "Construction Striper Operations Daily Log" form after applying the pavement markings. This form can be found at the website http://www.dot.state.mn.us/products/pavementmarkings/pdf/construction-striper-operations-daily-log.pdf.

The Construction Striper Operations Daily Log shall be incidental.

2582.4 METHOD OF MEASUREMENT

A Pavement Messages

The Engineer will measure pavement messages by the area in square feet [square meter] of material installed as required by the contract.

B Lines

The Engineer will measure pavement marking lines by the length in feet [meter] of each type constructed in place as required by the contract. The Engineer will measure broken and dotted lines by the actual length of line marked. The Engineer will not include the gaps between the broken and dotted lines in the measurement.

C Crosswalks

The Engineer will measure crosswalk blocks by type and by the area in square feet [square meter] of material installed as required by the contract.

2582.5 BASIS OF PAYMENT

The contract unit price for pavement markings includes the costs of materials, installation, traffic control, surface preparation, and primers as required by the contract.

The Department will pay for pavement markings on the basis of the following schedule:

Item No.:	Item:	Unit:
2582.501	Pavement Message * † ‡ β	square foot [square meter]
2582.502	___in [__ mm] ‖ * † ‡ β	linear foot [meter]
2582.503	Crosswalk * † ‡ β	square foot [square meter]

‖ Specified type of line
* Specified material
† Specified if markings are Ground In
‡ Specified if markings are WR
β Specified if markings are Contrast

DIVISION III

MATERIALS

Cementing Materials

3101 PORTLAND CEMENT

3101.1 SCOPE
Provide portland cement material for use in concrete applications.

3101.2 REQUIREMENTS
Supply portland cement from the certified source listed on the Approved/Qualified Products List, meeting the requirements of AASHTO M 85.

Include the following standardized cement certification statement with delivery invoices: "(insert company name) certifies that the cement produced at (insert plant and location) conforms to AASHTO M 85 and MnDOT Specification 3101 for Type (insert type) cement."

Do not change the source or color, or both, of cement on a project without the written approval of the Engineer.

3101.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control. Measure fineness in accordance with the air permeability test in AASHTO M 85.

3102 SLAG CEMENT

3102.1 SCOPE
Provide slag cement or "slag" material for use in concrete applications.

3102.2 REQUIREMENTS
Provide slag from the certified source listed on the Approved/Qualified Products List, meeting the requirements of AASHTO M 302, and the following modifications:

(1) Provide Grade 100 or Grade 120 slag classifications, and
(2) Include the following standardized slag certification statement with delivery invoices: "(insert company name) certifies that the slag produced at (insert plant and location) conforms to AASHTO M 302 and MnDOT Specification 3102 for grade (insert grade) slag."

Do not change the source or color, or both, of slag on a project without the written approval of the Engineer.

3102.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control.

3103 BLENDED HYDRAULIC CEMENT

3103.1 SCOPE
Provide blended hydraulic cement material for use in concrete applications.

3103.2 REQUIREMENTS
Provide blended hydraulic cement from the certified source listed on the Approved/Qualified Products List, meeting the requirements of AASHTO M 240, Type IS or Type IP, or Type IL and the following modifications:

(1) Fly ash constituent of the blended cement no greater than 25 percent,
(2) Slag constituent of blended cement no greater than 35 percent,
(3) Silica fume constituent of blended cement no greater than 7 percent, and
(4) Include the following standardized cement certification statement with delivery invoices: "(insert company name) certifies that the cement produced at (insert plant and location) conforms to AASHTO M 240 and MnDOT Specification 3103 for type (insert type) cement."

Do not change the source or color, or both, of blended cement on a project without the written approval of the Engineer.

3103.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control.

3105 BAGGED PORTLAND CEMENT CONCRETE PATCHING MIX GRADE 3U18 AND 3U18M

3105.1 SCOPE
Provide dry, bagged concrete patching mix Grade 3U18 and 3U18M for repairing portland cement concrete pavement.

3105.2 REQUIREMENTS
A Materials
Provide materials for patching mix meeting the following requirements:

A.1 Cement 3101

A.2 Fine Aggregate 3126

A.3 Coarse Aggregate 3137

A.4 Blank

A.5 Admixtures 3113

B Quality Control (QC) Program
Prior to producing concrete patching mix each construction season, a Department Representative shall perform a thorough on-site inspection of the plant with a MnDOT Certified Plant Level 1 or Level 2 Technician representing the Producer.

Maintain an approved Quality Control Program, including a Quality Plan, for the production of Bagged Portland Cement Concrete Patching Mix.

The Producer will perform Quality Control (QC) as part of the production of Grade 3U18 concrete.
The Engineer will perform Quality Assurance (QA) as part of the acceptance process.

B.1 Quality Plan Requirements
Submit a quality control plan to the Concrete Engineer for review and approval prior to producing Grade 3U18 and Grade 3U18M. The Quality Plan includes the following QC Procedures:
(a) Moisture Content
(b) Batch Weight Verification
(c) Aggregate Gradation Testing
(d) Documentation and Submittals

B.2 Personnel
Provide a MnDOT Aggregate Production Technician to perform moisture content and aggregate gradation testing. Provide a MnDOT Concrete Plant Level 1 or Plant Level 2 Technician to review batch tickets, test results, and oversee all quality control requirements of 3105 and the QC Program.

B.3 Daily Production Requirements
Perform moisture content and gradation testing on all aggregates each day Grade 3U18 or 3U18M is produced. Complete MnDOT's *3U18 Quality Control Worksheet* and sign. Reviewed and signed by MnDOT Certified Concrete Plant Level 1 or Plant Level 2 Technician.

Electronically submit all *3U18 Quality Control Worksheets* and batch tickets to MnDOT the day following production.

C Gradation
Blend the coarse and fine aggregate at a 50-50 ratio (within ±2 percent) by volume and meet the following gradation requirements:

Table 3105-1 3U18 Gradation Requirements	
Sieve Size	**Percent Passing**
⅜ in [9.5 mm]	100
No. 4 [4.75 mm]	80 – 100
No. 8 [2.3 mm]	40 – 80
No. 16 [1.18 mm]	25 – 50
No. 30 [600 µm]	15 – 35
No. 50 [300 µm]	0 – 18
No. 100 [150 µm]	0 – 8
No. 200 [75 µm]	≤ 2.3

D Mix Proportions

Proportion the mix in accordance with Table 3105-2 per 75 lb [34.1 kg] bag of dry mix. Proportion other bag sizes of 3U18 or 3U18M in accordance with Table 3105-2.

Table 3105-2 Mix Proportions	
Material	**Weight, *lb [kg]***
Type I Cement	17.8 [8.1]
Coarse Aggregate	28.3 [12.9]
Fine Aggregate	28.9 [13.1]

E Blending

Provide a blending device meeting the following characteristics and requirements:

(1) Capable of producing the required mix proportions within ±2 percent,
(2) Contains a proportioning device equipped with a warning device to indicate when the system is out-of-tolerance,
(3) Capable of stopping the flow of cement to allow sampling of the blended coarse and fine aggregate, and
(4) Designed to allow cement and aggregate to run out separately for checking material weights and ensuring that the blending proportions meet mix requirements.

Before blending with the cement, dry the coarse and fine aggregates as approved by the Engineer. Blend the cement and aggregate before bagging the mix.

F Bags and Batch Identification

Provide moisture-proof bags resistant to tearing.

Print the following on the bags:

(1) The phrase, "MnDOT GRADE 3U18 CONCRETE PATCH MIX" or "MnDOT GRADE 3U18M CONCRETE PATCH MIX"
(2) Weight of the bag in pounds [kilograms]
(3) Mix date
(4) The instructions for mixing into concrete

3105.3 SAMPLING AND TESTING

Sample individual materials and the aggregate blend in accordance with an approved Quality Control Plan before blending at the bagging site.

3106 HYDRATED LIME

3106.1 SCOPE

Provide hydrated lime for use in soil drying or stabilization and for use in mortar for non-sewer applications or road pavement mixes.

3106.2 REQUIREMENTS

A Soil Drying/Stabilization

Provide hydrated lime for use in soil drying or stabilization meeting the requirements of AASHTO M 216.

B Mortar for Other Applications

For use in mortar, provide Type S hydrated lime meeting the requirements of ASTM C 207.

3106.3 SAMPLING AND TESTING

Provide sample at rates and sizes as required by the Schedule of Materials Control and the contract.

3107 MASONRY MORTAR

3107.1 SCOPE
Provide masonry mortar for use in sewer and other applications.

3107.2 REQUIREMENTS
A Sewer Application
Provide bag mixed mortar meeting the following requirements:

A.1 Bag Mix
Provide a dry, pre-blended, air-entrained, Type S or Type M bagged mortar mix meeting the requirements of ASTM C 270 "Standard Specification for Mortar for Unit Masonry" and ASTM C387 "Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete." Purposely air-entrain the bagged mortar mixture to an air content of at least 8 percent.

A.2 Mixing
Do not exceed the manufacturer allowable mixing water. Mix mortar onsite for the minimum time stated by the manufacture. If the manufacture does not recommend a minimum mixing time, mix the mortar for a minimum of 5 minutes. The Engineer will not allow re-tempering mortar mixture and will reject mortar mixtures not placed within 60 minutes of mixing.

B Other Applications
For applications other than for sewers, provide masonry mortar in accordance with ASTM C 270 based on the type of mortar required by the contract. Mix in accordance with the manufacturer's recommendations.

3107.3 SAMPLING AND TESTING
For bag mixed masonry mortar, provide a statement of compliance meeting the requirements of ASTM C 270 for air-entrained mortar. Label the type of mortar mix, either Type S or Type M, on each bag.

For site mixed masonry mortar, provide a statement of compliance meeting the requirements of ASTM C 91. Label the type of mortar mix, either Type S or Type M, on each bag. Provide samples for site mixed masonry mortar as required by the contract.

For applications other than for sewer applications, provide samples as required by the contract.

3113 ADMIXTURES FOR CONCRETE

3113.1 SCOPE
Provide admixtures for use in concrete applications.

3113.2 GENERAL
Provide admixtures in accordance with the following:

A Class I — Accelerating, Retarding, and Water-Reducing Admixtures

(1) Type A — Water-reducing
(2) Type B — Retarding
(3) Type C — Accelerating
(4) Type D — Water-reducing and retarding
(5) Type E — Water-reducing and accelerating
(6) Type F — Water-reducing, high range
(7) Type G — Water-reducing, high range and retarding
(8) Type S — Specific performance admixtures

B Class II — Air-Entraining Admixtures

C Class III — Calcium Chloride

3113.3 REQUIREMENTS
A Materials
Provide Class I admixtures from the Approved/Qualified Products List meeting the requirements of ASTM C 494. Provide Class II admixtures meeting the requirements of AASHTO M 154, except the tests for bleeding, bond strength, and volume change are not required.

Provide Class III admixtures from the Approved/Qualified Products List meeting the requirements of AASHTO M 144.

B Acceptance

Submit certified test reports including a print of the materials safety data sheet (MSDS), infrared spectrum and one-quart sample for the proposed Class I or Class II admixture from a CCRL Laboratory for each admixture. The Department will use the certified test results to determine if the admixtures meet the requirements of this section.

3113.4 SAMPLING AND TESTING

Take samples as specified in the Schedule of Materials Control.

The Department may perform tests on samples taken from the product proposed or on samples submitted and certified by the manufacturer as representative of the admixture to be supplied.

3115 FLY ASH FOR USE IN PORTLAND CEMENT CONCRETE

3115.1 SCOPE

Provide fly ash for use in concrete applications.

3115.2 REQUIREMENTS

Provide fly ash from the certified source listed on the Approved/Qualified Products List, meeting the requirements of ASTM C 618, Class F or Class C, except as modified by the following table:

Table 3115-1
MnDOT Modified Fly Ash Requirements

Requirement	Class F	Class C
Loss on ignition	≤ 3.5 %	≤ 3.5 %
Calcium Oxide (CaO)	≤ 18.0 %	>18.0 %

The use of fly ash produced at plants where lime is directly injected into the boiler for sulfur removal, is prohibited in Portland cement concrete.

Ensure the following standardized Fly Ash Certification Statement is included with delivery invoices: "(insert company name) certifies that the fly ash produced at (insert power plant and location) conforms to ASTM C 618 and MnDOT Specification 3115 for Class (insert class) fly ash."

Do not change the source or color, or both, of fly ash on a project without the written approval of the Engineer.

The Department will consider fly ash meeting the requirements of both Class C and Class F as Class C fly ash.

3115.3 SAMPLING AND TESTING

Provide samples for testing meeting the requirements of the Schedule for Materials Control.

Aggregates

3126 FINE AGGREGATE FOR PORTLAND CEMENT CONCRETE

3126.1 SCOPE

Provide fine aggregate for use in portland cement concrete.

3126.2 REQUIREMENTS

A General

Provide fine aggregate consisting of clean, sound, durable particles, uniform in quality and free from wood, bark, roots and other deleterious material.

The Engineer may consider the following as the basis for acceptance of fine aggregate for portland cement concrete:

(1) Results of laboratory tests,
(2) Behavior under natural exposure conditions,
(3) Behavior of portland cement concrete with aggregate from the same or similar geological formations or deposits, and
(4) Any other tests or criteria as deemed appropriate by the Engineer in conjunction with the Concrete Engineer.

B Composition

Provide fine aggregate from natural sand. If producing fine and coarse aggregates simultaneously from natural gravel deposits during the same operation, the Contractor may provide fine aggregate containing particles of crushed rock.

C Washing
Wash the fine aggregate.

D Deleterious Material
Provide fine aggregate containing a cumulative quantity of deleterious materials in accordance with Table 3126-1.

Table 3126-1
Deleterious Materials

Quality Test	Maximum Percent by Weight
Shale, Alkali, Mica, and Soft and Flaky Particles, Cumulative Total	2.5
Coal and Lignite, Cumulative Total	0.3

E Organic Impurities
Provide fine aggregate free of injurious quantities of organic impurities. The Engineer will reject aggregates that produce a color darker than the standard color when tested in accordance with AASHTO T 21, unless the mortar specimens pass the mortar strength requirements specified in 3126.2.F, "Structural Strength."

F Structural Strength
The Engineer will test the structural strength of fine aggregate in mortar specimens in accordance with AASHTO T 71 and Table 3126-2. The Engineer will prepare control mortar specimens using Ottawa sand with a Fineness Modulus (FM) from 2.30 to 2.50.

Table 3126-2
Structural Strength in Fine Aggregate

Mortar Specimens Containing:	Compressive Strength
Type I/II Portland Cement	≥ 90% of control at 7 days
Type III Portland Cement	≥ 90% of control at 3 days

G Gradation Requirements
Produce fine aggregate in accordance with the gradation requirements in Table 3126-3.

Table 3126-3
Fine Aggregate Gradation Requirements

Sieve Size	Percent Passing*
⅜ in [9.50 mm]	100
No. 4 [4.75 mm]	95 – 100
No. 8 [2.36 mm]	80 – 100
No. 16 [1.18 mm]	55 – 85
No. 30 [600 µm]	30 – 60
No. 50 [300 µm]	5 – 30
No. 100 [150 µm]	0 – 10
No. 200 [75 µm]	0 – 2.5

* Percent passing by weight through square opening sieves.

H Requirements for Uniformity of Grading
The uniformity of grading is determined by the Fineness Modulus (FM) of the fine aggregate.

Both the Engineer and Contractor will determine the FM of fine aggregate in accordance with Section 5-694.148 of the MnDOT Concrete Manual. Do not allow the material to deviate from the FM by greater than 0.20. Contact the Engineer, in conjunction with the Concrete Engineer, for an adjustment if the FM approaches the tolerance limit.

3126.3 SAMPLING AND TESTING
Provide fine aggregates in accordance with Table 3126-4.

Table 3126-4 Preliminary Fine Aggregate Testing	
Aggregate	**Notification and Testing Required**
New source	Notify the Engineer at least 1 month before use. Perform new source concrete aggregate testing.
Previously tested aggregate	Notify the Engineer at least 2 weeks before use. Perform additional testing as required by the Engineer in conjunction with the Concrete Engineer.

Sample and test fine aggregate in accordance with Table 3126-5.

Table 3126-5 Fine Aggregate Test Methods	
Test	**Testing Method**
Sampling	Concrete Manual 5-694.133
Sieve analysis	Concrete Manual 5-694.148
Deleterious substances	Laboratory Manual Method 1207
Quantity of material passing the No. 200 [75 µm] sieve	Concrete Manual 5-694.148
Organic impurities (color plate)	AASHTO T 21
Structural strength	AASHTO T 71
Specific gravity and absorption	Laboratory Manual Method 1205
Alkali silica reactivity	Laboratory Manual Method 1222

3127 FINE AGGREGATE FOR BITUMINOUS SEAL COAT

3127.1 SCOPE
Provide fine aggregate for use in bituminous seal coat.

3127.2 REQUIREMENTS
A Composition
Provide aggregate for use in bituminous seal coat meeting the following requirements:

(1) Consisting of sound, durable particles of sand, gravel or crushed stone,
(2) Clean,
(3) Uniform in quality,
(4) Free of deleterious materials and
(5) Meeting the requirements of Class A, B or C in accordance with 3137.2.B, "Classification."

B Gradation and Quality
Provide fine aggregate for bituminous seal coat meeting the following gradation requirements:

Table 3127-1 Fine Aggregate for Bituminous Seal Coat, *% Passing by Weight*						
Sieve Size	**FA-1**	**FA-2**	**FA-2½**	**FA-3**	**FA-3½**	**Job Mix Formula Tolerance *%***
½ in [12.5 mm]	100	100	100	100	100	—
⅜ in [9.5 mm]	100	100	100	100	90 – 100	± 5
¼ in [6.3 mm]	100	100	0 – 80	0 – 70	0 – 70	± 7
No. 4 [4.75mm]	0 – 100	0 – 100	0 – 50	0 – 25	0 – 25	± 7
No. 8 [2.36 mm]	—	0 – 40	0 – 12	0 – 5	0 – 5	± 4
No. 16 [1.18 mm]	0 – 30	0 – 10	0 – 5	—	—	± 4
No. 50 [300 µm]	0 – 15	0 – 5	—	—	—	± 4
No. 100 [150 µm]	0 – 5	—	—	—	—	± 4
No. 200 [75 µm]	0.0 – 1.0	0.0 – 1.0	0.0 – 1.0	0.0 – 1.0	0.0 – 1.0	—

Provide fine aggregate for bituminous seal coat meeting the following quality test requirements:

Table 3127-2 Fine Aggregate Durability for Bituminous Seal Coat Meeting the Requirements of AASHTO T96 as Modified by Mn/DOT					
Material Tests	**FA-1**	**FA-2**	**FA-2½**	**FA-3**	**FA-3½**
Shale, %	≤ 5	≤ 5	≤ 5	≤ 3	≤ 2
Flakiness index, % *	—	≤ 25	≤ 25	≤ 25	≤ 25
One Face Crush. % ‖	≥ 80	≥ 80	≥ 80	≥ 80	≥ 80
Insoluble residue for the portion of quarried carbonate aggregates passing the No. 200 sieve, %	≤ 10	≤ 10	≤ 10	≤ 10	≤ 10
Los Angeles Rattler, % loss	—	—	—	≤ 35	≤ 35
Bulk Specific Gravity	Required for Mix Design Submittal and verification. Verification tolerances between the Contractor and Agency are 0.040% for Bulk Specific Gravity, 8 pounds/cf for Loose Weight of Aggregate and 0.5% for Absorption.				
Loose Weight of Aggregate					
Absorption					
* Test aggregate retained on each sieve, if weight of retained aggregate comprises at least 4 percent of the total sample weight. ‖ For Class C aggregates only.					

3127.3 SAMPLING AND TESTING — (BLANK)

Report the No. 200 sieve results to the nearest 0.1 percent and all other sieve results to the nearest 1 percent.

A Sampling & Sieve Analysis MnDOT Bituminous Manual

B Flakiness Laboratory Manual Method 1223

C Shale Tests Laboratory Manual Method 1209

D Los Angeles Rattler Loss Laboratory Manual Method 1210

E Crushing Test Laboratory Manual Method 1214

F Loose Weight of Aggregate MN Seal Coat Handbook MN/RC-2006-34

G Bulk Specific Gravity Laboratory Manual Method 1205

H Insoluble Residue Laboratory Manual Method 1221

I Coarse Aggregate Absorption 1204

3128 AGGREGATE FOR USE IN MASONRY MORTAR

3128.1 SCOPE

Provide fine aggregate for use in masonry mortar.

3128.2 REQUIREMENTS

Provide aggregate for use in masonry mortar meeting the requirements of ASTM C 144. The gradation requirements of ASTM C 144 are shown in Table 3128-1.

Table 3128-1 Mortar Aggregate Gradation Limits	
Sieve Size	**Percent Passing**
No. 4 [4.75 mm]	100
No. 8 [2.36 mm]	95 – 100
No. 16 [1.18 mm]	70 – 100
No. 30 [600 µm]	40 – 75
No. 50 [300 µm]	10 – 35
No. 100 [150 µm]	2 – 15
No. 200 [75 µm]	0

The Engineer may allow aggregate meeting the gradation requirements of 3126.2.G, "Gradation Requirements," for joints thicker than ½ in [12.5 mm].

3128.3 SAMPLING AND TESTING — (BLANK)

3135 MODIFIED AGGREGATE BASES

3135.1 SCOPE

This specification lists the quality requirements for modified aggregate bases used for 2215, "Full Depth Reclamation" (FDR).

3135.2 REQUIREMENTS

A General

Produce aggregate materials that have uniform: appearance, texture, moisture content, and performance characteristics.

B Gradation

Provide modified aggregate bases for FDR mixtures in accordance with Table 3135-1.

Table 3135-1
Gradation Requirements

Sieve Size, *in [mm]*	Percent Passing
3 [75]	99 – 100
2 [50]	97 – 100
Note 1: Exclude rock that is larger the 2 inches [50 mm], in the gradation calculations, when it originates from material below the reclaimed bituminous pavement.	

C Add Materials

Supply materials as required by the contract.

3135.3 SAMPLING AND TESTING

Test the FDR mixture at the rates specified in the Schedule of Materials Control.

A Sampling and Sieve Analysis Grading and Base Manual

3136 DRAINABLE BASES

3136.1 SCOPE

This specification lists the quality requirements for drainable bases types: Open Graded Aggregate Base (OGAB) and Drainable Stable Base (DSB) used for 2212, "Drainable Aggregate Base".

3136.2 REQUIREMENTS

A Aggregate Composition

Provide certified aggregate along with Form G&B – 104.

A.1 Virgin Aggregates

Provide virgin aggregates, unless modified by the Contract to allow for recycled aggregates, meeting the following requirements:

(1) Comprised of naturally occurring mineral materials and
(2) Does not contain topsoil, organics or disintegrating rock as defined in Laboratory Manual section 1209.

B Quality and Gradation Requirements

Meet the requirements of Table 3136-1.

Table 3136-1 Drainable Base Requirements		
Total Percent Passing Requirement	**Type**	
	OGAB	**DSB**
1½ in [37.5 mm] Sieve	100	100
1 in [25.0 mm] Sieve	95 – 100	-
¾ in [19.0 mm] Sieve	65 – 95	75 – 100
⅜ in [9.5 mm] Sieve	30 – 65	45 – 75
No. 4 [4.75 mm] Sieve	10 – 35	30 – 60
No. 10 [2.00 mm] Sieve	3 – 20	10 – 35
No. 40 [425 μm] Sieve	0 – 8	5 – 20
No. 200 [75 μm] Sieve	0 – 3.5	0 – 5.0, for class B or C 0 – 6.5, for class A Class per specification 3137.
Other Requirements	**OGAB**	**DSB**
D_{60}/D_{10}*	≥ 4.0	≥ 8.0
Minimum Crushing (Two face) ‖	85%	60%
Maximum Los Angeles Rattler Loss (LAR)	40%	40%
Table 3136-1 Drainable Base Requirements		
Other Requirements	**OGAB**	**DSB**
Maximum Acid Insoluble Residue (IR) Minus No. 200 [75 μm] sieve †	10%	10%
Maximum Spall – Total Sample	5.0%	5.0%

* D_{60} is the diameter of the soil particle of which 60 percent is smaller, by weight. D_{10} is the diameter of the soil particle of which 10 percent is smaller, by weight.
‖ Material crushed from quarries is considered crushed material.
† For drainable base composed of crushed carbonate quarry rock.

3136.3 SAMPLING AND TESTING

Test in accordance with the following procedures:

A Sieve Analysis Laboratory Manual Method ..... 1202 & 1203

B Coarse Aggregate Angularity Laboratory Manual Method 1214

C Los Angeles Rattler Loss Laboratory Manual Method 1210

D Insoluble Residue Laboratory Manual Method 1221

E Spall Laboratory Manual Method..... 1209

3137 COARSE AGGREGATE FOR PORTLAND CEMENT CONCRETE

3137.1 SCOPE

Provide coarse aggregate for use in portland cement concrete.

3137.2 REQUIREMENTS

A General

Provide coarse aggregate consisting of clean, sound, durable particles, uniform in quality, and free from wood, bark, roots, and other deleterious material.

The Engineer, in conjunction with the Concrete Engineer, may consider the following as the basis for acceptance of coarse aggregate for portland cement concrete:

(1) Results of laboratory tests,
(2) Behavior under natural exposure conditions,
(3) Behavior of portland cement concrete with aggregate from the same or similar geological formations or deposits, and
(4) Any other tests or criteria as deemed appropriate by the Engineer, in conjunction with the Concrete Engineer.

B Classification

Provide coarse aggregate meeting the requirements of one of the following classifications:

(1) Class A: Crushed quarry rock including quartzite, gneiss, and granite, or mine trap rock including basalt, diabase, gabbro, and other igneous rock types. Class A aggregate may contain no greater than 4.0 percent non-Class A aggregate. The Department will not allow the intentional blending or adding of non-Class A aggregate.

(2) Class B: All other crushed quarry or mine rock types including carbonates, rhyolite, and schist.

(3) Class C: Natural or partly crushed gravel obtained from a natural gravel deposit.

(4) Class D: Mixture of at least two other classes of coarse aggregate. The Engineer, in conjunction with the Concrete Engineer, will determine the suitability of the Class D aggregate for the proposed use including proportioning.

(5) Class R: Aggregate obtained from recycling concrete. The Engineer, in conjunction with the Concrete Engineer, will determine the suitability of the Class R aggregate for the proposed use, including proportioning.

C Washing

Wash Class B, Class C, Class D, and Class R coarse aggregate. Wash Class A aggregate as needed to comply with the requirements of Table 3137-1.

D Quality

Quality requirements are based on each individual fraction unless otherwise approved by the Engineer, in conjunction with the Concrete Engineer, except for the following:

(1) If 100 percent of the fractions from a single source pass the 1 in [25 mm] sieve, base quality requirements on the composite value of the combined aggregates.

(2) If less than 100 percent of the fractions from a single source pass the 1 in [25 mm] sieve, base the quality requirements in accordance with the following:

(2.1) For fractions passing the 1 in [25 mm] sieve, base the quality requirement on the composite value of the combined aggregates;

(2.2) For fractions greater than or equal to 1 in [25 mm], base the quality requirement on each individual aggregate fraction.

D.1 Coarse Aggregate for General Use

Provide coarse aggregate for general use concrete in accordance with Table 3137-1.

Table 3137-1 Coarse Aggregate for General Use		
Quality Test		**Maximum Percent by Weight**
(a)	Shale:	
	Fraction retained on the ½ in [12.5 mm] sieve	0.4
	Fraction retained on the No. 4 [4.75 mm] sieve, as a percentage of the total material	0.7
(b)	Soft iron oxide particles (paint rock and ochre)	0.3
(c)	Total spall materials*:	
	Fraction retained on the ½ in [12.5 mm] sieve	1.0
	Fraction retained on the No. 4 [4.75 mm] sieve, as a percentage of the total material	1.5
(d)	Soft particles‖	2.5
(e)	Clay balls and lumps	0.3
(f)	Sum of (c) total spall materials, (d) soft particles, and (e) clay balls and lumps†	3.5
(g)	Slate	3.0
(h)	Flat or elongated pieces‡	15.0
(i)	Quantity of material passing No. 200 [75 µm] sieve:	
	Class A and Class B aggregates#	1.5
	Class C and Class D aggregates§	1.0
(j)	Los Angeles Rattler, loss on total sample	40.0
(k)	Soundness of magnesium sulfate**	15.0

* Includes the percentages retained by shale and soft iron oxide particles, plus other iron oxide particles, unsound cherts, pyrite, and other materials with similar characteristics.
‖ Exclusive of shale, soft iron oxide particles, and total spall materials.
† For total spall materials, use the percent in the total sample retained on the No. 4 [4.75 mm] sieve.
‡ Thickness less than 25 percent of the maximum width. Length greater than 3 times the maximum width.
\# Each individual fraction at the point of placement consists of dust from the fracture and free of clay or shale.
§ For each individual fraction at the point of placement.
** Loss at 5 cycles for any fraction of the coarse aggregate. Do not blend materials from multiple sources to obtain a fraction meeting the sulfate soundness requirement.

D.2 Coarse Aggregate for Bridge Superstructure

Provide coarse aggregate in accordance with 3137.2.D.1, "Coarse Aggregate for General Use," except as modified by Table 3137-2, for use in the following:

(1) Bridge superstructure (deck, railing, posts, curbs, sidewalks, and median strips);
(2) Approach panels; and
(3) Precast concrete panel facings for Mechanically Stabilized Earth walls.

Table 3137-2 Coarse Aggregate for Bridge Superstructure		
Quality Test		**Maximum Percent by Weight**
(a)	Shale:	
	Fraction retained on the ½ in [12.5 mm] sieve	0.2
	Fraction retained on the No. 4 [4.75 mm] sieve as a percentage of the total material	0.3
(b)	Soft iron oxide particles (paint rock and ochre)	0.2
(c)	Total spall materials*:	
	Fraction retained on the No. 4 [4.75 mm] sieve as a percentage of the total material	0.5
(d)	Soft particles‖	2.5
(e)	Clay balls and lumps	0.3
(f)	Sum of (c) total spall materials, (d) soft particles, and (e) clay balls and lumps, use the percent in the total sample retained on the No. 4 [4.75 mm] sieve †	3.0
(g)	Absorption for Class B aggregate	1.75
(h)	Absorption for Class B aggregate for all concrete bridge decks and bridge rails	1.10
(i)	Carbonate in Class C and Class D aggregates by weight	30.0

* Includes the percentages retained by shale and soft iron oxide particles, plus other iron oxide particles, unsound cherts, pyrite, and other materials with similar characteristics.
‖ Exclusive of shale, soft iron oxide particles, and total spall materials.
† For total spall materials, use the percent in the total sample retained on the No. 4 [4.75 mm] sieve.

D.3 Coarse Aggregate for Concrete Pavement

Provide coarse aggregate in accordance with 3137.2.D.1, "Coarse Aggregate for General Use," except as modified by Table 3137-3, for use in the following:

(1) Concrete pavement, and
(2) Concrete pavement rehabilitation.

Table 3137-3 Coarse Aggregate for Concrete Pavement		
Quality Test		**Maximum Percent by Weight**
(a)	Absorption for Class B aggregate	1.75
(b)	Carbonate in Class C aggregate by weight	30.0

E Gradation

Provide coarse aggregate in accordance with Table 3137-4 including all sizes within the specified limits. The Department defines coarse aggregate as the uniform product of the producing plant, unless some sizes are removed to meet the gradation requirements. Do not use broken or non-continuous gradations.

If the coarse aggregate contains less than 100 percent passing the 1 in [25 mm] sieve, use at least two fractions to proportion the coarse aggregate. Base gradation requirements on the composite value of the combined coarse aggregates.

If producing Class R aggregate, remove reinforcing steel from the concrete and any concrete material passing the No. 4 [4.75 mm] sieve.

Table 3137-4 Coarse Aggregate Designation for Concrete, *percent by weight passing square opening sieves*				
	Coarse Aggregate Designation			
	1	**2**	**3**	**4**
Sieve Sizes	**ASTM #467**	**ASTM #67***	**ASTM #7***	**ASTM #89**
2 in [50 mm]	100	-	-	-
1½ in [37.5 mm]	95 – 100	-	-	-
1 in [25.0 mm]	-	100	-	-
¾ in [19.0 mm]	35 – 70	90 – 100	100	-
½ in [12.5 mm]	-	-	90 – 100	100
⅜ in [9.5 mm]	10 – 30	20 – 55	40 – 70	90 – 100
No.4 [4.75 mm]	0 – 5	0 – 10	0 – 15	20 – 55
No.8 [2.36 mm]	-	-	-	5 – 30
No.16 [1.18 mm]	-	-	-	0 – 10
No.50 [300 µm]	-	-	-	0 - 5
*ASTM #67 and ASTM #7 Gradations are MnDOT Modified.				

3137.3 SAMPLING AND TESTING

A Preliminary Coarse Aggregate Testing

Sample and test coarse aggregate fractions separately in accordance with Table 3137-5.

Table 3137-5 Preliminary Coarse Aggregate Testing	
Aggregate	**Notification and Testing Requirement**
New source	Notify the Engineer at least 1 month before use. Perform new source concrete aggregate testing.
Previously tested aggregate	Notify the Engineer at least 2 weeks before use. Perform additional testing as directed by the Engineer, in conjunction with the Concrete Engineer.

B Coarse Aggregate Test Methods

Sample and test coarse aggregate in accordance with Table 3137-6.

Table 3137-6 Coarse Aggregate Test Methods	
Test	**Testing Method**
Sampling	Concrete Manual 5-694.131, 5-694.132
Sieve analysis	Concrete Manual 5-694.145
Shale test	Laboratory Manual Method 1207
Quantity of material passing the No. 200 [75 µm] sieve	Concrete Manual 5-694.146
Specific gravity and absorption	Laboratory Manual Method 1204
Density	AASHTO T 19 or Laboratory Manual Method 1211
Los Angeles Rattler loss	AASHTO T 96
Void content	AASHTO T 19* or Laboratory Manual Method 1211
Deleterious materials	Laboratory Manual Method 1209
Soundness; magnesium sulfate	Laboratory Manual Method 1219
Soft particles	Laboratory Manual Method 1218
Flat or elongated pieces	ASTM D 4791
Clay balls or lumps	Concrete Manual 5-694.147
* Base the void content on an oven-dry and compacted-by-rodding condition of the aggregate and a value of 62.4 lb per cu. ft [1,000 kg per cu. m] for water.	

3138 AGGREGATE FOR SURFACE AND BASE COURSES

3138.1 SCOPE

Provide certified aggregate along with Form G&B-104 for 2118, 2211 and 2221.

3138.2 REQUIREMENTS

A General

Use aggregate sources meeting the requirements of 1601, "Source of Supply and Quality."

Provide certified aggregate materials that have uniform: appearance, texture, moisture content and performance characteristics.

Provide binder soils from sources meeting the requirements of 3146, "Binder Soil." Add binder soils during the crushing and screening operations.

B Virgin Materials

Provide virgin aggregates meeting the following requirements:

(1) Comprised of naturally occurring mineral materials, and contains no topsoil, organics or disintegrating rock as defined in Laboratory Manual section 1209,
(2) Class 2 must be composed of 100% crushed quarry rock and
(3) Conforms to the quality requirements of Table 3138-1.

Table 3138-1 Quality Requirements for Virgin Materials				
Requirement	**Class**			
	1 and 2	**3 and 4**	**5 and 5Q**	**6**
Max Shale, if No. 200 ≤ 7 % by mass	NA	10.0%	10.0%	7.0%
Max Shale, if No. 200 > 7 % by mass	NA	7.0%	7.0%	7.0%
Minimum Crushing Requirements *	NA	NA	10%	15%
Maximum Los Angeles Rattler (LAR) loss from carbonate quarry rock	40%	40%	40%	35%
Maximum Insoluble residue for the portion of quarried carbonate aggregates passing the No. 200 sieve	10%	10%	10%	10%
* Material crushed from quarries is considered crushed material.				

C Recycled Materials

The Contactor may substitute recycled aggregates for virgin aggregates, if meeting the following requirements:

(1) Recycled aggregates contain only recycled asphalt pavement (RAP), recycled concrete materials, recycled aggregate materials, or certified recycled glass, and
(2) Must meet the requirements of Table 3138-2.

Table 3138-2
Quality Requirements for Recycled Materials

Requirement	Classes 1, 3, 4, 5, 5Q and 6
Maximum Bitumen Content of Composite	3.5%
Maximum Masonry block %	10%
Maximum percentage of glass *	10%
Maximum size of glass *	¾ in [19 mm]
Crushing (Class 5, 5Q and 6) ‖	10% for Class 5 †, 60% for Class 5Q † and 15% for Class 6 †
Maximum amount of Brick	1.0% #
Maximum amount of other objectionable materials including but not limited to: wood, plant matter, plastic, plaster and fabric	0.3% #

* Glass must meet certification requirements on the Grading and Base website. Combine glass with other aggregates during the crushing operation.
† If material ≥ 20% RAP and/or Concrete, Class 5 crushing requirement is met.
† If material ≥ 60% RAP and/or Concrete, Class 5Q crushing requirement is met.
† If material ≥ 30% RAP and/or Concrete, Class 6 crushing requirement is met.
‖ Material crushed from quarries is considered crushed material.
\# The Contractor/Supplier may not knowingly allow brick and other objectionable material and must employ a QC process to screen it out, before it becomes incorporated into the final product.

D Surfacing Aggregates

Provide surfacing aggregates in accordance with 3138.2.A, "General," 3138.2.B, "Virgin Materials," and 3138.2.C, "Recycled Materials," and meeting the following requirements:

(1) 100% of the material passes the ¾" sieve, regardless of the class specified; this modifies the requirements of Tables 3138-3, 3138-4 and 3138-5 for surfacing aggregates.
(2) Does not use glass,
(3) Recycled concrete materials may only be used for the roadway shoulders and
(4) There is no restriction on the bitumen content, if used for shouldering.

Note: Class 2 must be composed of 100% crushed quarry rock per 3138.2.B.3.

E Gradation Requirements

(1) For products containing less than 25 percent recycled materials, conform to Table 3138-3.
(2) For products containing 25 percent or more recycled materials and less than 75% recycled concrete, conform to Table 3138-4.
(3) For products containing 75 percent or more recycled concrete, conform to Table 3138-5.
(4) Perform gradation tests prior to bituminous extraction.

Table 3138-3
Base and Surfacing Aggregate
(containing less than 25 percent recycled aggregates)
Total Percent Passing

Sieve Size	Class 1 (Surfacing)	Class 2 (Surfacing)	Class 3 (Subbase)	Class 4 (Subbase)	Class 5 (Base)	Class 5Q (Base)	Class 6 (Base)
2 in	—	—	100	100	—	100	—
1½ in	—	—	—	—	—	—	—
1 in	—	—	—	—	100	65 – 95	100
¾ in	100	100	—	—	90 – 100	45 – 85	90 – 100
⅜ in	65 – 95	65 – 90	—	—	50 – 90	35 – 70	50 – 85
No. 4	40 – 85	35 – 70	35 – 100	35 – 100	35 – 80	15 – 45	35 – 70
No. 10	25 – 70	25 – 45	20 – 100	20 – 100	20 – 65	10 – 30	20 – 55
No. 40	10 – 45	12 – 30	5 – 50	5 – 35	10 – 35	5 – 25	10 – 30
No. 200	8.0–15.0	5.0–13.0	5.0–10.0	4.0–10.0	3.0–10.0	3.0–10.0	3.0–7.0

Table 3138-4
Base and Surfacing Aggregate
(containing 25% or more recycled aggregates & less than 75% recycled concrete)
Total Percent Passing*

Sieve Size	Class 1 (Surfacing)	Class 3 (Subbase)	Class 4 (Subbase)	Class 5 (Base)	Class 5Q (Base)	Class 6 (Base)
2 in	—	100	100	—	100	—
1½ in	—	—	—	100	—	100
1 in	—	—	—		65 - 95	
¾ in	100	—	—	70 – 100	45 – 85	70 – 100
⅜ in	65 – 95	—	—	50 – 90	35 – 70	50 – 85
No. 4	40 – 85	35 – 100	35 – 100	35 – 80	15 – 45	35 – 70
No. 10	25 – 70	20 – 100	20 – 100	20 – 65	10 – 30	20 – 55
No. 40	10 – 45 † 5 – 45	5 – 50	5 – 35	10 – 35	5 – 25	10 – 30
No. 200	5.0 – 15.0 † 0 – 15.0	0 – 10.0	0 – 10.0	0 – 10.0	0 – 10.0	0 – 7.0

*Add letters in parentheses for each aggregate blend designating the type of recycled products included in the mixture.
(B) = Bituminous, (C) = Concrete, (G) = Glass
(BC) = Bituminous and Concrete, (BG) = Bituminous and Glass
(CG) = Concrete and Glass, (BCG) = Bituminous, Concrete and Glass
† Note: For Class 1, if the bitumen content is ≥ 1.5%, the gradation requirement is modified to 5 – 45% for the #40 sieve and 0 – 15.0% for the #200 sieve.

Table 3138-5
Base and Surfacing Aggregate
(containing more than 75 percent recycled concrete)
Total Percent Passing*

Sieve Size	Class 1 (Surfacing)	Class 3 (Subbase)	Class 4 (Subbase)	Class 5 (Base)	Class 5Q (Base)	Class 6 (Base)
2 in	—	100	100	—	100	—
1½ in	—	—	—	100		100
1 in	—	—	—		65 – 95	
¾ in	100	—	—	70 – 100	45 – 85	700 – 100
⅜ in	65 – 95	—	—	50 – 90	35 – 70	50 – 85
No. 4	40 – 85	35 – 100	35 – 100	35 – 80	15 – 45	35 – 70
No. 10	25 – 70	20 – 100	20 – 100	20 – 65	10 – 30	20 – 55
No. 40	10 – 45	0 – 8	0 – 8	0 – 8	0 – 8	0 – 8
No. 200	5.0 – 15.0	0 – 3.0	0 – 3.0	0 – 3.0	0 – 3.0	0 – 3.0

* Add letters in parentheses for each aggregate blend designating the type of recycled products included in the mixture.
(B) = Bituminous, (C) = Concrete, (G) = Glass, (BC) = Bituminous and Concrete,
(BG) = Bituminous and Glass, (CG) = Concrete and Glass,
(BCG) = Bituminous, Concrete and Glass

3138.3 SAMPLING AND TESTING
Report the No. 200 sieve results to the nearest 0.1 percent and all other sieve results to the nearest 1 percent.

A **Sampling, Sieve Analysis and Crushing Tests Grading and Base Manual**

B **Los Angeles Rattler Loss Laboratory Manual Method..... 1210**

C **Shale Tests Laboratory Manual Method ..... 1207 & 1209**

D **Bitumen Content Laboratory Manual Method 1852**

E **Insoluble Residue Laboratory Manual Method..... 1221**

F **Reclaimed Glass AGI Visual Method..... (AGI Data sheet 15.1 and 15.2)**

3139 GRADED AGGREGATE FOR BITUMINOUS MIXTURES

3139.1 SCOPE

Provide graded aggregate for use in bituminous mixtures.

3139.2 PLANT MIXED ASPHALT REQUIREMENTS

A Composition

Provide graded aggregate composed of any combination of the following sound durable particles as described in 3139.2B.

Do not use graded aggregate containing objectionable materials including:

(1) Metal,
(2) Glass,
(3) Wood,
(4) Plastic,
(5) Brick, or
(6) Rubber.

Provide coarse aggregate free of coatings of clay and silt.

Do not add soil materials such as clay, loam, or silt to compensate for a lack of fines in the aggregate.

Do not blend overburden soil into the aggregate.

Feed each material or size of material from an individual storage unit at a uniform rate.

Do not place blended materials from different sources, or for different classes, types, or sizes together in one stockpile unless approved by the Engineer as a Class E aggregate.

B Classification

B.1 Class A

Provide crushed igneous bedrock consisting of basalt, gabbro, granite, gneiss, rhyolite, diorite, and andesite. Rock from the Sioux Quartzite Formation may contain no greater than 4.0 percent non-Class A aggregate. Do not blend or add non-Class A aggregate to Class A aggregate.

B.2 Class B

Provide crushed rock from other bedrock sources such as carbonate and metamorphic rocks (Schist).

B.3 Class C

Provide natural or partly crushed natural gravel obtained from a natural gravel deposit.

B.4 Class D

Provide 100 percent crushed natural gravel produced from material retained on a square mesh sieve with an opening at least twice as large as Table 3139-2 allows for the maximum size of the aggregate in the composite asphalt mixture. Ensure the amount of carryover, material finer than the selected sieve, no greater than 10 percent of the Class D aggregate by weight.

B.5 Class E

Provide a mixture consisting of at least two of the following classes of approved aggregate:

(1) Class A,
(2) Class B, and
(3) Class D.

B.6 Steel Slag

Steel slag cannot exceed 25% of the total mixture aggregate and be free from metallic and other mill waste.

The Engineer will accept stockpiles if the total expansion is no greater than 0.5 percent as determined by ASTM D 4792

B.7 Taconite Tailings

Obtain taconite tailings from ore mined westerly of a north-south line located east of Biwabik, Minnesota (R15W-R16W) or from ore mined in southwestern Wisconsin.

B.8 Recycled Asphalt Shingles (RAS)

Provide recycled asphalt shingles manufactured from waste scrap asphalt shingles (MWSS) or from tear-off scrap asphalt shingles (TOSS). Consider the percentage of RAS used as part of the maximum allowable Recycled Asphalt Pavement (RAP) percentage. See Table 3139-3.

B.8.A RAS Gradation ..... MnDOT Laboratory Procedure 1801

Provide RAS in accordance with the following gradation requirements:

Table 3139-1 RAS Gradation	
Sieve size	**Percent passing**
½ in [12.5 mm]	100
No. 4 [4.75 mm]	90

B.8.B Binder Content

Determine the binder content using chemical extraction meeting the requirements of MnDOT Lab Procedure 1851 or 1852.

B.8.C Bulk Specific Gravity

The Contractor may use an aggregate bulk specific gravity (Gsb) of 2.650 in lieu of determining the shingle aggregate Gsb in accordance with MnDOT Lab Procedure 1205.

B.8.D Waste Materials

Do not allow extraneous materials including metals, glass, rubber, nails, soil, brick, tars, paper, wood, and plastics greater than 0.5 percent by weight of the graded aggregate as determined by material retained on the No. 4 [4.75 mm] sieve as specified in MnDOT Laboratory Procedure 1801.

B.8.E Stockpile

Do not blend an RAS stockpile with other salvage material. Do not blend MWSS and TOSS. The Contractor may blend virgin sand material with RAS to minimize agglomeration if the Contractor accounts for the blended sand in the final mixture gradation.

B.8.F Certification

Ensure the processor provides RAS certification on the following Department form "Scrap Asphalt Shingles from Manufacture Waste" or "Tear-Off Scrap Asphalt Shingles" at www.dot.state.mn.us/materials/bituminous.html.

B.9 Crushed Concrete and Salvaged Aggregate

The Contractor may incorporate no greater than 50 percent of crushed concrete and salvaged aggregate in non-wear mixtures. Do not use crushed concrete in wearing courses.

B.10 Ash

Sewage sludge ash and waste incinerator ash are allowed as an aggregate source at a maximum of 5% of the total weight of the mixture. Sewage sludge ash for use as an aggregate source in wear or non-wear courses must be approved by examination with the Hazard Evaluation Process by MnDOT's Office of Environmental Stewardship.

B.11 Recycled Asphalt Pavement (RAP)

B.11.A Aggregate Angularity

Provide combined RAP and virgin aggregates that meet the composite coarse and fine aggregate angularity for the mixture being produced.

B.11.B Objectionable Material

Do not use RAP containing objectionable materials including metal, glass, wood, plastic, brick, or rubber.

B.11.C Asphalt Binder Content

Determine the asphalt binder content using the MnDOT Lab Manual Method 1851 and 1852.

B.11.D Bulk Specific Gravity

Determine the bulk specific gravity in accordance with MnDOT Laboratory Procedure 1205 or 1815.

C Quality

C.1 Los Angeles Rattler Test..... MnDOT Laboratory Procedure 1210

Ensure a coarse aggregate loss no greater than 40 percent.

C.2 Soundness (Magnesium Sulfate)..... MnDOT Laboratory Procedure 1219

Maximum loss after 5 cycles on the coarse aggregate fraction (material retained on No. 4 [4.75 mm] sieve for any individual source within the mix) as follows:

(1) Percent passing the ¾ in [19 mm] sieve to percent retained on the ½ in [12.5 mm] sieve, ≤ 14%,

(2) Percent passing the ½ in [12.5 mm] sieve to percent retained on the ⅜ in [9.5 mm]sieve, ≤18%,
(3) Percent passing the ⅜ in [9.5 mm] sieve to percent retained on the No. 4 [4.75 mm] sieve, ≤ 23%,
(4) For the composite if all three size fractions are tested, the composite loss ≤ 18%, and acceptance will be granted if:
  (4.1) If the Contractor meets the composite requirement, but fails to meet at least one of the individual components, the Engineer may accept the source if each individual component is no greater than 110 percent of the requirement for that component.
  (4.2) If the Contractor meets each individual component requirement, but fails to meet the composite, the Engineer may accept the source if the composite is no greater than 110 percent of the requirement for the composite.

Coarse aggregate that exceeds the requirements in this section for material passing the No. 4 [4.75 mm] sieve cannot be used.

C.3 Spall Materials and Lumps..... MnDOT Laboratory Procedure 1219

Spall is defined as shale, iron oxide, unsound cherts, pyrite, highly weathered and/or soft phyllite and argillite (may be scratched with a brass pencil), and other materials having similar characteristics.

Lumps are defined as loosely bonded aggregations and clayey masses.

If the percent of lumps measured in the stockpile or cold feed exceed the specification limits, stop asphalt production and determine compliance by dry batching. This procedure may be repeated at any time at the discretion of the Engineer.

Maximum limits for Spall and lumps, expressed as percentages by mass, are listed in Table 3139-3.

C.4 Insoluble Residue Test..... MnDOT Laboratory Procedure 1221
Use Statewide (except for District 6)

If using Class B carbonate materials ensure the portion of the insoluble residue passing the No. 200 [75 µm] sieve is no greater than 10 percent.

Use for District 6 ONLY.

If crushed carbonate quarry rock (limestone or dolostone) is used, the minus #200 [75 µm] sized portion of the rock insoluble residue shall not exceed 10% by weight.

Blending of sources and/or beds with an insoluble residue up to 15% is allowed to meet the 10% insoluble residue requirement. Individual beds thinner than 6 inches [150 mm] or up to 5% of the total face height, are exempt from the 15% maximum insoluble residue requirement. However, the aggregate producer shall practice good quality control at all times and exclude poor quality stone to the extent practical, regardless of the bed thickness and/or pocket size and location.

No carbonate quarry rock from the Platteville Geological Formation is allowed.

D Gradation

Ensure the aggregate gradation broad bands meet the following requirements in accordance with AASHTO T-11 (passing the No. 200 [75 µm] wash) and AASHTO T-27.

Table 3139-2
Aggregate Gradation Broad Bands (percent passing of total washed gradation)

Sieve size	A	B	C	D
1 in [25.0 mm]	—	—	100	—
¾ in [19.0 mm]	—	100*	85 – 100	—
½ in [12.5 mm]	100*	85 – 100	45 – 90	—
⅜ in [9.5 mm]	85 – 100	35 – 90	—	100
No. 4 [4.75 mm]	60 – 90	30 – 80	30 – 75	65 – 95
No. 8 [2.36 mm]	45 – 70	25 – 65	25 – 60	45 – 80
No. 200 [0.075 mm]	2.0 – 7.0	2.0 – 7.0	2.0 – 7.0	3.0 – 8.0

* The Contractor may reduce the gradation broadband for the maximum aggregate size to 97 percent passing for mixtures containing RAP, if the oversize material originates from the RAP source. Ensure the virgin material meets the requirement of 100 percent passing the maximum aggregate sieve size.

Table 3139-3 Mixture Aggregate Requirements				
Aggregate Blend Property	Traffic Level 2	Traffic Level 3	Traffic Level 4	Traffic Level 5
20 year Design ESAL's	<1 million	1 - 3 million	3 - 10 million	10 – 30 million
Min. Coarse Aggregate Angularity (ASTM D5821) (one face / two face), %- Wear (one face / two face), %- Non-Wear	30/- 30/-	55 / - 55 / -	85 / 80 60/ -	95 / 90 80 / 75
Min. Fine Aggregate Angularity (FAA) (AASHTO T304, Method A) %- Wear %-Non-Wear	40 40	42 40	44 40	45 40
Flat and Elongated Particles, max % by weight, (ASTM D 4791)	-	10 (5:1 ratio)	10 (5:1 ratio)	10 (5:1 ratio)
Min. Sand Equivalent (AASHTO T 176)	-	-	45	45
Max. Total Spall in fraction retained on the #4 [4.75mm] sieve – Wear Non-Wear	5.0 5.0	2.5 5.0	1.0 2.5	1.0 2.5
Maximum Spall Content in Total Sample – Wear Non-Wear	5.0 5.0	5.0 5.0	1.0 2.5	1.0 2.5
Maximum Percent Lumps in fraction retained on the #4 [4.75mm] sieve	0.5	0.5	0.5	0.5
Class B Carbonate Restrictions				
Maximum% -#4 [-4.75mm] Final Lift/All other Lifts	100/100	100/100	80/80	50/80
Maximum% +#4 [+4.75mm] Final Lift/All other Lifts	100/100	100/100	50/100	0/100
Max. allowable scrap shingles–MWSS(1) Wear/Non Wear	5/5	5/5	5/5	5/5
Max. allowable scrap shingles –TOSS(1) Final Lift/All other Lifts	5/5	5/5	0/5	0/0

(1) MWSS is manufactured waste scrap shingle and TOSS is tear-off scrap shingle.

3139.3 PERMEABLE ASPHALT STABILIZED STRESS RELIEF COURSE (PASSRC) AND PERMEABLE ASPHALT STABILIZED BASE (PASB) REQUIREMENTS

A Restrictions

Do not use recycled materials including glass, concrete, bituminous, shingles, ash, and steel slag.

B Gradation

The Gradation limits are also considered the Job Mix Formula (JMF) limits.

B.1 PASB

Table 3139-4 PASB Aggregate Gradation	
Sieve Size	Percent Passing
1 ½ inch [37.5 mm]	100
1 inch [25.0 mm]	95 - 100
¾ inch [19.0 mm]	85 – 95
3/8 inch [9.5 mm]	30 – 60
No. 4 [4.75 mm]	10 – 30
No. 8 [2.36 mm]	0 – 10
No. 30 [600 µm]	0 – 5
No. 200 [75 µm]	0 – 3

B.2 PASSRC

Table 3139-5 PASSRC Aggregate Gradation	
Sieve Size	Percent Passing
5/8 inch [16.0 mm]	100
1/2 inch [12.5 mm]	85 – 100
3/8 inch [9.5 mm]	50 – 100
No. 4 [4.75 mm]	0 – 25
No. 8 [2.36 mm]	0 – 5

C Quality

Will meet all requirements of 3139.2.C.1 through 3139.2.C.3.

3139.2.C.4 changes to: If using Class B carbonate materials ensure the portion of the insoluble residue passing the No. 200 [75 µm] sieve is no greater than 10 percent.

D Mixture Quality Requirements

Table 3139-6 Mixture Aggregate Requirements for PASSRC & PASB	
Aggregate Blend Property	
Coarse Aggregate Angularity (ASTM D5821) (one face/two face) % PASSRC (1) PASB (1)	 95/- -/65
Fine Aggregate Angularity (FAA) (AASHTO T304, Method A) %	NA
Flat and Elongated Particles, max(2) % by weight, (ASTM D 4791)	NA
Clay Content (2) (AASHTO T 176)	NA
Total Spall in fraction retained on the 4.75mm [**#4**] sieve	3.0
Maximum Spall Content in Total Sample	5.0
Maximum Percent Lumps in fraction retained on the 4.75mm [**#4**] sieve	0.5

Note (1) Carbonate Restrictions: If Class B (as defined in 3139.2.B.2), crushed carbonate quarry rock (limestone or dolostone), is used in the mixture, or if carbonate particles in the material retained on the 4.75 mm [**No. 4**] sieve exceeds 55 percent, by weight, the minus 0.075 mm [# **200**] sieve size portion of the insoluble residue shall not exceed 10 percent.

3139.4 ULTRA THIN BONDED WEARING COURSE (UTBWC) REQUIREMENTS.

A Restrictions

Do not use recycled materials including glass, concrete, bituminous, shingles, ash, and steel slag.

B Quality

Will meet all requirements of 3139.2.C.

C Coarse Aggregate

Provide a Class A aggregate, as defined in 3139.2.B.1, in accordance with the following requirements:

Table 3139-7 UTBWC Coarse Aggregate Requirements		
Tests	**MnDOT Laboratory Manual Method**	**Limit, %**
Flat and elongated ratio at 3:1	1208	≤ 25
Los Angeles Rattler Test (LAR)	1210	≤ 40
Bulk Specific Gravity	1204	

D Fine Aggregate

Provide fine aggregate, passing the No. 4 [4.75 mm] sieve in accordance with the following requirements:

Table 3139-8 UTBWC Fine Aggregate Requirements		
Tests	**Method**	**Limit, %**
Sand equivalent*	AASHTO T 176	≥ 45
Uncompacted void content	MnDOT Laboratory Manual 1206	≥ 40
Bulk Specific Gravity	MnDOT Laboratory Manual 1205	

E Aggregate Gradation Broadband

Table 3139-9 UTBWC Aggregate Gradation Broadband	
Aggregate Size Typical application rates	3/8 inch [9.5 mm] 65-75 lbs/sy
Sieve Size	**Gradation Broadband Limits % Passing**
3/4 inch [19.0 mm]	
1/2 inch [12.5 mm]	100
3/8 inch [9.5 mm]	85 – 100
No. 4 [4.75 mm]	28 – 42
No 8 [2.36 mm]	21 – 33
No. 16 [1.18 mm]	14 – 24
No. 30 [600 µm]	9 – 20
No. 50 [300 µm]	6 – 15
No. 100 [150 µm]	5 – 11
No. 200 [75 µm]	3.0- 7.0

3139.5 MICRO-SURFACING REQUIREMENTS

A Restrictions

Do not use recycled materials including glass, concrete, bituminous, shingles, ash, and steel slag.

B Gradation

Provide a Class A aggregate or Taconite Tailings as defined in 3139.2.B.1, "Graded Aggregate for Bituminous Mixtures", in accordance with the gradation requirements of Table 3139-10, "Micro-Surfacing Gradation Limits and QC Tolerances".

The Contractor may use Class B aggregate blended with Class A aggregate or Taconite Tailings if using the following methods:

If blending aggregate types, ensure that material passing the ⅜ in [9.5 mm] sieve and retained on No. 16 [1.18 mm] sieve is at least 90 percent Class A, or Taconite Tailings, or both by weight.

Table 3139-10 Micro-Surfacing Gradation Limits and QC Tolerances Percent Passing (AASHTO T 11, AASHTO T 27)				
Sieve Size	**Mn/DOT Type 1**	**Mn/DOT Type 2 ISSA* Type II**	**Mn/DOT Type 3 ISSA* Type III**	**QC TOLERANCES Percent in JMF for each sieve size**
⅜ inch [9.5 mm]	100	100	100	—
No. 4 [4.75 mm]	100	90–100	70–90	±5.0
No. 8 [2.38 mm]	85–100	65–90	45–70	±5.0
No. 16 [1.18 mm]	72–92	45–70	28–50	±5.0
No. 30 [600 µm]	50–75	30–50	19–34	±5.0
No. 50 [300 µm]	35–55	18–30	12–25	±4.0
No. 100 [150 µm]	15–35	10–21	7–18	±3.0
No. 200 [75 µm]	5–15	5–15	5–15	±2.0
* International Slurry Surfacing Association				

C Quality

Provide aggregate that meets the durability requirements of Table 3139-11, "Micro-Surfacing Aggregate Durability Requirements".

Table 3139-11 Micro-Surfacing Aggregate Durability Requirements		
Tests on Aggregate	**Test**	**Requirement, %**
Sand equivalent	AASHTO T 176	≥ 60
Abrasion resistance*	AASHTO T 96	≤ 30
Soundness (using MgSO4)‖	AASHTO T 104	≤ 25
* Use Grading C for Type 3 material. Use Grading D for Type 1 & 2 material. ‖ Perform the soundness test on the Class B aggregate of the blend, if applicable.		

3139.6 SAMPLING AND TESTING

Perform sampling, sieve analysis, lumps, crushing, and shale testing meeting the requirements of the MnDOT Laboratory Manual.

3145 MINERAL FILLER

3145.1 SCOPE

Provide mineral filler as a soil or mixture component.

3145.2 REQUIREMENTS

A Composition

Provide a mineral filler of carbonate dust, Portland cement, hydrated lime, crushed rock screenings[1], fly ash, or rotary kiln dust.

[1] Crushed rock needs to have a stability and durability equivalent to those of the comparable mixture containing on of the other acceptable filler materials and be free of clay and shale.

B Gradation

The mineral filler will be finer than a #4 [4.75 mm] sieve and contain less than 25% of the material passing a #200 [75µm] sieve. The portion passing the #200 [75µm] sieve will meet the following gradation[2].

Percent finer than 0.020 mm.....35 – 100
Percent finer than 0.005 mm.....10 – 40
Percent finer than 0.001 mm.....1 – 25

[2] Does not apply to Portland cement or hydrated lime

C Condition

Mineral filler which is to be added directly to the dried aggregate for the bituminous mixture will be thoroughly dry and free from lumps consisting of aggregates of fine particles. Crushed rock screenings used as mineral filler will be processed and handled in such a manner to prevent segregation and dried by passing through a dryer.

3145.3 SAMPLING AND TESTING

A Sample according to the Mn/DOT Bituminous Manual

B Fineness

B.1 Fine Aggregate Sieve Analysis according to Mn/DOT Laboratory Manual Method. 1203

B.2 Particle Size Analysis of Soil according to Mn/DOT Laboratory Manual Method…. ….. 1302

3146 BINDER SOIL

3146.1 SCOPE

Provide soil material for use as a binding agent for aggregate mixtures.

3146.2 REQUIREMENTS

Provide binder soil with the following characteristics:

(1) Contains no sod, roots, plants, organics, or other deleterious material and
(2) Contains no fly ash, incinerator ash, other manufacturing by-products or waste material.

3146.3 SAMPLING AND TESTING

A Sampling

The Engineer will sample binder soil in accordance with the Schedule of Materials Control.

B Sieve Analysis

The Engineer will perform the sieve analysis in accordance with test method 1302 of the Laboratory Manual.

3149 GRANULAR MATERIAL

3149.1 SCOPE

Provide certified granular materials along with Form G&B – 104.

3149.2 REQUIREMENTS

Use material sources meeting the requirements of 1601, "Source of Supply and Quality."

Provide certified granular material meeting the specified gradation.

Report the No. 200 sieve results to the nearest 0.1 percent and all other sieves to the nearest whole number.

Certify all granular materials on Form G&B-104, *Certification of Aggregate and Granular Materials.*

Provide certified granular material that has similar appearance, texture, moisture content, and performance characteristics.

A Granular Materials

A.1 Virgin Materials

Provide virgin aggregate meeting the following requirements:
(1) Consists of naturally occurring mineral materials,
(2) Contains no topsoil, organics, or severely weathered rock, and
(3) Insoluble residue test results for the portion of quarried/bedrock carbonate aggregates, passing the No. 200 sieve is no greater than 10 percent.

A.2 Recycled Materials

For products not required to be 100% virgin aggregates, the Contractor may substitute recycled aggregates for virgin aggregates, if the recycled aggregates meet the following requirements:

(1) Recycled aggregates consist only of recycled asphalt pavement (RAP), recycled concrete materials, and recycled aggregate materials;

(2) The bitumen content of the blended material is no greater than 3.0 percent;
(3) The recycled concrete material is:
  (3.1) No greater than 75 percent of the material blend,
  (3.2) No greater than 10 percent masonry block.

B Granular and Select Granular Materials
Provide granular materials meeting the requirements of Table 3149-1.

Table 3149-1
Granular Material Gradation Ratio Requirements

	% Passing Ratio No. 200/1 in [75 µm/25 mm]	**% Passing Ratio No. 40/No. 10 [425 µm/2.0 mm]**	**% Passing Ratio No. 200/No. 10 [75 µm/2.0 mm]**
1 Granular Material	0 – 20%	Not Applicable	Not Applicable
2 Select Granular Material	0 – 12%	Not Applicable	Not Applicable
3 Select Granular Material (Super Sand)	Not Applicable	0 – 65%	0 – 10%
4 Select Granular Materials Modified 10%	0 – 10%	Not Applicable	Not Applicable

C Stabilizing Aggregate
Provide stabilizing aggregate meeting the requirements of Table 3149-2 and the following.

Table 3149-2
Stabilizing Aggregate Gradation Requirements

Sieve Size	**Percent Passing**
1 in [25 mm]	100
¾ in [19 mm]	90 – 100
⅜ in [9.5 mm]	50 – 95
No. 4 [4.75 mm]	35 – 85
No. 10 [2.0 mm]	20 – 70
No. 40 [425 µm]	10 – 45
No. 200 [75 µm]	7 – 15.5

The minimum crushing requirement is 10 percent. Material crushed from quarries is considered crushed material.

D Backfill Materials

D.1 Granular Backfill
Provide granular backfill meeting the requirements of Table 3149-3.

Table 3149-3
Granular Backfill Requirements

% Passing 3 in [25 mm] Sieve	100%
Percent Passing Ratio No. 200/1 in [75 µm/25 mm]	0 – 20%

D.2 Structural Backfill
Provide 100% virgin structural backfill meeting the requirements of Table 3149-4, and the following.

Table 3149-4
Structural Backfill Requirements

% Passing ¾ in [19 mm] Sieve	100%
Percent Passing Ratio No. 40/No. 10 [425 µm/2.00 mm]	0 – 65%
Percent Passing Ratio No. 200/No. 10 [75 µm/2.00 mm]	0 – 10%

(1) Provide screened material meeting the requirements of 3137.2.B.3, "Classification," for Class C.

(2) Provide material with a minimum angle of friction (Φ) of 34° in accordance with AASHTO T 236. Perform tests on the sample portion passing the No. 10 sieve and compacted to 95 percent of Moisture Density Test Method (Proctor).

D.3 Select Granular Backfill

Provide select granular backfill meeting the requirements of Table 3149-5.

Table 3149-5 Select Granular Backfill Requirements	
% Passing 3 in [25 mm] Sieve	100%
Percent Passing Ratio No. 200/1 in [75 µm/25 mm]	0 – 12%

E Aggregate Backfill

Provide aggregate backfill meeting the requirements of Table 3149-6.

Table 3149-6 Aggregate Backfill Gradation Requirements	
Sieve Size	**Percent Passing**
2 in [25 mm]	100
No. 4 [4.75 mm]	35 – 100
No. 10 [2.00 mm]	20 – 70
No. 40 [425 µm]	10 – 35
No. 200 [75 µm]	3 – 10.5

F Granular Bedding

Provide granular bedding meeting the requirements of Table 3149-7.

Table 3149-7 Granular Bedding Gradation Requirements	
Sieve Size	**Percent Passing**
1 in [25 mm]	100
No. 200 [75 µm]	0 – 10.5

G Aggregate Bedding

Provide aggregate bedding meeting the type specified:

G.1 Fine Aggregate Bedding

Provide fine aggregate bedding meeting the requirements in 3138, "Aggregate for Base and Surface Courses," for Class 5.

G.2 Coarse Aggregate Bedding

Provide 100% virgin coarse aggregate bedding meeting the requirements of Table 3149-8.

Table 3149-8 Coarse Aggregate Bedding Gradation Requirements	
Sieve Size	**Percent Passing**
1½ in [37.5 mm]	100
No. 4 [4.75 mm]	0 – 10

G.3 Conduit Aggregate Bedding

Provide 100% virgin conduit aggregate bedding meeting the requirements of Table 3149-9.

Table 3149-9 Conduit Aggregate Bedding Gradation Requirements	
Sieve Size	**Percent Passing**
No. 4 [4.75 mm]	100
No. 200 [75 µm]	0 – 8.5

H Coarse Filter Aggregate

Provide 100% virgin coarse filter aggregate excluding quarried carbonates, meeting the requirements of Table 3149-10.

Table 3149-10 Coarse Filter Aggregate Gradation Requirements	
Sieve Size	**Percent Passing**
1 in [25 mm]	100
¾ in [19 mm]	85 – 100
⅜ in [9.5 mm]	30 – 60
No. 4 [4.75 mm]	0 – 10

I Blank

J Filter Aggregates

Provide filter aggregate meeting the requirements of the type specified:

J.1 Medium Filter Aggregate

Provide naturally rounded and 100% virgin medium filter aggregate meeting the requirements of Table 3149-11 and the following.

Table 3149-11 Medium Filter Aggregate Gradation Requirements	
Sieve Size	**Percent Passing**
¾ in [19 mm]	100
⅜ in [9.5 mm]	50 – 95
No. 4 [4.75 mm]	20 – 60
No. 10 [2.00 mm]	0 – 15
No. 40 [425 µm]	0 – 4
No. 200 [75 µm]	0 – 2.5

(1) The maximum shale and soft rock content of the material retained on the No. 4 sieve is 5.0 percent.
(2) The maximum carbonate content is 55 percent.
(3) The maximum crushing content is 15 percent. Material crushed from quarries is considered crushed material.

J.2 Fine Filter Aggregate

Provide 100 percent virgin fine filter aggregate meeting the requirements of Table 3149-12.

Table 3149-12 Fine Filter Aggregate Gradation Requirements	
Sieve Size	**Percent Passing**
⅜ in [9.5 mm]	100
No. 4 [4.75 mm]	90 – 100
No. 10 [2.00 mm]	45 – 90
No. 40 [425 µm]	5 – 35
No. 200 [75 µm]	0 – 3.5

K Sand Cover

Provide 100 percent virgin natural glacial material meeting the requirements of Table 3149 – 13.

Table 3149-13 Sand Cover Gradation Requirements	
Sieve Size	**Percent Passing**
No. 4	100
No. 10	95 – 100
No. 40	0 – 50
No. 200	0 – 8.5

3149.3 SAMPLING AND TESTING

Sample and test at the rates specified in the Schedule of Materials Control.

A Sampling, Sieve Analysis, Crushing Tests and Moisture Density Test Method (Proctor) Grading and Base Manual

B Bitumen Content Laboratory Manual Method 1852

C Insoluble Residue Laboratory Manual Method 1221

D Light Weight Pieces in Aggregate Laboratory Manual Method 1207

E Lithological Count Laboratory Manual Method 1209

F Standard Method of Test for Direct Shear Test of Soils under Consolidated Drained Conditions AASHTO T236

Bituminous Material

3151 BITUMINOUS MATERIAL

3151.1 SCOPE

Provide bituminous materials consisting of asphalt binder, cut-back asphalt, and emulsified asphalt.

3151.2 REQUIREMENTS

Provide bituminous material from a certified source listed on the Approved/Qualified Products List meeting the following requirements for the type and grade required by the contract.

A Asphalt Binder

Only use Performance Grade (PG) Asphalt Binder meeting the requirements of AASHTO M 320 and the Combined State Binder Group Method of Acceptance for Asphalt Binder, available on the Asphalt Products page of the Approved/Qualified Products List.

Use asphalt binder supplier recommendations for mixing and compaction temperatures.

B Medium Curing Liquid Asphalt

Provide medium curing liquid asphalt meeting the requirements of AASHTO M 82. Only use cutback asphalt as approved by the Engineer.

C Emulsified Asphalt

Provide emulsified asphalt meeting the requirements of AASHTO M 140 for the type and grade required by the contract.

D Cationic Emulsified Asphalt

Provide cationic emulsified asphalt meeting the requirements of AASHTO M 208.

D.1 Diluted CSS-1h

Provide diluted CSS-1h meeting the requirements of AASHTO M 208 with the following modifications:

1) Dilute the CSS-1h at a rate of one part emulsion to one part water at the place of manufacture.
2) Meets a distillation residue of at least 29 percent.
3) Saybolt viscosity, storage stability and particle charge only required on undiluted CSS-1h.

D.2 Cationic Fast Set Emulsified Asphalt for Fog Seal (CFS-1h)

Provide cationic emulsified asphalt using the testing methods referenced in AASHTO M208 to meet the following properties:

1) Residue Asphalt content minimum 29%.
2) Penetration 40 to 90 dmm.
3) Sieve maximum 0.1 %.

E Polymer Modified Cationic Emulsified Asphalt

E.1 CRS-2P

Provide polymer-modified cationic emulsified asphalt meeting the requirements of AASHTO M 316 CRS-2P with the following modifications:

1) Distilled at 400 °F [204 °C] for 15 min,
2) Meets a residue penetration from 100 to 150 dmm,
3) Produced using only polymer modified base asphalt. Do not use Latex modification.

E.2 CRS-2Pd- diluted CRS-2P

Provide diluted polymer-modified cationic emulsified asphalt meeting the requirements of AASHTO M-316 CRS-2P with the following modifications:

1) Distilled at 400 °F [204 °C] for 15 min,
2) Diluted at a rate of three parts emulsion to one part water, by volume, at the place of manufacture,
3) Meets a distillation residue of at least 50 percent,
4) Meets a residue penetration from 100 to 150 dmm,
5) Produced using polymer modified base asphalt. Do not use Latex modification.
6) Saybolt viscosity, storage stability and particle charge only required on undiluted CRS-2P.

F Polymer Modified High Float Medium Set Emulsified Asphalt HFMS-2P

Ensure that emulsified asphalt is homogenous after thorough mixing provided separation has not been caused by freezing.

Perform the polymer modification step before the emulsification process.

Provide emulsified asphalt meeting the requirements of Table 3151-1.

Table 3151-1
HFMS-2P Emulsified Asphalt Requirements

Test	Method	Minimum	Maximum
Tests on emulsion:			
Viscosity, Saybolt Furol at 122 °F [50 °C],	AASHTO T 59	50 s	450 s
Storage stability test*, 24 h	AASHTO T 59	—	1.0%
Sieve test	AASHTO T 59	—	0.1%
Residue by distillation‖	AASHTO T 59	65%	—
Oil distillate by distillation	AASHTO T 59	—	3.0%
Tests on residue from distillation:			
Penetration at 77 °F [25 °C]	AASHTO T 49	100 dmm	200 dmm
Float test, 140 °F [60 °C]	AASHTO T 50	1,200s	—
Elastic recovery, at 77 °F [25 °C]	AASHTO T 301	58%	—

* After standing undisturbed for 24 hours, ensure the surface has a smooth, homogenous color.
‖ AASHTO T 59 with modifications to include a 400°F ±9 °F [204°C ±5 °C] maximum temperature to be held for a period of 15 min.

G Ultrathin Bonded Wearing Course (UTBWC) Polymer Modified Emulsion Membrane

Provide a polymer modified emulsion membrane meeting the requirements of Table 3151-2:

Table 3151-2 UTBWC Polymer Modified Emulsion Membrane Requirements			
Test	**Method**	**Minimum**	**Maximum**
Tests on emulsion:			
Viscosity, Saybolt Furol at 77 °F [25 °C]	AASHTO T 59	20 s	100 s
Storage stability test*, 24h	AASHTO T 59	—	1.0%
Sieve test	AASHTO T 59	—	0.05%
Residue by distillation‖	AASHTO T 59	63%	—
Oil distillate by distillation	AASHTO T 59	—	2.0%
Demulsibility, 12 oz [35 mL], 0.8% dioctyl sodium sulfosuccinate	AASHTO T 59	60%	—
Tests on residue from distillation:			
Penetration, at 77 °F [25 °C]	AASHTO T 49	60 dmm	150 dmm
Solubility in trichloroethylene	AASHTO T 44	97.5%	—
Elastic recovery, at 77 °F [25 °C]	AASHTO T 301	60%	—

* After standing undisturbed for 24 h, ensure the surface has a smooth, homogenous color.
‖ AASHTO T 59, except at no greater than 392 °F ± 9 °F [200 °C ± 5 °C] for 15 min.

H Micro Surfacing Emulsified Asphalt

Provide CQS-1h bituminous material meeting the requirements of AASHTO M 208 and the following modifications.

H.1 Polymer Modified with Hard Base Asphalt, CQS-1hP

Provide a CQS-1h meeting the requirements of AASHTO M 208 with the following modifications:

Ensure the emulsion is polymer modified with a minimum of 3 percent natural latex polymers or a Department approved manmade latex polymer or SBS (styrene-butadiene-styrene) polymer and meets the requirements of Table 3151-3, column H.1.

H.2 Polymer Modified with Soft Base Asphalt, CQS-1P

Provide a bituminous material meeting the requirements of 3151H.1 except meeting the requirements of Table 3151-3, column H.2.

Table 3151-3 Micro Surfacing Emulsified Asphalt Requirements			
Test	**Method**	**3151.3.H.1 Requirement**	**3151.3.H.2 Requirement**
Quality on emulsion:			
Residue after distillation*	AASHTO T 59	≥ 62%	≥ 62%
Quality on residue:			
Softening point	AASHTO T 53	≥ 135°F [57°C]	≥ 128°F [53°C]
Penetration, at 77°F [25°C] 100 g, 5 s	AASHTO T 49	40 – 90 dmm	90 – 200 dmm
Solubility on base asphalt	AASHTO T 44	99%	99%

* AASHTO T 59, except the temperature for the distillation procedure shall be held at 350°F ±9°F [177°C ±5°C] for 20 min. Complete the entire distillation procedure within 60 min from the first application of heat.

I Mixing Grade Engineered Emulsion for Stabilization / Reclamation

Provide a cationic emulsion according to the job mix design for cold in-place recycling, central plant cold mix, stabilized base, or stabilized full depth reclamation; using the testing methods referenced in AASHTO M208 to meet the following properties for the types listed:

I.1 Soft Base Engineered Emulsion

1) Residue asphalt content minimum 64%,
2) Penetration range of 200-350 dmm

I.2 Hard Base Engineered Emulsion

1) Residue asphalt content minimum 64%,
2) Penetration range of 100-200 dmm

3151.3 SAMPLING AND TESTING

Provide Bill of Ladings with a certification statement that the bituminous material meets the requirements in 3151.2, "Requirements." Sample at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

The Materials Engineer will test samples submitted and certified by the manufacturer as representative of the bituminous material to be provided.

3161 ANTI-STRIPPING ADDITIVE

3161.1 SCOPE

Provide anti-stripping additives to improve the moisture sensitivity and adhesion properties between the asphalt binder and aggregate.

3161.2 REQUIREMENTS

Provide anti-stripping additives meeting the following requirements:

(1) Composition meeting the requirements of AASHTO M 320,
(2) Miscible with all types of bituminous materials without showing separation or settlement,
(3) Not affecting the long term stability of the asphalt binder, and
(4) With a concentration meeting the requirements of the Modified Lottman Test (Laboratory Manual Method 1813).

Ship and store anti-stripping additives in containers provided by the manufacturer and labeled with the following information:

(1) Name of the manufacturer,
(2) Trade name or trade mark,
(3) Manufacturer's lot number,
(4) Date of manufacture, and
(5) Net weight of the contents.

Maintain uniform consistency from drum to drum within shipments.

3161.3 SAMPLING AND TESTING — (BLANK)

3165 ASPHALT PRIMER FOR DAMPPROOFING AND WATERPROOFING

3165.1 SCOPE

Provide asphalt primer for damp proofing and waterproofing concrete and masonry surfaces above or below ground level

3165.2 REQUIREMENTS

Provide asphalt primer meeting the requirements of ASTM D 41.

3165.3 SAMPLING AND TESTING

Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

3166 ASPHALT FOR DAMPPROOFING AND WATERPROOFING

3166.1 SCOPE

Provide asphalt for use as a mopping coat for dampproofing or as a plying or mopping cement in the construction of a membrane system of waterproofing.

3166.2 REQUIREMENTS

Provide Type II asphalt meeting the requirements of ASTM D 449, unless otherwise required by the contract.

3166.3 SAMPLING AND TESTING

Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract

Bituminous Products

3201 SATURATED FABRIC FOR WATERPROOFING

3201.1 SCOPE
Provide asphalt saturated fabric for waterproofing.

3201.2 REQUIREMENTS
Provide fabric meeting the requirements of AASHTO M 117 and saturated with asphalt. Use the asphalt saturated fabric in conjunction with asphalt for waterproofing in accordance with 3166, "Asphalt for Dampproofing and Waterproofing."

3201.3 SAMPLING AND TESTING — (BLANK)

3204 PREMOLDED ASPHALT PLANK

3204.1 SCOPE
Provide premolded asphalt plank.

3204.2 REQUIREMENTS
Provide asphalt plank meeting the requirements of ASTM D 517 for the type required by the contract.

3204.3 SAMPLING AND TESTING — (BLANK)

Culvert Pipe and Sewer Pipe

3222 CORRUGATED ALUMINIZED STEEL PIPE (TYPE 2)

3222.1 SCOPE
Provide corrugated aluminized steel (CAS) pipe and pipe arches for use in the construction of culverts, underdrains, and sewers.

3222.2 REQUIREMENTS
Use Type 2 aluminum-coated steel sheets meeting the requirements of AASHTO M 274 to fabricate pipe in accordance with AASHTO M 36M and as specified in 3226, "Corrugated Steel Pipe."

Use pipe sections with identification marks meeting the requirements of AASHTO M 274.

3222.3 SAMPLING AND TESTING — (BLANK)

3225 CORRUGATED ALUMINUM PIPE

3225.1 SCOPE
Provide corrugated aluminum alloy (CA) pipe for use as culverts and underdrains.

The Department will designate the size of circular pipes by the nominal inside diameter and the size of pipe-arches by the span width.

3225.2 REQUIREMENTS
Provide pipe meeting the requirements of AASHTO M 196 and the following:

A Physical Properties
The Contractor may provide pipe in the least thickness of metal listed for a specified diameter, unless otherwise shown on the plans or special provisions.

B Coupling Bands
Use aluminum alloy coupling bands meeting the requirements of AASHTO M 196 and as shown on the plans to make field joints.

C Aprons

Provide aluminum aprons for circular pipes manufactured in accordance with this specification for corrugated aluminum pipe and as shown on the plans.

D Identification Marks

Mark each pipe section with identification meeting the requirements of AASHTO M 196.

3225.3 SAMPLING AND TESTING

The Engineer will inspect corrugated aluminum pipe in accordance with AASHTO M 196.

3226 CORRUGATED STEEL PIPE

3226.1 SCOPE

Provide prefabricated corrugated steel (CS) pipe to construct culverts and underdrains. The unmodified term "pipe" refers to any or all types of pipe.

The Department will designate the size of the circular pipe by the nominal inside diameter. The Department will designate the size of the pipe-arches by the span width measured from the inside crest of the corrugations.

3226.2 REQUIREMENTS

Provide pipe meeting the requirements of AASHTO M 36M for the type required by the contract and in accordance with the following:

A (Blank)

B Dimensions

Ensure that pipe dimensions meet the requirements of AASHTO M 36M except as modified by the following:

(1) Provide each size of pipe with a nominal sheet thickness as shown on the plans and meeting the requirements for specified thickness in Table 4 of AASHTO M 218,

(2) Provide pipes with a corrugation size of 1½ in × ¼ in [38 mm × 6.5 mm], 2⅔ in × ½ in [68 mm × 13 mm], 3 in × 1 in [75 mm × 25 mm], or 5 in × 1 in [125 mm × 25 mm] as shown on the plans and meeting the requirements in Table 1 of AASHTO M 36M for the provided pipe sizes, and

(3) Provide spiral ribbed pipes with a corrugation size of ¾ in × ¾ in × 7 ½ in [19 mm × 19 mm × 190 mm] and meeting the requirements of AASHTO M 36M, "Table 3" for the provided pipe sizes. Provide the pipes with section properties meeting the requirements of AASHTO *LRFD Bridge Design Specifications* Appendix A12.

C (Blank)

D Appurtenant Parts and Sections

Provide metallic coated steel aprons fabricated in accordance with this section and 3351, "Sheet Steel Products."

Provide elbow, tee, and wye sections as shown on the plans and fabricated from standard pipe sections, using mitered and welded joints, forming the required intersection angles for each installation. Provide special adapters as necessary to make connections between different sizes and types of pipe.

Provide an outlet screen at each free end of underdrain systems. The Contractor may provide metal end caps to close the dead ends of pipe instead of installing concrete or vitrified clay plugs.

E Identification Marks

Mark each pipe section with identification meeting the requirements of AASHTO M 196.

Provide pipe with a sheet thickness, as designated in the markings on sheets and coils, meeting the requirements in Table 4 of AASHTO M 218.

3226.3 SAMPLING AND TESTING

The Engineer will not accept units of pipe if the zinc (galvanized) coating has been burned by shop welding or otherwise damaged in shop fabrication, unless the Contractor re-galvanizes the pipe units using the hot-dip process or the metalizing process specified in AASHTO M 36M. Do not make shop repairs with zinc paint. Use the metalizing process to make zinc coating repairs on butt-welded seams of helical corrugated pipe, if the adjacent zinc coating is burned to a width greater than three times the metal thickness.

After the Contractor delivers the pipe to the project, the Engineer will inspect each unit for compliance with the details of construction, workmanship, and finish requirements. In addition to all other defects as listed in AASHTO M 36M constituting cause for rejection, the Engineer may reject, at the project, any units damaged during shipment or fabrication.

The Contractor may use zinc paint to repair pipe coating damage caused by job site field welding or fabrication in lieu of re-galvanizing. Use organic zinc primer paint specified on the MnDOT Approved/Qualified Products List under "Bridge Structural Steel Coating" as Three Coat Systems - Organic. Clean the damaged area by sandblasting or as otherwise approved by the Engineer. Apply the zinc paint in accordance with instructions from the paint manufacturer.

3229 POLYMERIC COATED CORRUGATED STEEL PIPE

3229.1 SCOPE

Provide polymeric-coated corrugated steel (PC-CS) pipe for use as culverts and underdrains.

3229.2 REQUIREMENTS

Use precoated galvanized steel sheets meeting the requirements of AASHTO M 246 to fabricate pipe meeting the requirements of AASHTO M 245 and in accordance with 3226, "Corrugated Steel Pipe."

Provide steel sheets with a polymer coating on both sides that is 0.01 in [250 µm].

3229.3 SAMPLING AND TESTING — (BLANK)

3231 GALVANIZED STEEL STRUCTURAL PLATE FOR PIPE, PIPE-ARCHES, AND ARCHES

3231.1 SCOPE

Provide galvanized corrugated steel (CS) structural plate and fasteners for use in constructing pipe, pipe-arches, underpasses, and special shapes for field assembly.

3231.2 REQUIREMENTS

Provide structural plates and fasteners meeting the requirements of AASHTO M 167 and the following:

A Fabrication

Provide the plate thickness specified in Table 6 of AASHTO M 167, unless otherwise specified on the plans. Provide steel plate with the section modulus shown on the plans. A different thickness and section modulus is acceptable if the strength is at least equal to the strength of the thickness and section modulus shown on the plans.

Provide plates of a size and shape that yield a finished structure of the dimensions shown on the plans. Stagger either the longitudinal or the transverse seams.

Punch bolt holes before galvanizing the sheets.

B Workmanship and Finish

The Engineer will reject individual plates or shipments of plates with the following defects:

(1) Plates without careful and finished workmanship;
(2) Incorrect plate shape;
(3) Unevenly lined or spaced bolt holes;
(4) Plates with ragged edges;
(5) Plates with illegible or improper markings;
(6) Bruised, scaled, broken, or improperly repaired zinc (galvanized) coating; or
(7) Metal plates with dents or bends.

3231.3 SAMPLING AND TESTING 3226.3

3233 ALUMINUM ALLOY STRUCTURAL PLATE FOR PIPE, PIPE-ARCHES, AND ARCHES

3233.1 SCOPE

Provide corrugated aluminum alloy (CA) structural plate, accessories, and fasteners for the construction of pipe, pipe-arches, arches, and special shapes, for field assembly.

3233.2 REQUIREMENTS

Provide structural plates, accessories, and fasteners meeting the requirements of AASHTO M 219 and the following:

A Fabrication

Provide the plate thickness, pipe shape, sheet fabrication details, and assembly bolting as shown on the plans.

B Workmanship and Finish

The Engineer will reject individual plates or shipments of plates with the following defects:

(1) Plates without careful and finished workmanship,
(2) Incorrect plate shape,
(3) Unevenly lined or spaced bolt holes,
(4) Plates with ragged edges,
(5) Plates with illegible or improper markings, or
(6) Metal plates with dents or bends.

3233.3 SAMPLING AND TESTING — (BLANK)

3236 REINFORCED CONCRETE PIPE

3236.1 SCOPE

Provide precast concrete items manufactured in a facility meeting the requirements of 3240, Precast Concrete Manufacturing. Provide reinforced concrete pipe of circular, arch, elliptical, or special shape and design, with appropriate appurtenances to construct culverts, sewers, or underpasses.

3236.2 REQUIREMENTS

Provide reinforced concrete pipe meeting the following design requirements and as modified in this section:

Table 3236-1
Reinforced Concrete Pipe

Pipe type	AASHTO reference
Circular	AASHTO M 170
Pipe-Arch	AASHTO M 206
Elliptical	AASHTO M 207

Provide concrete aprons manufactured as shown on the plans. Attach aprons compatible with pipe.

Provide concrete cattle pass units manufactured as shown on the plans and meeting the requirements of AASHTO M 170 for Class III pipe of equivalent wall thickness.

The Department will not require external load bearing tests on cattle passes and aprons.

A Materials

A.1 Aggregate Quality ..... 3126 and 3137

A.2 Form Release Agents 3902

A.3 Portland Cement 3101

The Department will allow admixtures in accordance 2461, "Structural Concrete," except do not use calcium chloride.

The Department will allow the following cement substitutions:

(1) 30 percent Class F or Class C fly ash by weight,
(2) 35 percent ground granulated blast furnace slag by weight,
(3) 35 percent substitution with a combination of ground granulated blast furnace slag, and
(4) Class F or Class C fly ash by weight.

A.4 Flyash for Use in Portland Cement Concrete 3115

A.5 Ground Granulated Blast Furnace Slag Cement 3102

A.6 Structural Concrete 2462

A.7 Metal Reinforcement 2472

A.8 Preformed Gasket Seals for Concrete Pipe 3726

B Pipe Design

Provide pipe designed as shown on the plans or meeting the AASHTO requirements referenced in Table 3236-1, if approved as an alternate by the Engineer for the different classes of pipe meeting the following design requirements:

(1) Pipe shape (circular, arch, elliptical),
(2) Diameter,
(3) Wall thickness,
(4) Compressive strength of concrete, and
(5) Area and type of circumferential reinforcement.

Provide pipe with reinforcement placed in accordance with applicable AASHTO Specifications referenced in Table 3236-1, except as otherwise shown on the plans or as approved by the Engineer. Do not use circular pipe with elliptical reinforcement. Lap wire mesh at least one full mesh or twenty wire diameters, whichever is greater. Do not weld laps of reinforcement for pipe unless the Engineer approves the welder, in conjunction with the Materials Engineer.

If the plans show pipes with rubber gasket seals, ensure the joint surfaces adjacent to the gasket are smooth and free of imperfections to allow the rubber gasket seal to meet the specified performance requirement.

C Manufacture

Provide products manufactured in a precast concrete manufacturing plant pre-approved by the Materials Engineer and listed on the Approved/Qualified Products List. Provide certified products as required by the contract from a manufacturer with production set-up on a pre-approved basis. The Engineer will limit acceptance of products to each precast concrete manufacturer and to each of the plants as pre-approved by the Materials Engineer. The Engineer, in conjunction with the Materials Engineer, will limit pre-approval to the identified sizes of circular pipe, arch pipe, elliptical pipe, and appurtenances.

Notify the Materials Engineer, before the manufacturer begins producing pipe requiring shear steel or Special Designs not listed on the Approved/Qualified Products List. Pin all shear steel.

Provide concrete units cured by the steam or water curing methods, unless using methods otherwise approved by the Materials Engineer. In all cases, use curing chambers with an atmospheric temperature no greater than 160 °F [71 °C]. Protect concrete units from freezing or drying after casting until the completion of curing.

D Permissible Variations

Provide pipe meeting the tolerance requirements of applicable AASHTO specifications referenced in Table 3236-1.

3236.3 SAMPLING AND TESTING

The Materials Engineer will approve each precast concrete manufacturer and its individual plants to provide precast concrete products under the pre-approval program. The Materials Engineer will not authorize precast concrete production if the manufacturer fails to abide by the terms, conditions, and requirements contained in this program.

If the Materials Engineer finds manufacturer non-compliance with the pre-approval program or evidence of non-conformance of certified products, the Materials Engineer, in conjunction with the Engineer, may perform the following:

(1) Reject the individual product,
(2) Reject the questioned shipment,
(3) Reject the identified day's production, or
(4) Revoke pre-approval privileges.

A Plant QC

Ensure the manufacturer establishes and implements a QC program, including the following elements for each pre-approved plant:

A.1 Internal QC Program

Ensure the manufacturer includes the following in the internal QC program:

(1) Sampling and testing of component materials or documentation of acceptability if materials were previously inspected and tested, or received from a certified source,
(2) Inspection of product manufacturing including the following:
    (2.1) Reinforcing steel fabrication and placement,
    (2.2) Concrete mix design and proportioning,
    (2.3) Concrete placement and consolidation, and
    (2.4) Concrete curing.
(3) Testing of finished products including the following:
    (3.1) Strength of concrete cylinders,
    (3.2) Three-edge-bearing test (round pipe), and

(3.3) Absorption and steel verification from pipe cores. For each class, size, and type of manufacture, on the first run of the year and as directed by the Materials Engineer, provide core specimens at least 4 in [100 mm] in diameter for the absorption test and steel verification.

(4) Final visual inspection and stamping, and

(5) Maintenance of plant facilities and equipment.

A.2 On-Site Quality Control Technicians

Ensure the manufacturer employs and has on-site during production QC technicians trained and certified meeting the requirements of Mn/DOT Level I, "Concrete Field Tester" or ACI Grade I, "Quality Control Technician" to perform the following:

(1) Ensure the conformance of all pre-approved products to the requirements,

(2) Maintain knowledge of the following:

(2.1) Plans and specification requirements,

(2.2) Product manufacturing operations, and

(2.3) Significance of the specification requirements in producing quality products.

(3) Correct, stop, or both, operations causing non-conforming attributes,

(4) Reject products not meeting the contract requirements,

(5) Ensure the manufacturer meets requirements related to producing pre-approved products, and

(6) Contact the Department's inspector before making repairs greater than 10 percent of the respective surface, inside or outside.

A.3 Equipment 2461

A.4 System of Record Keeping

Ensure the manufacturer maintains the following records:

(1) Component material sources and passing quality test results, authorized certification, or other evidence of inspection and satisfactory testing,

(2) Test results covering product manufacture and the finished product as listed in the records section of the ACPA manual,

(3) Records of manufactured products in accordance with the following:

(3.1) Date,

(3.2) Size, and

(3.3) Class.

(4) Running inventory of pre-approved products in stock, and

(5) Equipment calibration reports.

B Quality Assurance

The Materials Engineer will visit each plant to perform tasks in accordance with this specification and including the following:

(1) Random sampling and testing of the materials used in the manufacture of pre-approved products,

(2) Random sampling and testing of the pre-approved pipe produced,

(3) Observing the manufacturing process,

(4) Reviewing the manufacturer's quality control tests, inspection, records, and stockpiling practices, and

(5) Reviewing the pre-approved product inventory.

The Engineer will perform a final inspection upon delivery.

C Testing Rates

C.1 Concrete

Ensure the manufacturer tests the air content of concrete in each mix once a day for each positive slump mix.

Ensure the manufacturer tests the concrete strength of each mix meeting the requirements of "Cylinder and Core Guidelines for Precast Pipe and Box Culvert" kept on file by the Materials Engineer.

C.2 Load Bearing Test

Ensure the manufacturer conducts Three-Edge Bearing tests meeting the requirements of AASHTO M 170, on each size and class of pipe, and in accordance with the following schedule:

Table 3236-2 Load Bearing Test Rates		
Size Range, *in [mm]*	**Class Range**	**Test Rates**
12 – 15 [300 – 375]	≤ 5	1 per 1000 pieces
18 – 36 [450–900]	≤ 4	1 per 800 pieces
18 – 36 [450\ – 900]	5	1 per 400 pieces
42 – 60 [1,050 – 1,500]	≤ 3	1 per 400 pieces
42 – 96 [1,050– 2,400]	4 & 5	1 per 200 pieces
NOTE: Testing rates for sizes not shown are as required by the project specifications. Begin a new schedule of testing after changing the mix design, after shutting down the system for major repairs and renovations, when beginning a new production run, and when beginning a new season.		

Notify the Materials Engineer 2 full business days before testing. The Materials Engineer may select pipes for testing and may direct the manufacturer to perform additional testing at no additional cost to the Department.

Do not ship pipe that have not developed the specified D-load. Only pipe of equal or older age than a tested pipe section of the same size and class that has passed the three-edge bearing test may be shipped. Maintain documentation of all load tests performed.

D Pipe Marking

Provide pipe marked by the manufacturer in accordance with the following:

(1) Meeting the marking requirements of AASHTO M 170,
(2) Stamped with the word, "Certified,"
(3) Stamped with the manufacturing plant identification,
(4) For units at least 24 in [600 mm] in diameter, stamped on the inside, and
(5) For units smaller than 24 in [600 m] in diameter, stamped on the outside.

Before stockpiling, mark products manufactured for projects with special requirements not meeting the standards of the pre-approved program with an identifying project number or the buyer's name.

The Engineer may accept pre-approved shipments if the Contractor provides pipe marked with the following by the manufacturer:

(1) The phrase, "CERTIFIED PLANT COMPANY," in 4 in × 4 in [100 mm × 100 mm] letters,
(2) Company identification, and
(3) Individual production plant.

Provide the Engineer with a certified bill of materials or invoice, signed by a designated, responsible company representative with each shipment that identifies the following information:

(1) Project number;
(2) Contractor;
(3) Type of material;
(4) Number of pieces of each size, class, and length; and
(5) The following statement:

"The materials itemized in this shipment are certified to be in compliance with the applicable Minnesota Department of Transportation Specifications and the Project Plans, including 'Buy America' provisions."

_____
Authorized Signature and Date

Ensure the manufacturer does not ship pre-approved products until after the completion of QC tests and inspections, and as approved by the Materials Engineer.

E Stockpiling

Ensure the manufacturer stockpiles products meeting the above requirements to allow the Materials Engineer to inspect the products for QA, and that the manufacturer stockpiles special, non-pre-approved product in areas separate from pre-approved stock.

3238 PRECAST CONCRETE BOX CULVERTS

3238.1 SCOPE

Provide precast concrete items manufactured in a facility meeting the requirements of 3240, "Precast Concrete Manufacturing". Provide precast concrete single and multi-cell box culverts sections, headwalls, and aprons, including box culvert sections used in the as-cast position as manholes or manhole-type structures.

3238.2 REQUIREMENTS

A Fabrication Drawings, Falsework and Forms

If full construction details are not included in the plans, provide shop drawings according to 3240 before fabricating the units.

Provide shop drawings and design calculations for mitered culvert bends and other specialty culvert shapes.

Provide precast concrete box culverts with individual sections at least 4 ft long [1.2 m] capable of being tied to the adjacent section with concrete pipe ties as specified by Mn/DOT Standard Plate 3145 and as shown on the plans. Unless specifically called for in the plans, openings in the flow lineare not allowed. One formed opening with three-inch or less diameter in each sidewall of end sections will be allowed. Two lifting holes may be allowed for larger end sections with written permission of the Materials Engineer.

B Materials

B.1 Concrete 2462

Provide concrete with mix designations as shown on the plans for the specific items of work.

B.2 Reinforcement Bars 3301

B.3 Steel Fabric 3303

C Forms

Provide forms capable of withstanding pressure from concrete, vibration, and impact without distorting. Set and maintain forms in a mortar tight condition, free of warp, and on a rigid foundation. Provide joints in the sectional forms without offset. Set forms to create dimensions of the precast unit as shown on the plans. Repair or replace forms not meeting the dimensions shown on the plans before casting additional sections. When recesses around lifting devices are required, use forming devices provided by the lifting device manufacturer. Clean forms before use. Treat the face of the forms in contact with the concrete with form coating material in accordance with 3902, "Form Coating Material," before setting the forms.

D Lifting Devices and Other Steel Inserts

When lifting devices or other steel inserts will have less than 1.5 inches of concrete cover in the finished structure or if the recess is to be grouted in the field, provide items that are galvanized according to 3392.

E Reinforcement Steel

Place reinforcement steel as shown on the plans. Support reinforcement steel with chairs. Splice, secure, and tie reinforcement steel in accordance with 2472, "Metal Reinforcement." Provide concrete cover of at least 1½ in [40 mm] or as shown on the plans. Provide stainless steel, plastic, plastic tipped, hot dipped galvanized, or mechanically galvanized reinforcement supports in contact with the forms. Extend coatings on the supports at least 1 in [25 mm] from the form surface. Do not tack-weld reinforcement.

Lap wire mesh as detailed in the plans. Cut wire mesh so that the sum of the two end overhangs equals no more than one transverse wire spacing. When measuring the length of wire mesh for compliance with plans (splice lengths, etc.) the end overhang shall not exceed one-half of the transverse wire spacing.

F Placement of Concrete

Do not place concrete for precast units until the Materials Engineer inspects and approves the forms and steel placement.

Place the concrete in each precast unit without interruption. Vibrate the concrete internally, externally, or both, to produce uniformly dense concrete and to avoid displacement of enclosures or steel units. Internally vibrate in accordance with 2401.3.D., "Compaction of Concrete," except provide internal vibrators with a vibrating head no greater than 1¼ in [32 mm] in diameter and capable of operating at a frequency of at least 100 Hz [6,000 impulses per min].

G Concrete Curing

Cure until the concrete reaches a compressive strength of at least 2,500 psi [17 MPa] based on compressive strength test results from control cylinders cured according to 3240, Precast Concrete Manufacturing.

H Concrete Finishing and Repair

Provide formed surfaces of the precast units with a uniform dense surface finish in accordance with 2401.3.F.2.a, "Ordinary Surface Finish." After removing the forms, examine the concrete surfaces for areas of unsound concrete and defective surfaces caused by faulty forms or form assembly, improper concrete placement, improper form removal, and other causes.

Remove and replace concrete with porosity, honeycomb, delamination, hollow sound, or segregated materials as approved by the Materials Engineer.

The Materials Engineer will not allow the following repairs in the finished product:

(1) Individual repairs greater than 4 sq. ft [0.4 sq. m] on an inside or outside surface, and
(2) Repairs to the tongue or groove down to the steel and greater than 4 ft [1.2 m] long.

With the approval of the Materials Engineer and in compliance with the plant quality control program, the Contractor may repair minor surface cavities or irregularities before the unit completes curing.

I Certified Plant Requirement

Provide precast concrete box culverts, end sections, and appurtenances constructed in a precast concrete fabrication plant certified by the American Concrete Pipe Association, the National Precast Concrete Association, or another organization approved by the Materials Engineer. If requested, provide quality control and plant certification records to the Materials Engineer.

3238.3 SAMPLING AND TESTING

The Materials Engineer is the Engineer with authority regarding this Specification.

The Materials Engineer will inspect the units at the plant and will stamp approved units with the official mark of the Department. Store individual units in an upright position to facilitate inspection, unless otherwise approved by the Materials Engineer. Do not ship units without the official mark of the Department. Notify the Materials Engineer at least one full business day before intent to ship. Complete finishing and repair work on units before submitting notice of intent to ship. The units are subject to final inspection of the units after delivery.

Unless otherwise directed by the Materials Engineer, mark the inside of each box section with the following information:
(1) Project number,
(2) Overfill height,
(3) Size,
(4) Segment number as shown on the plans,
(5) Date of manufacture,
(6) Manufacturer's name and plant

3240 PRECAST CONCRETE MANUFACTURING

3240.1 SCOPE

Provide precast concrete items manufactured off-site at a permanent manufacturing facility, such as box culverts, pipe and manholes, bridge beams, abutments, pier caps, and other structures.

After seasonal or other delays in production, provide a minimum of one full week of notice that production will begin.

When a manufacturing facility has not produced items covered by this Specification in the current or previous calendar year, provide a minimum of sixty days' notice of intent to manufacture.

If a manufacturing facility is located outside of MnDOT-specified coverage areas, all costs of providing that inspection will be deducted from monies paid under the contract. A list of plants, locations and products with regular MnDOT inspection is on the Materials Office website.

3240.2 REQUIREMENTS

A Fabrication Drawings

If full construction details are not included in the plans, or if modifications of the plan drawings are necessary, provide shop drawings meeting the following requirements to the Engineer of Record for review and approval by the Office of Bridges and Structures or other project representative as designated by the Materials Engineer, before fabricating the units:

(1) Complete and comprehensive,
(2) Include the details of reinforcing steel, and
(3) Show mat makeup and configuration

Do not begin construction of the items until full approval of the shop drawings is attained. When shop drawings are transmitted electronically, the final, approved shop drawings should be sent from the approved project representative directly to the Precast Inspection Engineer and/or the State's inspector(s) for the manufacturing facility.

B Materials

B.1 Concrete 2462
Provide concrete with mix designations as shown on the plans for the specific items of work.

B.2 Reinforcement Bars 3301

B.3 Steel Fabric 3303

C Forms
Provide forms capable of withstanding pressure from concrete, vibration, and impact without distorting. Set and maintain forms in a mortar tight condition, free of warp, and on a rigid foundation. If evidence of mortar leakage is apparent after a pour, take corrective action to prevent the leakage from recurring.

Provide joints in the sectional forms without offset. Set forms to create dimensions of the precast unit as shown on the plans. Repair or replace forms not meeting the dimensions shown on the plans before casting additional sections. When recesses around lifting devices are required, use forming devices provided by the lifting device manufacturer.

Clean forms before use. Treat the face of the forms in contact with the concrete with form coating material in accordance with 3902, "Form Coating Material," before setting the forms.

D Concrete Curing

See the special provisions for curing requirements.

3240.3 PLANT QUALITY CONTROL

The Materials Engineer will approve each precast concrete manufacturer and its individual plants to provide precast concrete products. The Materials Engineer will withdraw authorization or will not authorize precast concrete production if the manufacturer fails to abide by the terms, conditions, and requirements contained in this specification.

If the Materials Engineer finds manufacturer non-compliance with the specification or evidence of non-conformance of precast products, the Engineer may perform the following:

(1) Reject the individual product,
(2) Reject the questioned shipment,
(3) Reject the identified day's production, or
(4) Revoke pre-approval privileges for the product or product class, if applicable.

A Plant QC
Ensure the manufacturer establishes and implements a QC program, including the following elements for each plant:

A.1 Internal QC Program
Ensure the manufacturer includes the following in the internal QC program:

(1) Sampling and testing of component materials according to the Schedule of Materials Control or documentation of acceptability if materials were previously inspected and tested, or received from a certified source,
(2) Inspection of product manufacturing including the following:
  (2.1) Reinforcing steel fabrication and placement,
  (2.2) Concrete mix design and proportioning,
  (2.3) Concrete placement and consolidation, and
  (2.4) Concrete curing.
(3) Testing of finished products, including strength of concrete cylinders.
(4) Maintenance and calibration of plant facilities and equipment.

A.2 On-Site Quality Control Technicians
Ensure the manufacturer employs and has on-site during production a QC technician trained and certified meeting the requirements of MnDOT "Concrete Plant 1", and either MnDOT "Concrete Field 1" or ACI "Concrete Field 1" to perform the following:

(1) Ensure the conformance of all products to the requirements,
(2) Maintain knowledge of the following:
  (2.1) Plans and specification requirements,
  (2.2) Product manufacturing operations, and
  (2.3) Significance of the specification requirements in producing quality products.

(3) Correct, stop, or both, operations causing non-conforming attributes,
(4) Reject products not meeting the contract requirements,
(5) Ensure the manufacturer meets requirements related to producing pre-approved products, and
(6) Contact the Department's inspector before making repairs.

A.3 System of Record Keeping

Ensure the manufacturer maintains the following records:

(1) Component material sources and passing quality test results, authorized certification, or other evidence of inspection and satisfactory testing,
(2) Test results covering product manufacture and the finished product,
(3) Records of manufactured products in accordance with the following:
  (3.1) Date,
  (3.2) Size,
  (3.3) Class.
(4) Equipment calibration reports and
(5) Concrete batch records.

B Quality Assurance

The Materials Engineer may visit each plant to perform tasks in accordance with this specification and including the following:

(1) Random sampling and testing of the materials used in the manufacture of precast products,
(2) Random sampling and testing of the items produced,
(3) Observing the manufacturing process,
(4) Reviewing the manufacturer's quality control tests, inspection, records, and stockpiling practices, and
(5) Reviewing the completed product inventory.

The Engineer will perform a final inspection upon delivery to the project site.

C Testing Rates

C.1 Concrete

Ensure the manufacturer tests the slump/spread of concrete in each mix at least once per 25 cubic yards for each positive slump mix.

Ensure the manufacturer tests the concrete strength of each mix meeting the requirements of "Cylinder and Core Guidelines for Precast Pipe and Box Culvert" kept on file by the Materials Engineer.

C.2

Notify the Materials Engineer 2 full business days before three-edge bearing testing, shipping strength testing, or other acceptance testing, or1 full business day if inspectors are present on a daily basis. The Materials Engineer may select items or cylinders for testing and may direct the manufacturer to perform additional testing at no additional cost to the Department.

Maintain documentation of all strength tests performed, including a signed, printed report from the cylinder testing machine that includes the following information:

(1) Unique identification of the original pour, such as pour number or date & time of the pour,
(2) Unique cylinder ID,
(3) Date and time of the test, and
(4) Breaking strength.

D Shipping

Do not ship items that have not developed the specified compressive strength.

3241 PLASTIC TRUSS PIPE

3241.1 SCOPE

Provide plastic truss (PT) pipe, couplings, and fittings for sewer piping.

3241.2 REQUIREMENTS

Provide plastic truss pipe, couplings, and fittings meeting the requirements of ASTM D 2680. Unless otherwise specified on the plans or special provisions, the Contractor may choose the joint type.

Store and handle PT pipe as recommended by the manufacturer. Do not expose PT pipe to direct sunlight for a total time greater than six months after fabrication. Do not use damaged pipe.

3241.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance with each pipe shipment.

3245 THERMOPLASTIC PIPE

3245.1 SCOPE

Provide thermoplastic (TP) pipe and fittings for use as pipe sewers or subsurface drains.

3245.2 REQUIREMENTS

Provide thermoplastic pipe and fittings meeting the requirements of one of the following:

(1) AASHTO M 278, Class PS 46, Polyvinyl Chloride (PVC) Pipe,
(2) ASTM D 2751, Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe, SDR 35,
(3) ASTM D 3034, Type PSM PVC Sewer Pipe, SDR 35,
(4) ASTM F 758, Smooth-Wall PVC, Type PS 46, or
(5) ASTM F 949, PVC Corrugated Sewer Pipe.

If perforated pipe is specified, provide pipe with perforations in accordance with the applicable specification or otherwise specified in the plans or special provisions.

If the perforation dimensions are not specified in the applicable specifications, plans, or special provisions, provide pipe with perforations meeting one of the following:

(1) Perforations from 0.2 in to 0.4 in [5 mm to 10 mm] in diameter, spaced 3 in [75 mm] center-to-center. Provide two rows of holes for 4 in [100 mm] pipe and four rows for 6 in to 10 in [150 mm to 250 mm] pipe, or
(2) Any of the configurations indicated for other pipe types allowed in this section.

Unless otherwise specified in the applicable specifications, plans, or special provisions, the Contractor may choose the joint type.

Do not use damaged pipe.

3245.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance with each pipe shipment.

3247 CORRUGATED POLYETHYLENE PIPE

3247.1 SCOPE

Provide corrugated polyethylene (CP) dual-wall pipe for use as culverts or pipe sewers.

3247.2 REQUIREMENTS

Provide corrugated polyethylene (CP) dual-wall pipe with couplings and fittings meeting the requirements of AASHTO M 294 Type "S" pipe, and Section 12 of the AASHTO LRFD Bridge Design Specifications.

Provide CP pipe and fittings manufactured from high-density polyethylene (HDPE) virgin compounds. The Contractor may provide clean, reworked HDPE materials from the manufacturer's own production, if the pipe fittings produced meet the requirements of this section.

Store and handle CP pipe as recommended by the manufacturer. Do not expose CP pipe to direct sunlight for a total time greater than six months after fabrication. Do not use damaged pipe.

3247.3 SAMPLING AND TESTING

Corrugated High Density Polyethylene Pipe (HDPE) manufacturing facilities are required to participate and be in compliance with AASHTO's National Transportation Product Evaluation Program (NTPEP) for producers of AASHTO M294 HDPE pipe. If a plant has a compliant NTPEP audit for AASHTO M294 pipe at the time the pipe is manufactured, then the plant has met requirements.

Compliant plants are listed on the NTPEP website and can also be accessed through the Approved Products List.

Submit to the Engineer a manufacturer's Certificate of Compliance with each pipe shipment.

3248 POLYVINYL CHLORIDE PIPE

3248.1 SCOPE
Provide polyvinyl chloride (PVC) pipe for use as culverts or pipe sewers.

3248.2 REQUIREMENTS
Provide PVC pipe with couplings and fittings meeting the requirements of the following:

(1) ASTM F 794,
(2) ASTM F 949, and
(3) Section 12 of the AASHTO LRFD Bridge Design Specifications.

Provide PVC pipe and fittings manufactured from virgin PVC compounds. The Contractor may use clean, reworked PVC materials from the manufacturer's own production if the pipe fittings meet the requirements of this section.

Store and handle corrugated PVC pipe as recommended by the manufacturer. Do not expose PVC pipe to direct sunlight for a total time greater than six months after fabrication. Do no use damaged pipe.

3248.3 SAMPLING AND TESTING
Submit to the Engineer a manufacturer's Certificate of Compliance with each pipe shipment.

3249 CULVERT LINER MATERIALS

3249.1 SCOPE
Provide pipe liner for use in lining culverts.

3249.2 REQUIREMENTS
Provide pipe liner meeting one of the following requirements:

(1) Polyethylene (PE) pipe meeting the requirements of ASTM F 714 (SDR 32.5), or
(2) Closed-profile PE pipe with an ASTM D 3350 cell classification of 345464C.

Store and handle liner pipe as recommended by the manufacturer. Do not expose liner pipe to direct sunlight for a total time greater than six months after fabrication. Do not use damaged pipe liner.

3249.3 SAMPLING AND TESTING
Submit to the Engineer a manufacturer's Certificate of Compliance with each pipe shipment.

3252 CAST IRON SOIL PIPE

3252.1 SCOPE
Provide cast iron soil pipe and fittings for use in gravity flow plumbing, drain, waste and vent sanitary and storm water applications.

3252.2 REQUIREMENTS
Provide cast iron soil pipe and fittings meeting the requirements of ASTM A 74 for the class shown on the plans or special provisions.

3252.3 SAMPLING AND TESTING — (BLANK)

Subsurface Drainage Units

3278 CORRUGATED POLYETHYLENE DRAINAGE TUBING

3278.1 SCOPE
Provide corrugated polyethylene (PE) tubing and fittings.

3278.2 REQUIREMENTS
Provide corrugated polyethylene (PE) tubing and fittings meeting the requirements of AASHTO M 252.

3278.3 SAMPLING AND TESTING
Submit to the Engineer a manufacturer's Certificate of Compliance with each tubing shipment.

Metals and Metal Products

3301 REINFORCEMENT BARS

3301.1 SCOPE
Provide deformed and plain reinforcing steel for use as reinforcement in concrete construction.

3301.2 REQUIREMENTS
Provide reinforcement bars, other than wire, meeting the requirements of the following AASHTO specifications for the size, type and grade as shown on the plans or as required by the contract:

Table 3301-1
AASHTO Specifications Per Bar Type

Reinforcement Bars	AASHTO Specification Requirement
Billet steel bars	AASHTO M 31
Rail steel bars	AASHTO M 322 M/AASHTO M 322
Axle steel bars	AASHTO M 322 M/AASHTO M 322

If the plans or specifications do not specify the type or grade of reinforcement bars, provide Grade 60 [Grade 420] of any type except as modified by the following:

(1) Provide deformed billet steel reinforcement bars for use in a concrete bridges, including precast units, box culverts, and retaining walls.
(2) Provide deformed reinforcement bars of any type or grade for use in all other concrete structures, and
(3) If required or allowed by the contract, weld bars meeting the requirements of ASTM A 706 and having a yield point of at least 60,000 psi [414 MPa].

If required in the plans, provide epoxy coated reinforcement bars meeting the requirements of ASTM A775. Apply the coating in a fusion bonded epoxy coating plant certified by the CRSI.

Ensure the plant's quality control office maintains documentation required by CRSI certification, including test data and measurements taken at times and locations as directed by the Materials Engineer.

Fabricate, store, and place reinforcement in accordance 2472, "Metal Reinforcement."

3301.3 SAMPLING AND TESTING
Sample and test reinforcement bars in accordance with the Schedule of Materials Control. If the Materials Engineer determines that the fusion bonded epoxy coating plant is not following approved coating procedures, correct the process and repair or replace the unacceptable material as directed by the Materials Engineer.

3302 DOWEL BARS

3302.1 SCOPE
Provide dowel bars for use in portland cement concrete pavements and other concrete applications as shown on the plans.

3302.2 REQUIREMENTS
Provide Grade 40 or Grade 60 steel dowel bars meeting the requirements of AASHTO M 31. Provide an epoxy coating meeting the requirements of AASHTO M 254. Epoxy coat the ends of the dowel bars as required by the manufacturer. Apply epoxy coating in a fusion bonded epoxy coating plant certified by the CRSI or another organization approved by the Materials Engineer. Use alternate dowel bar materials as required by the contract.

Ensure the manufacturer's plant quality control office maintains documentation containing the data required by certification, including test data and measurements taken at times and locations as required by the CRSI, the Materials Engineer, or both.

Store and protect dowel bars as specified in 2472, "Metal Reinforcement."

The Contractor may perform shearing if the epoxy coating is not damaged and subject to permissible deformation. The Engineer will ensure dowel bars do not contain deformations greater than the true shape by 0.04 in [1 mm] in diameter or thickness, or extend greater than 0.40 in [10 mm] from the dowel end.

3302.3 SAMPLING AND TESTING
Sample and test dowel bars in accordance with the Schedule of Materials Control.

3303 STEEL FABRIC

3303.1 SCOPE
Provide steel fabric for use as concrete reinforcement.

3303.2 REQUIREMENTS
Provide steel fabric for concrete reinforcement meeting the requirements of AASHTO M 55 or AASHTO M 221 for plain or deformed wire, except the Contractor may use oversized wire. If the Contractor uses oversize wire, the maximum and minimum diameter requirements will not apply. Provide flat sheets or rolls of fabric.

3303.3 SAMPLING AND TESTING
Sample and test the steel fabric in accordance with the Schedule of Materials Control.

3305 SPIRAL REINFORCEMENT

3305.1 SCOPE
Provide steel wire for use as spiral cage reinforcement for round columns.

3305.2 REQUIREMENTS
Provide cold drawn steel wire to fabricate spiral cage reinforcement for round columns meeting the requirements of AASHTO M 32 for the size shown on the plans. Alternatively, the Contractor may use plain or deformed Grade 60 billet steel bars in accordance with 3301, "Reinforcement Bars."

When required to splice spiral reinforcement by welding, perform welding in accordance with the requirements of ANSI/AWS D1.4, "Structural Welding Code - Reinforcing Steel."

3305.2 SAMPLING AND TESTING
Sample and test in accordance with the requirements of 3301, "Reinforcement Bars."

3306 LOW-CARBON STRUCTURAL STEEL

3306.1 SCOPE
Provide carbon steel shapes, plates, bars, sheets, and strips.

3306.2 REQUIREMENTS
Provide low-carbon structural steel meeting the requirements of ASTM, the tensile requirements in, and 3308, "General Requirements for Structural Steel."

Provide steel shapes, plates, and bars meeting the requirements of ASTM A 709/A 709M, for Grade 36 [250].

Provide steel sheets and strips meeting the requirements of ASTM A1011/A 1011M Grade 36 [250], Type 2.

3306.3 SAMPLING AND TESTING
Perform tensile tests for all sizes of shapes and bars in accordance with the Schedule for Materials Control.

3308 GENERAL REQUIREMENTS FOR STRUCTURAL STEEL

3308.1 SCOPE
Provide steel for structural applications referenced in 2471, "Structural Metals."

3308.2 REQUIREMENTS

A General
Provide steel for structural applications meeting the requirements of ASTM A 6/A 6M and the following:

B Quality

Submit a Nonconformance Report (NCR) to the Engineer for review and approval before performing any weld repairs of the base metal.

Correct injurious defects (e.g. pipes, seams, unapproved repairs, laminations, cracks, segregations) and perform necessary testing to determine the extent of the defects or confirm the adequacy of repairs, as required by the Engineer, at no additional cost to the Department.

The Engineer will reject plates or rolled beams with defects that reduce the thickness of the material in any given section by greater than 30 percent.

3308.3 SAMPLING AND TESTING

A Tensile Test

Take tensile specimens for rolled beams from the mid-thickness of the flange and oriented longitudinally to the rolling direction. Note the location and orientation of tensile specimens on the mill test report.

B Impact Tests

Perform impact tests for structural steel provided for use in major structural components as defined in 2471.3.A.1.b, "Major Structural Components," or the contract. The Department will not require impact testing for minor structural components unless otherwise required by the contract

Ensure that impact tested structural steel meets the requirements of ASTM A 709/A 709M for zone 3 welded material.

3309 HIGH-STRENGTH LOW-ALLOY STRUCTURAL STEEL

3309.1 SCOPE

Provide high-strength, low-alloy structural steel shapes, plates, bars, sheets, and strips.

3309.2 REQUIREMENTS

Provide high-strength, low-alloy shapes, plates, and bars meeting the requirements of ASTM A 709/A 709M, for Grade 50W [345W], and 3308, "General Requirements for Structural Steel."

Provide high-strength, low-alloy sheet and strip meeting the requirements of ASTM A 606, for Type 4 hot rolled material and 3308, "General Requirements for Structural Steel," except ensure the yield strength is at least 50,000 psi [345 MPa].

If the contract does not specify the type of steel, provide any material type listed on the Approved/Qualified Products List. For unpainted structures, provide all steel material of the same type.

3309.3 SAMPLING AND TESTING — (BLANK)

3310 HIGH-STRENGTH LOW-ALLOY COLUMBIUM-VANADIUM STEEL

3310.1 SCOPE

Provide high-strength, low alloy columbium-vanadium steel shapes, plates, bars, sheets, and strips.

3310.2 REQUIREMENTS

Provide shapes, plates, and bars for high-strength, low-alloy columbium-vanadium steel meeting the requirements of ASTM A 709/A 709M, for Grade 50 [345], and 3308, "General Requirements for Structural Steel."

Provide sheet and strip for high-strength, low-alloy columbium-vanadium steel meeting the requirements of ASTM A 1011/A 1011M, for Grade 50 [340] Class 1, and 3308, "General Requirements for Structural Steel."

3310.3 SAMPLING AND TESTING — (BLANK)

3312 STAINLESS STEEL

3312.1 SCOPE

Provide stainless steel plates, sheet, and strip.

3312.2 REQUIREMENTS

Provide stainless steel plates, sheet, and strip meeting the requirements of ASTM A 240 for Type 302 or Type 304.

For the finish, use a No. 4 polish, except on sheet and strip used in bearing and modular expansion joint assemblies, use a No. 8 polish.

Provide stainless steel bars meeting the requirements of ASTM A 276 for Type 302 or Type 304, Condition A (annealed). Provide pin stock in accordance with the requirements for Type IV in 3314, "Cold-Finished Bar Steel."

For free machining applications such as bolt stock, provide stainless steel meeting the requirements of ASTM A 582/A 582M Type 303, Condition A, cold finished, unless otherwise required by the contract. Provide bolt stock in accordance with 3391.2.E, "Stainless Steel Bolts."

De-scale and clean stainless steel surfaces in accordance with ASTM A 380.

If welding, use stainless steel with a carbon content no greater than 0.03 percent.

3312.3 SAMPLING AND TESTING — (BLANK)

3313 HOT ROLLED BAR STEEL

3313.1 SCOPE
Provide rounds, squares, hexagons, or flats for hot rolled bar steel of the following types, as required by the contract:

3313.2 REQUIREMENTS

A Type I — Carbon Bar Steel
Provide carbon bar steel with the following characteristics:

(1) A minimum yield strength of 45,000 psi [310 MPa],
(2) A minimum ultimate strength of 60,000 psi [420 MPa], and
(3) A minimum elongation of 20 percent in 2 in [50 mm].

Use ASTM A 400, "Practice for Steel Bars, Selection Guide, Composition, and Mechanical Properties," to select the material specifications and grade in accordance with the section and mechanical properties. Procure steel in accordance with the relevant procurement specifications.

B Type II — Alloy Bar Steel
Provide alloy bar steel with the following characteristics:

(1) A minimum yield strength of 55,000 psi [380 MPa],
(2) A minimum ultimate strength of 85,000 psi [585 MPa], and
(3) A minimum elongation of 15 percent in 2 in [50 mm].

Use ASTM A 400, "Practice for Steel Bars, Selection Guide, Composition, and Mechanical Properties," to select the material specifications and grade in accordance with the section and mechanical properties. Procure steel in accordance with the relevant procurement specifications.

C Type III — Heat-Treated Alloy Bar Steel (Round)
Provide heat-treated alloy bar (round) steel in accordance with ASTM A 434, with mechanical properties meeting the requirements for Class BC.

D Type IV — Corrosion Resisting Cold Finished Rounds
Provide cold-finished, hot-rolled stainless steel bars for bridge pins, finished to size in a fabrication shop. Manufacture bars for bridge pins from a base material that is annealed and hot-finished free machining, Type 303, as specified in ASTM A 582. After turning, ensure the size does not exceed a pin diameter of 5½ in [140 mm].

3313.2 SAMPLING AND TESTING — (BLANK)

3314 COLD-FINISHED BAR STEEL

3314.1 SCOPE
Provide rounds, squares, hexagons, or flats as required by the contract.

3314.2 REQUIREMENTS

A Type I — Carbon Bar Steel

Provide cold-finished carbon bar steel meeting the requirements of ASTM A 108 for Grade C 1035, and the following strength requirements, unless the contract requires otherwise:

(1) For rounds with a diameter no greater than 2⅞ in [73 mm] and hexagons and squares with a maximum dimension across flats no greater than 3 in [75 mm]:
- (1.1) A minimum yield strength of 60,000 psi [415 MPa],
- (1.2) A minimum ultimate strength of 70,000 psi [485 MPa], and
- (1.3) A minimum elongation of 10 percent in 2 in [50 mm].

(2) For rounds with a diameter greater than 2⅞ in [73 mm] and flats, hexagons, and squares with a maximum dimension across flats greater than 3 in [75 mm]:
- (2.1) A minimum yield strength of 45,000 psi [310 MPa],
- (2.2) A minimum ultimate strength of 60,000 psi [415 MPa], and
- (2.3) A minimum elongation of 20 percent in 2 in [50 mm].

B Type II — Alloy Bar Steel

Provide cold-finished alloy bar steel meeting the requirements of ASTM A 331 for the corresponding annealed and cold-finished Grade AISI A 4140 or Grade AISI A 4142 and the following strength requirements, unless the contract requires otherwise:

(1) For rounds with a diameter no greater than $2^{15}/_{16}$ in [74 mm] and hexagons and squares with a maximum dimension across the flats no greater than 3 in [75 mm]:
- (1.1) A minimum yield strength of 75,000 psi [520 MPa],
- (1.2) A minimum ultimate strength of 95,000 psi [655 MPa], and
- (1.3) A minimum elongation of 10 percent in 2 in [50 mm].

(2) For rounds with a diameter greater than $2^{15}/_{16}$ in [74 mm] and hexagons, squares, and flats with a maximum dimension across the flats greater than 3 in [75 mm]:
- (2.1) A minimum yield strength of 55,000 psi [380 MPa],
- (2.2) A minimum ultimate strength of 85,000 psi [585 MPa], and
- (2.3) A minimum elongation of 15 percent in 2 in [50 mm].

C Type III — Pre-Heat Treated Alloy Bar Steel (Rounds)

Provide cold-finished pre-heat treated alloy bar steel with the following characteristics:

(1) Base material meeting the requirements of ASTM A 331 for corresponding Grade AISI A 4140 or Grade AISI A 4142.

(2) Stock that is pre-heat treated by quenching and tempering to meet the physical properties specified in Table 3313-1, and is in a machinable condition.

D Type IV — Corrosion Resisting Cold Finished Rounds

Provide cold-finished stainless steel rounds for use as bridge pins meeting the requirements of ASTM A 276 for Type 316, annealed and center-less ground. Ensure the pin diameter does not exceed 4½ in [115 mm].

3314.3 SAMPLING AND TESTING — (BLANK)

3315 STEEL FORGINGS

3315.1 SCOPE

Provide material for steel forgings.

3315.2 REQUIREMENTS

A Material Requirements

Provide material for steel forgings meeting the requirements for one of the three types of steel specified in this section, as required by the contract. If the contract does not specify a steel type, provide Type I.

A.1 Type I — Carbon Steel Forgings

Provide carbon steel forgings meeting the requirements of ASTM A 668/A 668M for Class D forged from blooms, billets, bars, or slabs meeting the requirements of ASTM A 711 for Grade C 1035 or Grade C 1040.

A.2 Type II — Alloy Steel Forgings

Provide alloy steel forgings, for sizes no greater than 9 in [225 mm] thick or in diameter, meeting the requirements of ASTM A 668/A 668M for Class G.

Provide alloy steel forgings, for sizes greater than 9 in [225 mm] thick or in diameter, meeting the requirements of ASTM A 668/A 668M for Class H.

Provide alloy steel forgings made from alloy steel blooms, billets, bars, or slabs meeting the requirements of ASTM A 711 for Grade A 4140, Grade A 4142, or Grade A 4145.

A.3 Type III — Corrosion Resisting Steel Forgings

Provide corrosion resisting steel forgings made from billets or bars primarily produced for re-forging in accordance with ASTM A 314 for Type 316.

Provide steel forgings meeting the physical and chemical requirements for hot-rolled materials as specified in ASTM A 276. Provide Type 316 material that is fully annealed to develop maximum corrosion resisting properties. Workmanship, appearance, and finish must conform to ASTM A 484.

B Machine Finishing

Machine steel forgings after the annealing process is complete. Finish forgings in accordance with 2471, "Structural Metals."

Unless otherwise shown on the plans or required by the contract, bore a 2 in [50 mm] round hole longitudinally through the center of each type of forged steel pin roller measuring over 9 in [225 mm] in diameter.

3315.3 SAMPLING AND TESTING

Ensure the supplier performs the following physical and chemical tests required by the ASTM Specifications for Type I, Type II, and Type III material:

(1) Perform magnetic particle tests on Type I forgings in accordance with ASTM E 709.
(2) Perform magnetic particle tests on Type II forgings in accordance with ASTM A 275/A 275M.
(3) Perform ultrasonic tests on Type III forgings in accordance with ASTM A 388/A 388M.

Ensure the supplier performs magnetic particle testing after machining operations are complete. The Engineer will reject material with serious defects such as bursts, cracks, pipes, internal cracks and flakes, or laminations.

Submit to the Engineer certified test reports for physical, chemical, magnetic particle, and ultrasonic tests from the supplier.

3316 HIGH PERFORMANCE STEEL (345 MPA Y.S.)

3316.1 SCOPE

Provide high-strength, low-alloy structural steel shapes, plates, and bars to enhance atmospheric corrosion resistance, weldability, and mechanical properties.

3316.2 REQUIREMENTS

Provide material for high-performance steel meeting the requirements of ASTM A 709/A 709M, Grade HPS 50W (HPS 345W), and 3308, "General Requirements for Structural Steel." Provide Grade HPS 50W (HPS 345W) high-performance steel with a minimum specified yield strength of 50 ksi [345 MPa].

3316.3 SAMPLING AND TESTING — (BLANK)

3317 HIGH PERFORMANCE STEEL (485 MPA Y.S.)

3317.1 SCOPE

Provide high-strength, low-alloy structural steel shapes, plates, and bars, to enhance atmospheric corrosion resistance, weldability, and mechanical properties.

3317.2 REQUIREMENTS

Provide materials for high-performance steel meeting the requirements of ASTM A 709/A 709M, Grade HPS 70W [HPS 485W], and 3308, "General Requirements for Structural Steel." Provide high-performance steel Grade HPS 70W [HPS 485W] with a minimum specified yield strength of 70 ksi [485 MPa].

3317.3 SAMPLING AND TESTING — (BLANK)

3321 GRAY IRON CASTINGS

3321.1 SCOPE

Provide gray iron castings for drainage or structural use. The castings are classified according to tensile strength, but the Department will make provisions for acceptance of drainage castings and other ornamental or non-stress bearing castings on the basis of flexural tests.

3321.2 REQUIREMENTS

Provide gray iron castings meeting the requirements of AASHTO M 105 for the class required by the contract. Obtain the castings from foundries, approved by the Materials Engineer, in accordance with these specifications.

A Class Designation

If the contract does not specify a strength class, provide castings in accordance with the following:

(1) Provide Class 40C, or better, for stress bearing castings such as bridge rockers, bolsters, and sliding shoes; or
(2) Provide Class 35B, or better, for bridge rail posts, light standard bases, drainage and manhole castings, and other castings subject to vehicle impact or vehicle loading.

B Special Requirements

Provide drainage castings of metal with a Brinell Hardness Number from 190 to 265.

Provide round casting assemblies with lid-to-frame surfaces machine-milled to provide true bearing around the entire circumference.

C Foundry Control

Before beginning casting, the manufacturer and the Engineer will establish, in conference, a control procedure for correlating casting operations, arranging for foundry inspection, and establishing an approved identification system. Unless the Engineer otherwise agrees, the manufacturer will identify castings as follows:

(1) With a mark correlating the casting with test bars using a system of heat numbers or a calendar date and tap number, using numerals no greater than ½ in [13 mm];
(2) With a mark indicating the source of manufacture, using a symbol no greater than 1½ in [38 mm] in the largest dimension or a letter no greater than ¾ in [19 mm] high and 2 in [50 mm] long;
(3) With the Department's type or style number shown on the plans, in the size and location indicated.

Form these identification marks on castings of sufficient size during manufacture. If the casting size is insufficient for the marks, use stamped metal tags wired to the castings for markings not formed in the castings. Place identification marks, subject to approval by the Engineer, where they will not interfere with assembly of parts and will not be removed during machine finishing operations. Ensure the manufacturer does not place its name on castings except as specified above.

D Casting Details

Provide castings meeting the dimensions shown on the plans. Provide draft by increasing the net dimensions. Provide castings within a tolerance of ⅛ in [3 mm] for the overall general dimensions. Limit the tolerance in dimensions of grates and covers for drainage casting assemblies, and the openings into which they fit, to $^{1}/_{16}$ in [1.5 mm]. In no case is the metal thickness to be less than $^{1}/_{16}$ in [1.5 mm] less than the thickness shown on the plans.

Provide castings with a density of at least 95 percent of the theoretical density of that type, based on 442 lb/cu. ft [7080 kg/cu. m], cast to the exact dimensions shown on the plans.

Pour castings in closed molds with gating, feeders, risers, and sprues. Ensure castings completely fill the molds. Do not remove castings from the molds until properly cooled. Do not chill the castings.

Boldly fillet castings on the inside and re-entrant corners. Round the outside corners and edges to a radius of at least ⅛ in [3 mm]. For bridge bearings, use a ½ in [13 mm] fillet except where the fillet may interfere with assembly.

E Workmanship and Finish

Remove attachments of gates, risers, and sprues from the castings and grind remaining extensions flush to the casting surface. The Engineer will reject castings damaged through careless removal of attachments. Do not repair by welding.

Fabricate castings free of sponginess, cracks, blow holes, warping, sand inclusions, cold shuts, chilled iron shrinks, and other defects that affect the strength and value of the casting for the purpose intended. Ensure the contact surfaces between different castings in an assembly provide a firm, even bearing, without rattling or rocking.

Clean castings of foundry sand, rust, scale, and other deleterious material.

3321.3 SAMPLING AND TESTING

Ensure the manufacturer casts the required number of test bars, as stated below, and machine finishes tension test specimens to the dimensions required in the Schedule for Materials Control. Unless otherwise approved by the Engineer, the manufacturer will deliver test specimens to the Materials Laboratory for testing.

Cast three test bars for each heat or tap. If adding alloys in the ladle, cast three test bars for each ladle. For continuous furnace pouring, cast two test bars at the beginning and two test bars at the end of cast.

For bridge bearing castings, cast at least one test bar for each casting. Pour castings and test bars in the presence of the Engineer, unless the test bars are cast as an integral part of the bearing castings.

Identify each test bar separately and to the corresponding castings using symbols, letters, or numbers cast on the test bar and casting.

If properly identifying castings and corresponding test bars is not possible, the Engineer may require test specimens to be cut from selected castings that are representative of a lot, and perform tests on those samples.

3322 CARBON STEEL CASTINGS

3322.1 SCOPE

Provide mild to medium strength carbon steel castings for general applications requiring a tensile strength of no more than 70,000 psi [485 MPa].

3322.2 REQUIREMENTS

Provide carbon steel castings meeting the requirements of ASTM A 27M for the grade required by the contract and this section.

A Grade Designations

If the contract does not specify a strength grade, provide castings in accordance with the requirements for ASTM A 27 Grade 70-36 [485-250].

Supply castings in a normalized or normalized and tempered condition.

B Casting Details

Provide casting patterns that will produce a finished casting with the dimensions and details shown on the plans. Provide draft by increasing the net dimensions without reducing the metal thickness as required by the contract.

Boldly fillet sharp angles. Provide fillets of a size that does not reduce the clearance required by the contract. Round external corners on castings, except ornamental types, to a radius of $^{3}/_{16}$ in [5 mm].

Make allowance for shrinkage and provide enough material on surfaces requiring a finish to produce castings of the specified size and shape after the completion of finishing operations as shown on the plans.

The Engineer will not allow split cores between unfinished surfaces of restricted clearance. Provide face cores of one piece, unless castings require machine finishing. Provide chaplets spaced, and in numbers to prevent the chaplets from impairing the strength of the casting. Provide chaplets that are completely fused.

Fabricate castings using methods that will ensure corners, arises, and edges are completely filled. For castings with one machine surface, cast with the machine surface down. Do not use metal from different melts in the same casting.

Do not withdraw castings from the mold until properly cooled. Do not quench castings to speed up cooling.

C Workmanship and Finish

The Engineer will reject castings with structural defects in a casting, including blow hole shrink pipes, sand hole cracks, checks, slag inclusions, cold shuts, unfilled arises, warped surfaces, or deformation from core or flask movement. Do not repair castings with minor defects until the Engineer provides permission and approves the repair method.

Grind extensions, high spots, and rough edges resulting from pouring connections, smooth and flush with the casting surface. Clean castings of foundry sand, rust, scale, and other deleterious material before painting, galvanizing, or metalizing as required by the contract.

Clean, paint, galvanize and metalize castings in accordance with 2471, "Structural Metals."

3322.3 SAMPLING AND TESTING

If the Engineer suspects the soundness of a casting, the Engineer has the right to subject castings to radiographic or magnetic particle inspection, at no additional cost to the Department.

A Test Specimens

Attach test coupons using the preferred method of a keel block, but do not make attachments that may structurally weaken the casting.

Cast two test coupons integrally for each casting greater than 750 lb [340 kg]. Provide two test coupons for each casting heat less than 750 lb [340 kg], and cast the test coupons as ribs, integrally and below a special block no less than 6 in × 6 in × 2 in [150 mm × 150 mm × 50 mm].

B Foundry Control

Identify castings with embossed markings, indicating the heat from which the casting was poured, together with the bridge and piece numbers. Die mark the same information on the representative test coupons.

Mark test coupons and castings for each heat. Do not remove coupons until after the castings are heat-treated. The Engineer will reject castings without proper identification unless the inspector can identify corresponding test coupons by matching fractures.

3323 ALLOY STEEL CASTINGS

3323.1 SCOPE

Provide alloy steel castings meeting the requirements of ASTM A 743, for Grade CA-15 and this section.

3323.2 REQUIREMENTS

Provide alloy steel castings meeting the requirements of ASTM A 743, for Grade CA-15 and this section.

Provide castings in a normalized or normalized and tempered condition. Ensure that the reduction of area is at least 30 percent.

3323.3 SAMPLING AND TESTING

Provide test specimens, foundry control, casting details, workmanship and finish, and inspection and testing in accordance with 3322.2.B, "Casting Details," 3322.2.C, "Workmanship and Finish," 3322.3.A, "Test Specimens," and 3322.3.B, "Foundry Control," except cast two test coupons integrally with each casting regardless of mass.

3324 MALLEABLE IRON CASTINGS

3324.1 SCOPE

Provide malleable iron castings.

3324.2 REQUIREMENTS

Provide malleable iron castings meeting the requirements of ASTM A 47M for the grade required by the contract and this section.

For galvanized castings, heat treat to meet the requirements for the specified grade. Galvanize in accordance with ASTM A 153.

3324.3 SAMPLING AND TESTING — (BLANK)

3325 WROUGHT BRONZE PLATES

3325.1 SCOPE

Provide wrought bronze plates.

3325.2 REQUIREMENTS

Provide wrought bronze plates that are cold-finished and meet the requirements of ASTM B 100 for Alloy C51000 or Alloy C65500, or ASTM B 169 for Alloy C61400.

For plates fabricated in accordance with ASTM B 169, meet the following hardness requirements:

Table 3325-1 Wrought Bronze Plates		
Plate Thickness ***in [mm]***	**Hardness**	
	Brinell	**Rockwell by Conversion**
≥ $^{5}/_{16}$ – ½ [8 – 13]	≥ 128	≥ B73
≥ ½ – 2 [13 – 50]	≥ 121	≥ B70

3325.3 SAMPLING AND TESTING — (BLANK)

3327 BRONZE CASTINGS — TYPE 1

3327.1 SCOPE
Provide Type 1 bronze castings for nameplates and other castings.

3327.2 REQUIREMENTS
Provide Type 1 bronze castings meeting the requirements of ASTM B 584, Alloy C83600.

Use this low-strength copper alloy for nameplates and other castings with light detail allowing lightly filleted corners and a natural patina.

3327.3 SAMPLING AND TESTING — (BLANK)

3328 BRONZE CASTINGS — TYPE 2

3328.1 SCOPE
Provide Type 2 bronze castings for bridge bearing plates, medium pressure bearing sleeves, and bright ornamental castings and other items having light details.

3328.2 REQUIREMENTS
Provide Type 2 bronze castings meeting the requirements of ASTM B 148, Alloy C95300 or ASTM B 584, Alloy C86500, subject to the following:

(1) Modify the chemical composition of Alloy C86500 to allow a maximum manganese content of 3.5 percent; and
(2) Unless the plans specify one alloy, the Contractor may use either of the two alloys designated in this section.

Use Type 2 bronze castings for bridge bearing plates, medium pressure bearing sleeves, bright ornamental castings, and other items with light detail allowing medium filleted corners and slightly rounded arises and a medium bright finish.

3328.3 SAMPLING AND TESTING — (BLANK)

3329 LUBRICATED BRONZE BEARING PLATES AND BUSHINGS

3329.1 SCOPE
Provide aluminum bronze bearing plates and manganese bronze bushings.

3329.2 REQUIREMENTS
Provide aluminum bronze bearing plates meeting the requirements of ASTM B 148, Alloy C95400 or Alloy C95500; or ASTM B 169/B 169M, Alloy C61400, Temper M20. Provide manganese bronze bushings meeting the requirements of ASTM B 584, Alloy C86200 or Alloy C86300. Provide bearing plates and bushings from standard production.

Provide bronze bearing plates and bushings with recesses completely filled with lubricating compound. Form recesses by trepanning, drilling, or the shell molding process, as shown on the plans, but at least $^{3}/_{16}$ in [5 mm] deep. Ensure recesses have straight sides without grooves, and do not intersect the edges of the parent plate or bushing. Provide plates with recesses that are uniformly spaced in a geometric pattern over the area of the bearing, with adjacent rows overlapping in the direction of motion.

Provide lubricating compound consisting of graphite, metallic substances, and a lubricant binder to form a dense, non-plastic, lubricating insert, capable of withstanding spalling and atmospheric elements. Do not use shellac or other gummy materials

as the lubricant binder. Ensure the top surface of the bearing insert is flush with or slightly above the surface of the bearing plate or bushing.

For both bearing plates and bushings, provide a lubricated area that comprises 25 percent to 30 percent of the total area. If the plate or bushing manufacturer uses a bearing insert in the shape of a hollow cylinder, ensure the net lubricated area is at least 20 percent of the total area of the plate or bushing.

If the plans do not indicate which surfaces to lubricate, provide inserts for surfaces that have provisions for movement other than flexural.

Provide bearing plates and bushings with contact surfaces with at least a 125 µin [3.175 µm] finish.

Provide bearing plates that are true to detail, flat surfaces truly flat and curved surfaces curved true to the radius with an allowable working tolerance of 0.02 in [500 µm] between male and female fittings. Provide a minimum net section of ½ in [13 mm] for the bronze.

Provide bushings with a wall thickness of at least ⅜ in [10 mm]. Provide the machine allowances for the I.D. and O.D. operating fit of bushings recommended by the manufacturer unless otherwise shown on the plans.

Ensure the bronze and steel portions of bearing plates and bushings are assembled in the fabricating shop and match-marked or bonded together and shipped as a unit.

3329.3 SAMPLING AND TESTING — (BLANK)

3331 SHEET BRASS

3331.1 SCOPE
Provide sheet brass.

3331.2 REQUIREMENTS
Provide sheet brass meeting the requirements of ASTM B 36/B 36M, Alloy C26000 or Alloy C26800, in H02, H03, or H04 temper.

3331.3 SAMPLING AND TESTING — (BLANK)

3332 SHEET COPPER

3332.1 SCOPE
Provide sheet copper.

3332.2 REQUIREMENTS
Provide sheet copper meeting the requirements of ASTM B 152/B 152M for any type of copper with a total copper and silver content at least 99.9 percent, and the following:

(1) Provide a light cold-rolled temper;
(2) The Engineer will waive the requirements for resistivity and embrittlement tests; and
(3) Ensure the copper sheet withstands the bend test by cold-bending the sheet through an angle of 180° flat upon itself without fractures on the outside of the bend portion.

3332.3 SAMPLING AND TESTING — (BLANK)

3335 SHEET LEAD

3335.1 SCOPE
Provide sheet lead prepared from pig lead.

3335.2 REQUIREMENTS
Provide sheet lead prepared from pig lead meeting the requirements of ASTM B 29. Provide sheets with a thickness within a tolerance of 5 percent of the thickness required by the contract.

3335.3 SAMPLING AND TESTING — (BLANK)

3336 WROUGHT AND EXTRUDED ALUMINUM

3336.1 SCOPE
Provide aluminum alloy for specified applications.

3336.2 REQUIREMENTS
Provide aluminum alloy products meeting relevant requirements of the ASTM specifications listed in this section. Provide the alloy and temper for a specified application as required by the contract.

Provide sheet and plate products meeting the requirements of ASTM B 209/B 209M (B 209) for Alloy 1100, Alclad 2024, Alclad 3003, Alclad 5083, Alclad 5154, Alclad 5456, or Alclad 6061.

Provide standard structural shapes, rolled or extruded, meeting the requirements of ASTM B 308/B 308M for Alloy 6061-T6.

Provide pipe and tube products meeting the following requirements:

(1) Drawn, seamless tube in accordance with ASTM B 210/B 210M for Alloy 6061 or Alloy 6063;
(2) Seamless pipe and seamless extruded tube in accordance with ASTM B 241/B 241M for Alloy 6061 or Alloy 6063; and
(3) Extruded structural pipe in accordance with ASTM B 429 for Alloy 6061 or Alloy 6063. Provide sand castings meeting the requirements of ASTM B 26/B 26M for Alloy SG70A [356.0] or Alloy S5B [443.0]. Provide permanent mold castings meeting the requirements of ASTM B 108 for Alloy SG70A [9356.0], Alloy SG70B [A356.0], Alloy S5B [443.0], or Alloy S7A [A444.0].

Provide other miscellaneous aluminum products as shown on the plans or the special provisions.

3336.3 SAMPLING AND TESTING — (BLANK)

3340 STAINLESS STEEL CLAD PLATE

3340.1 SCOPE
Provide stainless steel clad plate.

3340.2 REQUIREMENTS
Provide stainless steel clad plate meeting the requirements of ASTM A 264 and this section.

Provide Type 316L stainless steel cladding. Unless the contract requires otherwise, provide a plate clad on one side with a nominal thickness of 10 percent, at least 9 percent of the total plate thickness, or no greater than ½ in [13 mm] of cladding.

Provide cladding and base metal with a shear strength of at least 20,000 psi [140 MPa] when tested in accordance with ASTM A 264.

Provide the clad surface of the plate with a sand blasted and pickled finish or a blast cleaned and pickled finish.

Provide the plate in a heat-treated condition. Perform heat treatment so cladding develops maximum corrosion-resistant properties.

3340.3 SAMPLING AND TESTING — (BLANK)

3348 SEVEN-WIRE STRAND FOR PRESTRESSED CONCRETE

3348.1 SCOPE
Provide one of two grades of seven-wire, uncoated, low-relaxation steel strand for pretensioned and posttensioned prestressed concrete construction.

3348.2 REQUIREMENTS
Provide steel strands meeting the requirements of ASTM A 416, Grade 250 [1725] with an ultimate tensile strength of 250,000 psi [1,725 MPa], and ASTM A 416, Grade 270 [1860], with an ultimate tensile strength of 270,000 psi [1,860 MPa], based on the nominal area of the strand.

3348.3 SAMPLING AND TESTING
Submit two copies of the mill certificate, two copies of the stress-strain curve representing the lot, and steel strand samples to the Engineer. Provide mill certifications with bond strength test results representative of the current year's production, showing that the manufacturing process produces strand with a bond strength of at least 36,000 psi [248 MPa] at a measured free-

end slip no greater than $^{3}/_{32}$ in [2.4 mm]. Ensure an accredited, independent testing laboratory performs or certifies bond strength tests. Perform bond strength tests on an embedment length of 18 in [457 mm] in accordance with standard test procedures on file in the Department's Office of Materials.

3351 SHEET STEEL PRODUCTS

3351.1 SCOPE

Fabricate galvanized sheet steel products for erosion control or other uses, including open metal flumes or gutters, culvert headwalls or aprons, anti-seepage diaphragms, erosion dams, and cribbing.

3351.2 REQUIREMENTS

The term, "metal unit" refers to the products specified in this section.

A Materials

Provide galvanized steel in the fabrication of metal units meeting the requirements of ASTM A 929/A 929M, except as modified for different coating classes.

If the plans or specifications specify a galvanized coating requirement other than 2 oz per sq. ft [610 g per sq. m] of sheet, provide galvanized coating in accordance with ASTM A 653/A 653M instead of ASTM A 929/A 929M.

Provide the steel thickness shown on the plans.

Galvanize or sherardize rivets consisting of the same base metal as used for the sheets. Unless the contract requires otherwise, provide bolts, nuts, and washers of commercial grade and galvanized in accordance with ASTM A 153/A 153M. Provide other unspecified steel shapes, plates, bars, and rods made of steel meeting the requirements of 3306, "Low-Carbon Structural Steel," and galvanized in accordance with ASTM A 123/A 123M.

B Fabrication

Provide units fabricated to the shape and dimensions shown on the plans. Avoid cracking or breaking the spelter coating on galvanized sheets.

Ensure fabricated units of the same nominal size and type are interchangeable. Do not drill, punch, or drift to correct defects in manufacture. Ensure the centers of rivets or bolt holes are at least twice the diameter of the holes from the edge of the metal. Locate slots, holes, and lugs for accurate field assembly as shown on the plans.

Drive rivets cold, and ensure the plates are drawn tightly together throughout the entire lap. Provide rivets with full hemispherical heads or heads of a form acceptable to the Engineer. Drive rivets without bending and completely fill the hole with driven rivets.

3351.3 SAMPLING AND TESTING 3226.3

3352 SIGNS, DELINEATORS, AND MARKERS

3352.1 SCOPE

Provide fabricated traffic signs, delineators, and markers consisting of sign panels complete with border, legend, route markers and legend components as individual items.

The Department defines the term "Legend" as all letters, numerals, arrows and symbols that convey the message on signs.

3352.2 REQUIREMENTS

Use traffic signs, delineators and markers as specified in the MnDOT Standard Signs Manual and the MN MUTCD and in accordance with this section.

A Materials

Fabricate signs, delineators, and markers in the colors meeting the FHWA Color Tolerance Charts unless otherwise specified in this section. If using color tolerance charts, determine color compliance by visual comparison with the appropriate chart.

A.1 Base Material for Sign Panels, Delineators and Markers

Use sign base material with no warps or twists and flat so the finished sign, delineator, or marker will lay flat against the post or mounting structure.

A.1.a Sheet Aluminum

Provide sheet aluminum for sign panels, delineators, and markers meeting the requirements of ASTM B 209M for Alloy 5052-H38 or Alloy 6061-T6.

Provide sheet aluminum thickness for single section sign panels, delineators, markers, panel sections of multiple section signs, and sign panels type overlay in accordance with the following:

Table 3352-1
Sheet Aluminum Thickness

Length of Longest Side, *in [mm]*	**Thickness, *in [µm]***
≤18 [≤460]	0.063 ± 0.004 [1600 ± 100]
>18 [460] – 30 [760]	0.080 ± 0.005 [2030 ± 130]
>30 [>760]	0.100 ± 0.005 [2540 ± 130]
Overlays	0.040 ± 0.004 [1020 ± 100]

A.1.b Extruded Aluminum, Bolted Type

Provide extruded aluminum panels meeting the requirements of ASTM B 221M for Alloy 6063-T6 and in accordance with the following sizes and weights:

(1) 12 in [300 mm] wide and at least 2.53 lb per ft [3,765 g per m] of length, and
(2) 6 in [150 mm] wide and at least 1.02 lb per ft [1,518 g per m] of length.

Use aluminum alloy hardware, as recommended by the manufacturer, or stainless steel hardware to assemble the panel sections and to attach to the supports, except use nylon insert stainless steel locknuts meeting the requirements of ASTM F594, Type 304 for the nuts for post clip bolts.

A.2 Retroreflective Sheeting

Provide retroreflective sheeting on the Approved/Qualified Products List for signs, barricades, reboundable drums, cones, and other traffic control devices as specified in this section. Materials on this list meet the performance requirements and impact resistance of ASTM 4956 along with requirements of 23 CFR 655 Appendix to Subpart F. Some standard sheeting types have been modified to reflect MnDOT requirements.

A.2.a Sign Sheeting Type III

Provide Sign Sheeting Type III MC for traffic cones and Sign Sheeting Type III MT for tubular markers and yellow cylinder style delineators. Additionally, test to ensure the impact resistance of the material at 32 °F [0 °C].

A.2.b Sign Sheeting Type IV

Provide white and fluorescent orange Sign Sheeting Type IV for reboundable plastic drums and weighted channelizers. Additionally, test to ensure the impact resistance of the material at 32 °F [0 °C].

A.2.c Sign Sheeting Type V

Provide Sign Sheeting Type V for cylinder style delineators and tubular markers. Additionally, test to ensure the impact resistance of the material at 32 °F [0 °C]..

A.2.d Sign Sheeting Type VI

Provide Sign Sheeting Type VI for temporary roll-up signs.

A.2.e Sign Sheeting Type VIII

Provide white and fluorescent orange Sign Sheeting Type VIII for reboundable plastic drums, weighted channelizers, and white cylinder style delineators. Additionally, test to ensure the impact resistance of the material at 32 °F [0 °C].

A.2.f Sign Sheeting Type IX

Provide fluorescent orange Sign Sheeting Type IX for rigid substrate construction signs, delineators, and markers.

A.2.g Sign Sheeting Type XI

Provide Sign Sheeting Type XI for highway signing, markers, and delineators.

Provide fluorescent orange Sign Sheeting Type XI for rigid substrate construction signs.

Provide Sign Sheeting Type XI for work zone barricade sheeting.

A.3 Warranty Requirements

Ensure the sign sheeting materials are included on the MnDOT Approved/Qualified Products List at the time of letting, and ensure the warranty provided by the sign sheeting materials manufacturer meets or exceeds the requirements in Table 3352-2.:

Table 3352-2
Reflective Sheeting Manufacturer Warranties

Material	Warranty
Prismatic sign sheeting for permanent signs and white cylinder style delineators (non-fluorescent)	12 years total. The first 7 years covers 100 percent full replacement of all material and labor costs associated with fabricating and installing the sign or device. The final 5 years covers 100 percent of sheeting replacement.

Table 3352-2
Reflective Sheeting Manufacturer Warranties

Material	Warranty
Fluorescent prismatic sign sheeting for permanent signs	10 years total. The first 7 years covers 100 percent full replacement of all material and labor costs associated with fabricating and installing the sign or device. The final 3 years covers 100 percent of sheeting replacement.
Encapsulated lens sign sheeting for permanent signs and yellow cylinder style delineators	10 years total. The first 7 years covers 100 percent full replacement of all material and labor costs associated with fabricating and installing the sign or device. The final 3 years covers 100 percent of sheeting replacement.
Encapsulated lens sign sheeting for traffic cones	Replacement of defective products.
Encapsulated lens sign sheeting for tubular markers	Replacement of defective products.
Prismatic sign sheeting for rigid Signs (work zone use)	3 years covers 100 percent sheeting replacement.
Prismatic sign sheeting for reboundable plastic drums and weighted channelizers	Replacement of defective products.
Prismatic sign sheeting for work zone barricades	Prorated warranty for 3 years covers sheeting replacement.
Rollup Sign Sheeting (work zone use)	Prorated warranty for 3 years covers sheeting replacement.

Ensure that the sign sheeting, ink, and overlay film manufacturer(s) provide warranties covering the loss of retroreflectivity, loss of colorfastness, cracking, and other conditions inherent to the sheeting, including inks and overlay film that causes ineffectiveness in meeting the intended use.

If the sheeting color does not meet the color specifications of ASTM D 4956 , Table 11, along with requirements of 23 CFR 655 Appendix to Subpart F during the warranty period, the Department will consider the sheeting to have lost colorfastness.

Maintain retroreflectivity values during the warranty in accordance with the following:

Table 3352-3
Minimum Retroreflectivity Values

Sign Sheeting Type	Warranty Period, *years*	Minimum Allowable Retroreflection	Total Daytime Luminance Factor Minimum
Type III	1 – 7	80%	—
Type III	8 – 10	70%	—
Type III MC	None	—	—
Type III MT	None	—	—
Type IV Drums and Channelizers	None	—	—
Type VI	1 – 3	50%	20%
Type VIII Cylinder Style Delineators	1 – 7	80%	—
Type VIII Cylinder Style Delineators	8 – 12	70%	—
Type VIII Fluorescent Orange	None	—	—
Type IX	1 – 7	80%	—
Type IX	8 – 12	70%	—
Type IX Fluorescent Yellow-Green	1 – 10	70%	60%
Type IX Fluorescent Yellow	1 – 10	70%	40%
Type XI FO Fluorescent Orange	1 – 3	70%	20%
Type XI	1 – 7	80%	—
Type XI	8 – 12	70%	—
Type XI Fluorescent Yellow Green	1 – 10	70%	60%
Type XI FO Fluorescent Yellow	1 – 10	70%	40%
Type XI FO Fluorescent Orange	1 – 10	70%	20%
Type XI B	1 – 10	50%	—

Note: Percentages are based on minimum original values meeting the requirements of ASTM D 4956-

Enforce warranties provided by sign sheeting materials manufacturer(s) and assist the Department in enforcing such warranties as necessary and as requested by the Department.

A.4 Pigmented Plastic Film Sign Face

Ensure the pigmented plastic film sign sheeting materials are included on the MnDOT Approved/Qualified Products List at the time of letting, and ensure the warranty provided by the sign sheeting manufacturer meets the requirements of respective retroreflective sign sheeting material used in Table 3352-2.

Use sign faces made of pigmented, flexible, weather-resistant plastic film free from streaks, blisters, wrinkles, and other surface imperfections. Use plastic film with a high gloss surface that, if applied over a contrasting black and white surface, can completely hide the colors, and can be applied over embossed surfaces. Apply the film to aluminum panels in accordance with the sign sheeting materials manufacturer's recommendations. Cure the film for 48h from 70 °F [21 °C] to 90 °F [32 °C] and ensure the film meets the following characteristics:

(1) Film does not shrink more than $^{1}/_{32}$ in [1 mm] from the edge of a panel at 150 °F [65 °C] for 48h,
(2) Film and adhesive do not separate at −10 °F [−23 °C] for 24h,
(3) Adhesion, color, and general appearance show no visible effects from immersion in distilled water for 24h, and
(4) Film and adhesive do not delaminate at 150 °F [65 °C] after 24 h.

A.5 Direct Applied Legend

Do not apply the legend to demountable shapes before applying the legend. Directly apply the legend to the sign face in accordance with the following:

A.5.a Sign Sheeting Type IX 3352.2.A.2.e

A.5.b Sign Sheeting Type XI 3352.2.A.2.f

A.5.c Screen Processed Painted Legend

Use a direct or reverse screening process to apply the painted legend to the face. Use screen process paints approved by the sign sheeting materials manufacturer that will adhere to the retroreflective sheeting surface in accordance with sign sheeting materials manufacturer's recommendations. Digitally printed legend and border will not be accepted.

A.5.d Pigmented Plastic Film Legend

Provide a legend consisting of shapes cut from pigmented plastic film as specified in 3352.2.A.4, "Pigmented Plastic Film Sign Face." Apply the pigmented plastic film directly to the sign face.

A.6 Fasteners

A.6.a Fasteners for Flat Sheet Sign Panel Sections

Use solid, grooved pin rivet fasteners, consisting of a pin meeting the requirements of ASTM B 209M, Alloy 2024-T4 and a collar meeting the requirements of ASTM B 209M, Alloy 6061-T6A, to assemble sign panel sections. The grooved pin shall provide a secure grip for the swaged collar. Use brazier head pins, except use counter sunk head pins or aluminum, stainless steel, nylon, or vinyl plastic shim collars to eliminate interference with legend components or overlays.

A.6.b Fasteners for Type Overlays

Use aluminum alloy pull-through rivet fasteners to attach Type Overlays. Place nylon washers under fastener heads to protect the surface of the retroreflective sheeting.

B Fabrication

B.1 General

Fabricate signs, delineators and markers as shown on the plans and with details and alphabets contained in the MnDOT Standard Signs Manual and Federal Standard Highway Signs and Markings book. Fabricate signs, delineators, and markers as recommended by the sign sheeting materials manufacturer and free of cracks, wrinkles, blisters, and other blemishes.

B.2 Design and Dimensions

Fabricated finished signs, delineators, and markers must be in accordance with the designs, dimensions, and punching as shown on the plans or in the special provisions.

B.3 Surface Treatment of Metal

B.3.a Aluminum Signs

Clean and treat the metal in accordance with sign sheeting materials manufacturer's recommendations before applying the sign face material. Do not use chromate type chemical conversion treatment.

Apply cleaning or treatment chemicals or detergents as directed by the sign sheeting materials manufacturer. Maintain laboratory facilities to test and control the concentration of the solutions used at the treatment plant. Maintain a log of the concentration of treating solutions.

B.3.b Cleaning and Handling

Before painting or applying reflectorizing material, clean surfaces with detergents or cleaners that will not harm any surface treatment on the metal.

After treatment and cleaning, use a device or clean canvas gloves to handle sign base material until after the application of sign face material.

B.4 Applying Sign Face and Legend Sheeting

Apply retroreflective sheeting, pigmented plastic film sign face, and legend material as recommended by the sign sheeting materials manufacturer.

Do not splice retroreflective sign sheeting on panels with dimensions smaller than 48 in [122 cm] in height and 48 in [122cm] in width. If the retroreflective sign sheeting material is not available in this width, use the widest width material available for that type.

Splice the retroreflective sign sheeting so that all sheeting joints are vertical. Use the least number of seams possible. Butt-joint gaps so that gap does not exceed 1/32 in [0.8 mm].

Match colors of adjacent sheets of retroreflective sign sheeting on sign panels so that there is no noticeable difference in color.

Do not splice pigmented plastic film sign materials except on sign panels where the background changes color.

C Packaging

Before packaging, allow signs to stand for at least 12 h. Pack single panel signs in corrugated paper cartons or other containers to prevent the package from breaking and to protect the signs from damage during shipment. Separate signs with coated paper that will not stick to the sign face material. Package single-panel signs in packages weighing no greater than 125 lb [57 kg] and no thicker than 3½ in [90 mm]. The Department will not require packaging of multiple-panel signs unless shipped by public carrier. Deliver multiple-panel signs without damage.

3352.3 SAMPLING AND TESTING

The Engineer may inspect sign fabrication and materials at the fabrication site, at the sign sheeting materials manufacturer's plant or at the project.

Notify the Engineer at least 14 days before fabricating the signs. The Engineer may send an inspector to the plant to inspect the raw materials or the fabrication. If the inspector inspects the signs during fabrication, the inspector will stamp each package of signs with the Department inspection mark or with the mark of its delegated representative.

3354 PREFORMED PAVEMENT MARKING TAPE FOR PERMANENT TRAFFIC LANE DELINEATION AND LEGENDS

3354.1 SCOPE

Provide white and yellow retroreflective pavement marking tape prefabricated for recessed traffic marking on bituminous and concrete pavements.

3354.2 REQUIREMENTS

A General

Provide pavement marking tape meeting the following requirements and characteristics:

(1) Made of prefabricated retroreflective pliant polymer material,
(2) Provides a cushioned resilient substrate that reduces bead crushing and loss,
(3) Weather resistant,
(4) Under traffic wear, shows no appreciable fading in accordance with the color requirements in 3354.2.C, "Color," lifting, or shrinkage throughout the life of the marking,
(5) Shows no significant tearing, roll back, or other signs of poor adhesion,

(6) Underside of the pavement marking tape precoated with pressure sensitive adhesive, and
(7) Protected during shipment and in storage.

Apply the preformed pavement marking tape as recommended by the manufacturer to provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Use equipment and application methods specified by the manufacturer.

Uniformly distribute beads throughout the polymer with strongly bonded protruding surface beads.

Provide precut messages and symbols meeting the requirements of MN MUTCD and FHWA *Standard Alphabets for Highway Signs and Pavement Markings* in custom kits. Use separate pieces or segments to form individual letters or symbols only to the extent supplied by the manufacturer. Do not use standard rolls of line material to piece together individual letters or symbols. Provide lane line widths, tape colors, and adhesive type as required by the contract.

B Retroreflectivity

Provide preformed pavement marking material meeting the minimum initial pavement marking retroreflectivity values using 30 m geometry and meeting the testing procedures of ASTM E 1710:

Table 3354-1
Minimum Initial Pavement Marking Retroreflectivity

	White	Yellow
Tape	600 mcd/sq. m/lux	500 mcd/sq. m/lux

C Color

Provide preformed pavement marking tape meeting the following requirements:

(1) White color no darker or yellower than 17778 of Federal Standard Number 595C,
(2) Daytime color of yellow meeting the following CIE Chromaticity limits using illuminant "D65"

Table 3354-2
Daytime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

(3) Luminance Factor, Cap Y meeting the requirements of ASTM D 6628, Table 3, and
(4) Nighttime color of yellow meeting the following chromaticity limits as specified in ASTM D 6628, Table 2:

Table 3354-3
Nighttime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

D Tensile Stress

Provide preformed pavement marking tape with a tensile stress of at least 40 psi [276 kPa] at maximum load when tested in accordance with ASTM D 638. Test a sample 6 in × 1 in × 0.060 in [150 mm × 25 mm × 1.5 mm] at a temperature from 70 °F to 81 °F [21 °C to 27 °C] using a jaw speed of 6 in [150 mm] per min.

E Elongation

Provide preformed pavement marking tape with an elongation of at least 15 percent at maximum load, when tested in accordance with ASTM D 638.

F Skid Resistance

Ensure the surface of the retroreflective pliant polymer provides a skid resistance value of at least 45 British Pendulum Number (BPN) when tested in accordance with ASTM E 303.

G Thickness

G.1 Unpatterned

Provide unpatterned retroreflective pavement marking tape at least 0.060 in [1.5 mm] thick.

G.2 Patterned

Provide patterned retroreflective pavement marking tape at least 0.065 in [1.6 mm] thick at the thickest portion of the patterned cross-section and at least 0.020 in [0.5 mm] thick at the thinnest portion of the cross-section.

3354.3 SAMPLING AND TESTING

Submit samples at least 10 ft [3 m] long of each color required to the Materials Laboratory. Submit to the Engineer a manufacturer's Certificate of Compliance.

Mark the samples with the following information:

(1) Name of manufacturer,
(2) Place of manufacture,
(3) Batch or lot number, and
(4) Month and year of manufacture.

3355 REMOVABLE PREFORMED PAVEMENT MARKING TAPE FOR TRAFFIC LANE DELINEATION AND LEGENDS

3355.1 SCOPE

Provide white and yellow removable retroreflective preformed pavement marking tape for use as temporary traffic markings.

3355.2 REQUIREMENTS

A General

Provide removable retroreflective preformed pavement marking tape listed on the Approved/Qualified Products List and meeting the following requirements and characteristics:

(1) Precoated with a pressure sensitive adhesive;
(2) Capable of adhering to asphalt concrete and portland cement concrete surfaces as recommended by the manufacturer without the use of heat, solvents, or other additional adhesive means, and immediately ready for traffic after application;
(3) Capable of performing for the duration of six non-winter months;
(4) Capable of being removed intact or in large pieces without the use of heat, solvents, grinding, or blasting;
(5) Reinforced by a non-metallic medium to facilitate removal;
(6) Provided in the widths and shapes required by the contract;
(7) Available in preformed words and symbols meeting the requirements for the applicable shapes and sizes in accordance with the MN MUTCD;
(8) Packaged in a way that the chemical composition is not altered or compromised; and
(9) Meets all requirements in this specification for at least 1 year after the date of purchase, when stored in a cool dry indoor area.

B Color

Provide white retroreflective preformed pavement marking tape no darker or yellower than 17778 of Federal Standard Number 595C.

Provide yellow retroreflective preformed pavement marking tape meeting the following requirements:

(1) Daytime color meeting the following CIE Chromaticity limits using illuminant "D65/2:"

Table 3355-1
Daytime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

(2) Luminance Factor, Cap Y, meeting the requirements of ASTM D 6628, Table 3, and
(3) Nighttime color meeting the following chromaticity limits as specified in ASTM D 6628, Table 2:

Table 3355-2
Nighttime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

C Retroreflectivity

Provide retroreflective preformed pavement marking material meeting the minimum initial pavement marking retroreflectivity values using 30 m geometry and meeting the testing procedures of ASTM E 1710:

Table 3355-3 Minimum Initial Pavement Marking Retroreflectivity		
	White	**Yellow**
Tape	600 mcd/m²/lux	500 mcd/m²/lux

D Frictional Resistance

Ensure the surface of the retroreflective pavement marking film provides a frictional resistance value of at least 45 British Pendulum Number (BPN) when tested in accordance with ASTM E 303.

E Thickness

Provide retroreflective pavement marking film, including beads, at least 50 mils [1.3 mm] thick.

3355.3 SAMPLING AND TESTING

Submit samples at least 10 ft [3 m] long of each color to be used. Submit to the Engineer a manufacturer's Certificate of Compliance. Clean the surface of the tape sample of dirt, adhesive, and asphalt. Provide tape samples capable of being unrolled for the entire length on a surface for testing.

Mark the rolls of material with the following information:

(1) Name of manufacturer,
(2) Place of manufacture,
(3) Batch or lot number, and
(4) Month and year of manufacture.

3356 PREFORMED THERMOPLASTIC PAVEMENT MARKING

3356.1 SCOPE

Provide retroreflective thermoplastic pavement marking product prefabricated for recessed traffic marking on bituminous and concrete pavements.

3356.2 REQUIREMENTS

A General

Provide thermoplastic pavement marking product meeting the following requirements and characteristics:

(1) Made of prefabricated retroreflective, resilient thermoplastic material;
(2) Contains glass beads uniformly distributed through the entire cross sectional area;
(2) Capable of being affixed to bituminous or concrete pavement by heating;
(3) Resistant to deterioration due to exposure to sunlight, water, salt, and adverse weather conditions;
(4) Under traffic wear, shows no appreciable fading in accordance with the color requirements in 3356.2.C, lifting, or shrinkage throughout the life of the marking;
(5) Capable of conforming to pavement contours, breaks, and faults through the action of traffic at normal pavement temperatures;
(6) Possesses resealing characteristics, such that it is capable of fusing with itself and previous thermoplastic markings when heated; and
(7) Protected during shipment and in storage.

Apply the preformed thermoplastic pavement marking as recommended by the manufacturer to provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Use equipment and application methods specified by the manufacturer.

Provide precut messages and symbols meeting the requirements of the MN MUTCD *and the MnDOT Standard Signs Manual* in custom kits. Use separate pieces or segments to form individual letters or symbols only to the extent supplied by the manufacturer. Provide shapes, sizes, and colors as required by the contract.

B Retroreflectivity

Provide preformed thermoplastic pavement marking material meeting the minimum initial pavement marking retroreflectivity values using 30 m geometry and meeting the testing procedures of ASTM E 1710:

Table 3356-1 Minimum Initial Pavement Marking Retroreflectivity		
	White	**Yellow**
Thermoplastic	400 mcd/sq. m/lux	250 mcd/sq. m/lux
Thermoplastic, enhanced skid resistance (ESR)	250 mcd/sq. m/lux	150 mcd/sq. m/lux

C Color

Provide preformed thermoplastic pavement marking material meeting the following requirements:

(1) White color no darker or yellower than 17778 of Federal Standard Number 595C;
(2) Daytime color of yellow meeting the following CIE Chromaticity limits using illuminant "D65/2°":

Table 3356-2 Daytime Chromaticity Coordinates (Corner Points)				
	1	**2**	**3**	**4**
x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

(3) Luminance Factor, Cap Y meeting the requirements of ASTM D 6628, Table 3, of 35 % min for white and 25% min for yellow; and
(4) Nighttime color of yellow meeting the following chromaticity limits as specified in ASTM D 6628, Table 2:

Table 3356-3 Nighttime Chromaticity Coordinates (Corner Points)				
	1	**2**	**3**	**4**
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

D Glass Beads

Ensure intermixed glass beads provided in the preformed thermoplastic material meet the requirements of AASHTO M 247 Type 1 and/or Type 3 to meet the retroreflectivity requirements of section 3356.2B above, and have a minimum of 80% rounds.

E Skid Resistance

Ensure the surface of the retroreflective preformed thermoplastic material provides a skid resistance value of at least 45 British Pendulum Number (BPN) when tested in accordance with ASTM E 303. Ensure that the surface of preformed thermoplastic material with enhanced skid resistance provides a skid resistance value of at least 60 BPN.

F Thickness

Provide retroreflective thermoplastic pavement marking material at least 90 mils thick.

3356.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance. Provide a sample measuring at least 6"x 6" of precut legends or 1 sheet of precut line material of each color used to the Materials Laboratory.

Mark the samples with the following information:

(1) Name of manufacturer,
(2) Place of manufacture,
(3) Batch or lot number, and
(4) Month and year of manufacture.

3361 STRUCTURAL STEEL TUBING

3361.1 SCOPE
Provide steel tubing for structural use in trusses or bridge rails.

3361.2 REQUIREMENTS
Provide steel tubing that conforms to the following requirements:

(1) The ASTM requirements below and 3308, "General Requirements for Structural Steel,"
(2) The requirements for Type A or the plans,
(3) Either welded or seamless tubing for all applications, and
(4) Easily weldable using conventional shop practices.

A Type A — Cold formed Carbon Steel Tubing
Provide Type A square or rectangular structural tubing meeting the requirements of ASTM A 500, for Grade B.

B Type B — Hot formed Carbon Steel Tubing
Provide Type B square or rectangular structural tubing meeting the requirements of ASTM A 501.

C Type C — High Strength Low Alloy Weathering Steel Tubing
Provide Type C square or rectangular structural tubing meeting the requirements of ASTM A 847 or ASTM A 618, for Grade Ia, Grade Ib, or Grade II.

3361.3 SAMPLING AND TESTING — (BLANK)

3362 STRUCTURAL STEEL PIPE

3362.1 SCOPE
Provide steel pipe for structural use in railing.

3362.2 REQUIREMENTS
Provide steel pipe for structural use meeting the requirements of ASTM A 53/A 53M, ASTM A 106 (seamless pipe); ASTM A 135 (welded pipe); or provide structural steel tubing meeting the requirements of ASTM A 500, or ASTM A 501 with the following modifications:

(1) Unless the contract requires a different mass or wall thickness, provide pipe with a mass of at least the standard mass for Schedule 40 in accordance with ASTM A 53/A 53M;
(2) Provide pipe with a minimum yield strength of 35,000 psi [240 MPa];
(3) Unless required by the contract, the Engineer will not require hydrostatic testing;
(4) Provide pipe free of dirt, grease, loose scale, and rust;
(5) Provide pipe with plain ends unless the contract requires threaded ends;
(6) Provide pipe free of mill stamps and large or heavy knurl marks;
(7) Provide screw fittings 3 in [75 mm] or less in diameter made from either steel or malleable iron. Provide cast steel for screw fittings over 3 in [75 mm] in diameter;
(8) Provide high-strength low-alloy structural tubing meeting the requirements of ASTM A 618, for Grade 1; and
(9) Provide welding fittings meeting the requirements of ASTM A 234/A 234M for factory-made wrought carbon steel and ferritic alloy steel welding fittings. Use a grade equivalent to the tensile properties specified for the steel pipe.

3362.3 SAMPLING AND TESTING — (BLANK)

3363 ALUMINUM TUBE FOR PIPE RAILING

3363.1 SCOPE
Provide aluminum alloy extruded tubes for bridge railing.

3363.2 REQUIREMENTS
Provide aluminum alloy extruded tubes for bridge railing meeting the requirements of ASTM B 221, Alloy 6061-T6510.

3363.3 SAMPLING AND TESTING — (BLANK)

3364 WROUGHT STEEL PIPE

3364.1 SCOPE
Provide wrought steel pipe for bridges and structures.

3364.2 REQUIREMENTS
Provide wrought steel pipe meeting the requirements of ASTM A 53/A 53M with a mass or wall thickness that at least meets the requirements of ASTM A 53/A 53M, Schedule 40, unless the contract requires otherwise.

Galvanize the pipe and fittings, unless the contract requires otherwise.

The Contractor may provide cast steel or malleable iron screw fittings for fittings no greater than 3 in [75 mm] in diameter. Provide cast steel screw fittings for fittings greater than 3 in [75 mm] in diameter.

Provide welding fittings meeting the requirements of ASTM A 234/A 234M for butt welding fittings.

3364.3 SAMPLING AND TESTING — (BLANK)

3365 DUCTILE IRON PRESSURE PIPE

3365.1 SCOPE
Provide ductile iron pressure pipe.

3365.2 REQUIREMENTS
Provide ductile iron pressure pipe meeting the requirements of ASTM A 377 for the diameter and relevant American Standard required by the contract. Provide ductile iron pressure pipe coated with bituminous enamel lining and exterior coating.

3365.3 SAMPLING AND TESTING — (BLANK)

3366 COPPER WATER TUBE AND FITTINGS

3366.1 SCOPE
Provide copper water tube and fittings.

3361.2 REQUIREMENTS
Provide copper water tube meeting the requirements of ASTM B 88/B 88M for Type A pipe, annealed. Provide red brass, flared fittings for copper water tube.

3361.3 SAMPLING AND TESTING — (BLANK)

3371 STEEL SHELLS FOR CONCRETE PILING

3371.1 SCOPE
Provide steel shells for cast-in-place concrete piling.

3371.2 REQUIREMENTS
Provide cylindrical steel shells for cast-in-place concrete piles meeting the physical strength and chemical requirements of ASTM A 252, Grade 3.

If specified in the plans as an alternative, the Contractor may provide cold-rolled fluted steel shells meeting the requirements of SAE 1010 or SAE 1015 with tensile yield strength of at least 50,000 psi [345 MPa] in accordance with ASTM A 370. Provide tapered piles with a tip diameter of at least 8 in [200 mm] and a butt diameter of at least the nominal diameter required by the contract.

Provide steel shells with a thickness and strength capable of withstanding the driving forces to substantial refusal in accordance with 2452.3.E, "Penetration and Bearing," and with a nominal wall thickness as specified in Table 3371-1, "Steel Shell Requirements."

For piling with a painted finish in accordance with 2452.3.J.1, "Painted Piles," or with a galvanized finish in accordance with 2452.J.2, "Galvanized Piles," provide piling free of irregularities or deleterious matter adversely affecting the finished coating.

The Contractor may request the Engineer's approval of the use of small quantities of piling representing less than 5 percent of the entire structure, from the Contractor's surplus of cut-offs and overruns. Submit mill test reports and a certification stating that the Department previously approved the piling for use on another Department project.

Table 3371-1 Steel Shell Requirements		
	Steel Shell Options	
Nominal Pile Size, *in [mm]*	**Nominal Outside Diameter, *in [mm]***	**Minimum Wall Thickness, *in [mm]****
10 [254]	10 [254]	0.219 [5.56]
	10¾ [273]	0.219 [5.56]
12 [305]	12 [305]	0.250 [6.35]
	12¾ [324]	0.250 [6.35]
	12 [305], fluted‖	0.179 [4.55]
16 [406]	16 [406]	0.312 [7.92]
	16 [457], fluted‖	0.203 [5.16]
18 [457]	18 [457]	0.375 [9.53]
	18 [457], fluted‖	0.250 [6.3]
20 [508]	20 [508]	0.375 [9.53]
24 [610]	24 [610]	0.500 [12.70]

* Unless otherwise shown on the plans or special provisions.
‖ Do not use fluted or tapered shells for exposed pile-bent piles unless otherwise shown on the plans or special provisions for a particular structure.

3371.3 SAMPLING AND TESTING

Provide one certified copy of mill test reports with heat numbers identified, including physical test reports and chemical analyses, and mill shipping papers to the Engineer before delivering the material to the project. Include the actual carbon, manganese, and phosphorus contents in the chemical analysis report.

3372 STEEL PILING

3372.1 SCOPE

Provide steel H-piles for structure construction.

3372.2 REQUIREMENTS

Provide steel H-piles for bearing sections in the size and weight per unit of length as shown on the plans and meeting the requirements of ASTM A 572/ASTM A 572M, Grade 50 [Grade 345] for structural quality carbon steel shapes.

Provide a steel H-pile tip listed on the MnDOT Approved/Qualified Products website under "H-Pile Tip Protection".

3372.3 SAMPLING AND TESTING

Provide one certified copy of mill test reports with heat numbers identified, including physical test reports and chemical analyses, and mill shipping papers to the Engineer before delivering the material to the project. Include the actual carbon, manganese, and phosphorus contents in the chemical analysis report.

3373 STEEL SHEET PILING

3373.1 SCOPE

Provide steel sheet piling for construction of bridges and piers.

3373.2 REQUIREMENTS

Provide a steel sheet piling of the style, dimensions, and mass required by the contract and meeting the requirements of ASTM A 328/A 328M or ASTM A 572/A 572M for Grade 290 [42], Grade 345 [50], or Grade 415 [60].

3373.3 SAMPLING AND TESTING — (BLANK)

3376 FENCE WIRE

3376.1 SCOPE

Provide barbed, woven, and chain link fencing wire, wire fasteners, tie wires, hardware, and tension wire.

3376.2 REQUIREMENTS

A Barbed Wire

Provide 4 point, full round barbs at least 0.375 in [9.5 mm] long. The Contractor may provide one of the following types of barbed wire, meeting the requirements of AASHTO M 280, unless the contract requires otherwise:

(1) Zinc-coated barbed wire meeting the requirements of Class 3,
(2) Standard security grade aluminum-coated barbed wire, or
(3) High security grade aluminum-coated barbed wire.

B Woven Wire

Provide metallic-coated, Type A or Type Z Class 3 steel woven wire fence fabric meeting the requirements of AASHTO M 279, for the size and construction required by the contract.

Provide No. 9 Grade 60 design woven wire fabric meeting the requirements of AASHTO M 279 if the contract does not specify the size and construction.

Use the hinge joint method with at least 1½ tightly wrapped twists to join the vertical stay wires to each horizontal line wire.

C Chain Link

Provide chain link fabric meeting the requirements of AASHTO M 181 for the type required by the contract. Use chain link fence with the finished wire size, mesh size, selvage type, and fabric height as shown on the plans. Use Class A extruded and bonded or Class B bonded Type IV fabric, PVC coated steel.

D Miscellaneous Items

Provide hardware items meeting the requirements of AASHTO M 181 unless otherwise specified in this section or required by the contract.

Use L-shaped staples with barbed, serrated, or ring shanks or U-shaped staples made of 9 gauge [3.8 mm] diameter wire galvanized after fabrication meeting the requirements of ASTM A 153 to attach wire to wood posts with shank length as specified in 2557.3.C.2, "Barbed Wire and Woven Wire.

Use flat metal bands instead of wire fasteners if approved by the Engineer.

Provide hog rings meeting the requirements of ASTM F 626. When polymer coating is required, provide hog rings with a Class 2A or Class 2B polymer coating thickness meeting the requirements of ASTM F 668.

Provide wire ties meeting one of the following requirements:

(1) 9 gauge steel meeting the requirements of AASHTO M 181, or
(2) At least 0.179 in [4.55 mm] aluminum alloy meeting the requirements of ASTM B 211, Alloy 1100 H18.

Provide polymer-coated wire ties meeting the same coating thickness requirements as polymer-coated fabric.

Provide tension wire meeting the requirements of AASHTO M 181.

Provide tension bars, truss rods, truss rod tighteners, barbed wire arms, tension bands, brace bands, rail and brace ends, rail sleeves, post and line caps, and cups meeting the requirements of AASHTO M 181.

Provide polymer-coated tension bars, truss rods, truss rod tighteners, tension bands, brace bands, post and line caps, and cups with a bonded polymer coating thickness of at least 0.010 in [0.25 mm].

Provide zinc coated nuts and bolts meeting the requirements of AASHTO M 232. Shop-paint or field-paint nuts and bolts when polymer-coated fence is required.

3376.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance for each fence component in this section including Buy America compliance, if required.

Sample and test in accordance with the Schedule of Materials Control.

3379 FENCE GATES

3379.1 SCOPE

Provide vehicular gates and pedestrian gates with pipe frames.

3379.2 REQUIREMENTS

A General

Use the same pipe, hardware, fittings, fence wire, and appurtenance materials to assemble all gates provided to the project.

B Materials

Use a frame made of galvanized steel pipe or aluminum alloy pipe.

B1 Galvanized Steel Pipe

Provide galvanized steel pipe meeting the requirements of ASTM A 53 for galvanized Standard Schedule 40 pipe with plain ends. Hydrostatic testing of the pipe is not required.

B2 Aluminum Alloy Pipe

Provide aluminum alloy pipe meeting the requirements of AASHTO M 181.

B3 Fittings and Hardware

As shown on the plans, use corner fittings, tops, stretcher bars, truss rods, and other required fittings, hardware, and appurtenances made of steel, malleable iron, wrought iron, or aluminum alloy. If using steel or iron, galvanize fittings or hardware in accordance with AASHTO M 181 after fabrication.

B4 Wire

Provide barbed wire, gate fabric for woven wire fence, and gate fabric for chain link fence as specified in 3376, "Fence Wire."

C Physical Properties

Use gate and members with physical properties as shown on the plans.

Use fittings, hardware, and other required appurtenances capable of being securely fastened and fitted to meet the requirements of the approved design.

Provide hinges and catch and locking devices meeting the requirements of an approved design.

3379.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance for each component in this section including Buy America compliance, if required.

Sample and test in accordance with the Schedule of Materials Control.

A Metal Pipe and Fittings.....3406

B Fence Wire and Fasteners 3376

3381 WIRE ROPE AND FITTINGS FOR CABLE GUARDRAIL

3381.1 SCOPE

Provide wire rope and accessory fittings for use in cable guardrail construction.

3381.2 REQUIREMENTS

Provide wire rope and fittings for proprietary high-tension cable guardrail systems meeting the manufacturer's specifications.

Provide wire rope and fittings for low-tension cable guardrail meeting the requirements of AASHTO M 30 and the following:

A Wire Rope Requirements

Provide wire rope meeting the requirements of Type 1 with Class A coating unless otherwise specified.

B Fitting Requirements

Unless the manufacturer specifies otherwise, provide bolts and nuts used to assemble the guardrail elements meeting the requirements of ASTM A 307.

Provide bolt heads and nuts with dimensions meeting the requirements of ANSI No. B 18.2 for the type shown on the plans.

Use externally threaded fittings including end tie rods, anchor rods, post loops, and splicing studs that transmit direct tensile stress having a tensile strength of at least 75,000 psi [520 MPa]. Use internally threaded fittings such as turnbuckles, cable

sockets, and nuts capable of withstanding a proof load equal to 85 percent of the proof load requirements for nuts as specified in ASTM A 307, Table III. Use expansion assemblies, cable splices, and connections capable of withstanding a proof load equal to the tensile strength required of the attached wire rope cable or as specified by the manufacturer.

Provide steel rectangular plate washers and cable clamps with a tensile strength of at least 60,000 psi [420 MPa]. Provide ferrous metal plain circular washers meeting the requirements of ANSI/ASME B 18.22.1, Type A.

3381.3 SAMPLING AND TESTING

Provide samples for testing as directed by the Engineer.

The Engineer will test wire rope and fittings for cable guardrail meeting the requirements of AASHTO M 30.

3382 STEEL PLATE BEAMS AND FITTINGS FOR TRAFFIC BARRIERS (GUARDRAIL)

3382.1 SCOPE

Provide steel plate beams and fittings for use in guardrail construction.

3382.2 REQUIREMENTS

Provide steel plate beams and fittings for guardrail construction meeting the requirements of AASHTO M 180 for the type and class required by the contract. Unless the plans show otherwise, provide beams meeting the requirements for Class A, Type II (galvanized).

Provide w-beam and thrie-beam rail elements, posts, blocks, soil plates, reducer sections, and end treatments that meet the requirements of *A Guide to Standardized Highway Barrier Hardware*, published by AASHTO, ARTBA, and AGC.

3382.3 SAMPLING AND TESTING

Triple-spot test galvanized beams and fittings.

3385 ANCHOR RODS

3385.1 SCOPE

Provide anchor rod material in four general strength levels. The plans may show, or the special provisions may specify other types of anchor rod material.

3385.2 REQUIREMENTS

Use the ASTM or product reference for each type of anchor rod material. Unless the contract requires otherwise, provide anchor rods meeting the requirements for Type A and fabricated from single rounds. Galvanize Type A, Type B, and Type C anchor rods in accordance with 3392, "Galvanized Hardware," unless otherwise shown on the plans.

A Type A — Carbon Steel Anchor Rods

Provide Type A anchor rods meeting the requirement of ASTM F 1554, for Grade 36, Type 2A, with supplementary requirement S3 for permanent grade identification. Provide nuts and washers as recommended in ASTM F 1554 for Grade 36 anchor rods.

B Type B — Intermediate Strength Anchor Rods

Provide Type B anchor rods meeting the requirements of ASTM F 1554, for Grade 55, Type 2A, with supplementary requirement S1 for weldability and supplementary requirement S3 for permanent grade identification. Provide nuts and washers as recommended in ASTM F 1554 for Grade 55 anchor rods.

C Type C — High Strength Anchor Rods

Provide Type C anchor rods meeting the requirements of ASTM F 1554, for Grade 105, Type 2A, with supplementary requirement S3 for permanent grade identification and supplementary requirement S5 for Charpy impact testing. Provide nuts and washers as recommended in ASTM F 1554 for Grade 105 anchor rods. Do not make an anchorage cage by tack-welding Type C anchor rods or welding anchor rods to other material. Hold Type C anchor rods in place mechanically using methods approved by the Engineer.

D Type D — Stainless Steel Anchor Rods

Provide Type D anchor rods, nuts, and washers meeting the requirements of ASTM A 276 for Type 304 or Type 316 stainless steel, and 3391.2, "Fasteners, Requirements," for stainless steel fasteners. Do not make an anchorage cage by tack welding Type D anchor rods or welding anchor rods to other material. Hold Type D anchor rods in place mechanically using methods approved by the Engineer.

3385.3 SAMPLING AND TESTING — (BLANK)

3391 FASTENERS

3391.1 SCOPE

Provide various types and grades of fasteners for use in general and structural applications.

3391.2 REQUIREMENTS

Provide fasteners of the type shown on the plans. Provide bolts, nuts, and washers meeting the requirements of ANSI for the type required by the contract. Unless otherwise required by the contract, provide threads that are ANSI Coarse Thread Series with a Class 2A tolerance for bolts and Class 2B tolerance for nuts.

A Common Structural Steel Bolts

Provide bolts and nuts meeting the requirements of ASTM A 307. For bolts at least ½ in [13 mm] in diameter, use Grade B bolts with heavy hexagon nuts.

B High Strength Structural Steel Bolts

Provide field and shop bolts for steel bridges meeting the requirements of ASTM A325, Type 3 bolts. Provide bolts that project through the nut from ⅛ in [3 mm] to ⅜ in [10 mm]. Provide field and shop nuts for steel bridges that meet ASTM A 563/A 563M, Grade C3 or DH3 nuts and shop washers for steel bridges that meet ASTM F 436/F 436M, Type 3 washers.

Provide bolts, nuts, and washers installed before the application of the prime coat, in the uncoated "Black" condition. Apply the same paint coatings to the bolts as applied to the structural steel. Provide mechanically galvanized fasteners that are to be field installed after the application of the prime coat meeting the requirements of ASTM B 695, Class 50, Type 1.

For all other bridges and structures, provide bolts meeting the requirements of ASTM A 325, Type 1, (for painted or galvanized applications) or Type 3 (for unpainted weathering steel applications). Provide bolts that project through the nut from ⅛ in [3 mm] to ⅜ in [10 mm]. Provide nuts meeting the requirements of ASTM A 563/A 563M and washers meeting the requirements of ASTM F 436/F 436M.

Only retighten bolts meeting the requirements of ASTM A 325 once.

Regardless of specified finish, provide nuts lubricated with a lubricant of contrasting color meeting the requirements of ASTM A 563 Supplementary requirements S1, S2, and S3 at the time of the installation of the fasteners.

C Bolts for Wood Construction

Unless otherwise shown on the plans, provide bolts for wood construction in accordance with 3391.2.A, "Common Structural Steel Bolts," and galvanized by a mechanical or hot-dip process. Provide the mass of coating meeting the requirements of ASTM A 153/A 153M.

D Stud Welded Fasteners

Provide studs in the size and configuration required by the contract. Provide defect-free, weldable carbon steel studs meeting the requirements of ASTM A 108 for cold drawn bars, Grade 1015, Grade 1018, or Grade 1020. For the purpose of welding, provide studs with fluxed tips or fluxed ferrules and equipped with a ceramic ring or ferrule arc shield.

Provide material for the studs meeting the following characteristics:

(1) An ultimate strength of at least 60,000 psi [420 MPa];
(2) A yield strength of at least 50,000 psi [345 MPa];
(3) A elongation of at least 20 percent in 2 in [50 mm]; and
(4) A reduction of area of at least 50 percent.

Provide threaded studs with nuts capable of developing the minimum ultimate strength requirement of the net cross section area of the threaded portion of the stud.

Provide shear connector studs with a head height and head diameter within a dimensional tolerance of $^{1}/_{16}$ in [1.5 mm].

Identify stud containers by the heat number of the steel from which the studs were produced.

E Stainless Steel Bolts

Provide stainless steel bolts made of material meeting the requirements of ASTM F 593, for Condition CW1, Type 304, Type 316, or Type 316L. Provide finished bolts with the following characteristics:

(1) A yield strength of at least 60,000 psi [415 MPa],
(2) An ultimate tensile strength of 95,000 psi [660 MPa], and
(3) A minimum elongation of 20 percent in 2 in [50 mm].

Provide stainless steel nuts made of material meeting the requirements of ASTM F 594, Condition CW1, Type 304, 316, or 316L.

After fabrication (if required), fully anneal bolts, nuts, and washers to promote maximum corrosion resistance of the stainless steel. After heat treatment, give parts a pacifying treatment in a nitric acid solution. Perform the pacifying treatment in accordance with standard commercial practice. Provide bolts of dimensions meeting the requirements of ANSI B 18.2 for Regular Hexagon-head Cap Screws. Finish surfaces in accordance with the American bolt, nut and rivet manufacturers. Provide nuts meeting the requirements for ANSI B 18.2 for Regular Finished Hexagon. Provide washers as shown on the plans.

F Tension Indicators

Provide and test compressible-washer-type, direct tension indicators (DTI) in accordance with ASTM F 959/F 959M. Submit three samples of each lot of tension indicators with the test reports to the Materials Laboratory for testing. The Engineer will reject lots if the representative washer samples fail the tests performed.

3391.3 SAMPLING AND TESTING

If the minimum bolt strength requirements are specified in the contract, perform testing in accordance with ASTM A 370, except only use a wedge for testing high-strength structural steel bolts. Do not use reduced-dimension specimens for test purposes. Determine the yield strength using relevant methods specified in ASTM E 8M. For bolts with nuts, provide nuts capable of withstanding a proof load equal to the required tensile strength of the bolt.

Provide test bolts and nuts of each type, in each size and length. Provide two test bolts and nuts for each increment of 1,000, or fraction of 1,000, bolts supplied.

3392 GALVANIZED HARDWARE

3392.1 SCOPE

Provide galvanized hardware as specified in the contract.

3392.2 REQUIREMENTS

Provide galvanized hardware and miscellaneous items as shown on the plans. Galvanize hardware items using the hot-dip process meeting the requirements of with ASTM A 153, or mechanically galvanize the hardware meeting the requirements of ASTM B 695, Class 50, Type I.

3392.3 SAMPLING AND TESTING

Sample and test in accordance with the requirements of the Schedule of Materials Control.

3394 GALVANIZED STRUCTURAL SHAPES

3394.1 SCOPE

Provide galvanized structural shapes, plates, bars, and castings for pipes and structures.

3394.2 REQUIREMENTS

Blast clean all items in accordance with SSPC-SP6/NACE No. 3 – Commercial Blast Cleaning before galvanizing. Exceptions to this blast cleaning requirement are listed in 2471.3.L.1, "Galvanizing."

Provide structural shapes, plates, bars, and castings galvanized meeting the requirements of ASTM A 123. Provide castings that have been pickled before galvanizing.

For galvanized items that are warped or distorted, straighten to tolerance no greater than ⅛ in [3 mm] in 10 ft [3,000 mm], or as directed by the Engineer.

For galvanized surfaces that have handling marks or minor chips that no greater than ½ in [12.5 mm] at the narrowest dimension, repair in accordance with ASTM A 780, Annex 1 or Annex 2 (brush applied paint only). Ensure the dry film thickness (DFT) of the coating repair is in accordance with ASTM A 123. Perform repairs in accordance with the supplier's quality procedures. Obtain an approved non-conformance report (NCR) for each repair.

3394.3 SAMPLING AND TESTING — (BLANK)

3399 FLAP GATES

3399.1 SCOPE

Provide flap-type drainage control gates for direct attachment to the outlet ends of culvert and sewer pipe as shown on the plans or required by the special provisions. If shown on the plans or required by the special provisions, provide gates with attachment to the outlet structure.

3399.2 REQUIREMENTS

A Base Metal

Provide frame, flap, flange, hinge bars, and other basic components of the gate assembly made of cast iron, cast steel, structural steel, or other metals approved by the Engineer. Provide hinge bushings and pins made of non-corrosive metal approved by the Engineer. Do not use bronze or brass fittings on gates attached to aluminum alloy drainage structures.

Provide iron castings meeting the requirements of ASTM A 48, Class 30B or better, ASTM A 47 or ASTM 47 M, Grade 32510. Provide steel castings meeting the requirements of ASTM A 27, Grade 60-30 or better. Provide steel components in accordance with 3306, "Low-Carbon Structural Steel," or 3309, "High-Strength Low-Alloy Structural Steel."

B Dimensions and Design

Provide flap gates designed to permit direct attachment to pipe of the type and size required by the contract, or to the outlet structure as shown on the plans or required by the special provisions. Ensure the gates provide practical water tightness against a face pressure and open automatically under a back head allowing free outflow.

Provide a double pivoted flap hinge or a flap hinge otherwise designed to provide accurate seating of the flap and frame and ensure complete closure of the flap using its own mass. Use a design that limits the hinge movement to prevent the flap from becoming lodged in the frame opening.

Provide gates designed to adequately withstand the seating head as shown on the plans. If the plans do not show seating head requirements, provide gates designed to withstand a 10 ft [3 m] seating head.

Provide gates designed or installed to hang closed at all times. Provide suitable flange or hinge fastening adjustments that provide a vertical frame seat when installed. Include provisions for attaching the gate assembly to the pipe or structure as shown in the plans or required by the special provisions, using bolts, flanges, and compression bands or other devices.

For metal pipe installations, the Contractor may shop assemble the gates on a 24 in [600 mm] section of pipe with rivets or bolts. Install the stub section of pipe, with gate attached, on a zero or flat grade when feasible.

The Engineer will approve all critical dimensions and design details of the gate assembly. Provide shop drawings to the Engineer upon request.

C Fabrication and Assembly

Provide castings and fabricated steel components that are free of defects that affect its ability to function for its intended purpose.

Machine mill or grind the contact surfaces between frame and flap to provide true bearing around the entire circumference.

Galvanize cast steel and fabricated steel components of the gate assembly, including steel bolts, nuts, and washers in accordance with ASTM A 153 for the appropriate class of material. In lieu of galvanizing, the Contractor may paint steel specified in 3309, "High-Strength Low-Alloy Structural Steel," in accordance with 2478, "Organic Zinc-Rich Paint System," with an aluminum finish coat. Paint iron castings with an asphalt or coal-tar pitch varnish, or galvanize as required for steel castings. Paint and galvanize after fabrication and before assembly.

3399.3 SAMPLING AND TESTING

Ensure the manufacturer prepared and tested physical test specimens for the tests required in accordance with this section at no additional cost to the Department. Submit to the Engineer the certified test reports provided by the manufacturer showing the results of each test before delivering the material to the project. The Engineer may require the manufacturer make check tests, if results of previous tests are not conclusive.

Posts

3401 FLANGED CHANNEL SIGN POSTS

3401.1 SCOPE

Provide rerolled rail steel and comparable new billet steel posts for signs, delineators, and guide posts.

3401.2 REQUIREMENTS

A Material

Use posts made of rerolled rail steel or a new billet steel meeting the mechanical requirements of ASTM A 499, Grade 60 [420]. For rails weighing at least 91 lb per yd [45 kg per m] of length, use steel meeting the chemical requirements of ASTM A 1.

B Length

Use posts with lengths within ½ inch [13 mm]as shown on the plans or in the special provisions.

C Weight

Use posts with the following nominal weights per length, as shown on the plans or in the special provisions:

(1) 2 lb per ft [3 kg per m],
(2) 2½ lb per ft [3.7 kg per m],
(3) 2¾ lb per ft [4.1 kg per m],
(4) 3 lb per ft [4½ kg per m],

Verify the nominal weights of the posts before punching and without galvanizing, or the addition of anchor plates or other attachments. Use posts weighing up to 5 percent under the weight shown on the plans or the special provisions.

D Shape and Dimensions

Use channel section design posts with flanges for the placement of the signs. Use flanges with a flat front face and positioned in the same plane to provide a smooth, uniform bearing for the sign. The back of the flanges and the posts shall be flat and parallel to the front. Connect the backs of the flanges and the posts flat and parallel to the front. Make the cross section of the posts symmetrical about the central axis, perpendicular to the front and back.

Use straight posts, free of bow, twist, burrs, and other unsightly defects.

E Punching

If the plans specify posts weighing 2 lb per ft [3 kg per m] of length, punch 7/16 in [11 mm] diameter holes along the centerline of the back on 3 in [75 mm] centers, beginning at 1½ in [38 mm] from the top and extending the full length of the post. Space the holes so that the variation in distance between the centers of any two holes is $\pm^{1}/_{16}$ in [1.6 mm] for each 1 in [25 mm] between the holes.

If using posts weighing at least 2½ lb per ft [3.7 kg per m] of length, punch ⅜ in [10 mm] diameter holes along the centerline of the back on either 1 in [25 mm] or 3 in [75 mm] centers, beginning 1 in [25 mm] or 1½ in [38 mm] from the top and extending the full length of the post. Space the holes so that the variation in distance between the centers of any two holes is $\pm^{1}/_{16}$ in [1.6 mm] for each 1 in [25 mm] between the holes.

Punch holes so that cracks do not radiate from the holes.

Table 3401-1
Nominal Dimensions

Requirement	Mass per Unit of Length				
	2.0 lb [3.0 kg]	**2½ lb [3.7 kg]**	**2¾ lb [4.1 kg]**	**3.0 lb [4½ kg]**	
Width, overall across front	3 in [76 mm]	3 in [76 mm]	3 in [76 mm]	3¼ in [83 mm]	
Width, back surface	1 in [25 mm]	1 in [25 mm]	1 in [25 mm]	1¼ in [32 mm]	
Width, flanges (bearing surface)	½ in [13 mm]	½ in [13 mm]	½ in [13 mm]	⅝ in [16 mm]	
Depth overall, front to back	1⅜ in [35 mm]	1⅜ in [35 mm]	1½ in [38 mm]	1½ in [38 mm]	
Thickness of metal, flanges, and back	⅛ in [3 mm]	⅛ in [3 mm]	$^{3}/_{16}$ in [5 mm]	0.16 in [4 mm]	
Side	$^{1}/_{10}$ in [3 mm]	⅛ in [3 mm]	⅛ in [3 mm]	0.15 in [4 mm]	

Note: Dimension requirements are for flat flange sections.

F Galvanizing

Provide posts galvanized in accordance with ASTM A 123.

3401.3 SAMPLING AND TESTING

Obtain a certified mill analysis from the supplier that states the chemical composition of each lot or heat of posts delivered.

The Engineer may take samples for testing from any of the provided posts.

During the inspection of any lot of posts, if the Engineer rejects more than 20 percent of the posts in the lot, the Engineer may reject the entire lot.

3402 SQUARE TUBULAR SIGN POSTS

3402.1 SCOPE

Provide square steel tubular posts for signs.

3402.2 REQUIREMENTS

A Material

Use steel posts meeting standard specification for hot rolled carbon sheet steel, structural quality, ASTM A 1011, Grade 50. The average minimum yield strength after cold forming shall be a minimum of 50,000 psi [345 MPa].

B Length

Use posts with lengths within ¼ inch [6 mm] of the length shown on the plans or in the special provisions.

C Weight

Use posts in accordance with the following, as shown on the plans or in the special provisions:

Size	U.S.S. Gauge	Weight
1 ½″ x 1 ½″ [38 mm x 38 mm]	12	1.7 lbs/ft [2.53 kg/m]
1 ¾″ x 1 ¾″ [44 mm x 44 mm]	12	2.06 lbs/ft [3.07 kg/m]
2″ x 2″ [51 mm x 51 mm]	12	2.42 lbs/ft [3.6 kg/m]
2 ¼″ x 2 ¼″ [57 mm x 57 mm]	12	2.77 lbs/ft [4.12 kg/m]
2 ½″ x 2 ½″ [64 mm x 64 mm]	12	3.14 lbs/ft [4.67 kg/m]
2 $^{3}/_{16}$″ x 2 $^{3}/_{16}$″ [56 mm x 56 mm]	10	3.43 lbs/ft [5.1 kg/m]
2 ½″ x 2 ½″ [64 mm x 64 mm]	10	4.01 lbs/ft [5.97 kg/m]

Use posts weighing anywhere in a range starting from the weight shown for the specified post size and gauge down to 5 percent under that weight.

D Cross Section

Use square tube formed of 12 gauge or 10 gauge steel as shown in plans or special provisions, carefully rolled to size and welded directly in the corner by high frequency resistance welding and externally scarfed to agree with corner radii.

E Hole Punching

Use posts with punched holes $^{7}/_{16}$ [11 mm] ± $^{1}/_{64}$ inches [0.4 mm] in diameter on 1 inch [25 mm] centers on all fours sides down the entire length of the post. Holes shall be on centerline of each side and in true alignment and opposite of each other directly and diagonally.

F Coating

Use posts hot dip galvanized steel in accordance with ASTM A 653, G90. The corner weld shall be zinc coated after scarfing operation. The steel shall also be coated with a chromate conversion coating and a clear organic polymer topcoat. Both the interior and the exterior of the post shall be galvanized. Modifications made to the post after the initial fabrication, such as additional welding or other alterations shall be galvanized.

G Telescoping Properties

Use straight posts, with a smooth uniform finish free of bow, twist and other unsightly defects. All holes and ends shall be free from burrs and ends shall be cut square. Telescoping systems shall meet dimensional requirements and shall permit consecutive sizes of square tubes to telescope freely without necessity of matching any particular face to any other face.

H Anchors

Use galvanized square tube anchors as shown in plans or in the special provisions.

3402.3 SAMPLING AND TESTING

Obtain a certified mill analysis from the supplier that states the chemical composition of each lot or heat of posts delivered.

The Engineer may take samples for testing from any of the provided posts.

During the inspection of any lot of posts, if the Engineer rejects more than 20 percent of the posts in the lot, the Engineer may reject the entire lot.

3403 HOT-ROLLED STEEL FENCE POSTS

3403.1 SCOPE

Provide hot-rolled steel posts and angles for fencing.

3403.2 REQUIREMENTS

Provide hot-rolled steel line posts and angle section post assemblies for end, gate, corner, or intermediate brace assemblies meeting the requirements of ASTM A 702 and as shown on the plans.

3403.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance and a certified mill analysis showing the chemical composition of each delivered lot or heat of posts and compliance with Buy America, if required.

Sample and test in accordance with the Schedule of Materials Control. The Engineer may take samples for testing from any of the provided posts.

3406 STRUCTURAL METAL FENCE POSTS

3406.1 SCOPE

Provide tubular metal posts and rails, metal rolled-formed "C" posts, and fittings for fencing.

3406.2 REQUIREMENTS

A Materials

Provide posts and rails meeting the requirements of AASHTO M 181, except as noted. Use Grade 1 round posts.

For Alternate Roll Formed posts, provide posts meeting the weight and property requirements of ASTM F 1043 for Heavy Industrial Fence Framework Grade 50 with Type A coating.

Use line posts weighing 2.40 lb per ft [3.6 kg per m] nominal.

Use brace bars weighing 1.35 lb per ft [2.0 kg per m] nominal.

Apply coatings on posts, rails, and fittings after welding and fabrication. Provide tie wires, clips, and bands for fastening chain link fabric to posts, rails, and braces as specified in 3376, "Fence Wire." Use Type IV (PVC) posts, rails, and frames first coated with zinc and then coated with PVC Class B bonded to a thickness of at least 0.010 in [250 µm].

B Dimensions

Provide posts, rails, and stretcher bars required by the contract meeting the requirements of AASHTO M 181, except the Engineer will not accept posts greater than 1 in [25 mm] shorter than the specified length.

Use fittings and hardware to fit securely over the posts.

3406.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance and a certified mill analysis showing the chemical composition of each delivered lot or heat of posts and compliance with Buy America, if required.

Sample and test in accordance with the Schedule of Materials Control. The Engineer may take samples for testing from any of the provided posts.

3412 WOOD GUARDRAIL POSTS

3412.1 SCOPE

Provide preservative treated wood posts for use in guardrail construction, including round posts and sawed timber posts with rectangular cross sections and offset blocks.

3412.2 REQUIREMENTS

A Round Posts

A.1 Species of Wood

Provide treated round posts made from the following species of wood:

(1) Northern White Cedar,
(2) Western Red Cedar,
(3) Jack Pine,
(4) Norway (Red) Pine,
(5) Lodgepole Pine,
(6) Ponderosa Pine, or
(7) Southern (Yellow) Pine.

A.2 Seasoning

Air-season wood for treated posts. The wood may be conditioned as part of the treating process for penetration of preservative without damage to the posts.

A.3 Dimensions and Finish

Provide naturally round posts. Shave off inner bark and closely trim knots.

Saw the bottom end of the posts square. Provide posts in the length, nominal diameter, and with a top finish as shown on the plans.

Complete debarking, trimming, and sizing of posts before applying the preservative treatment.

A.4 Quality

Do use wood with the following defects:

(1) Unsound and unsmooth knots that impair the post strength,
(2) Short kinks, defined by a line drawn between centers of the butt and tip falling outside the center of the post by more than 2 percent of the post length,
(3) Checks wider than ¼ in [6 mm],
(4) Unsightly and exaggerated winding twists,
(5) Decay, except Northern White Cedar may contain one pipe rot no greater than ⅜ in [10 mm] in diameter in the top of the post,
(6) Butt rot and ring rot totaling greater than 5 percent of the butt area in Northern White Cedar,
(7) Defects that affect the appearance or impair the strength or durability of the post as determined by the Engineer, and
(8) One-way sweep greater than 2 in [50 mm].

B Sawed Timber Posts

B.1 Species and Grade

Provide sawed timber posts made from the following species of wood:

(1) Douglas Fir,
(2) Southern (Yellow) Pine,
(3) Jack Pine,
(4) Norway (Red) Pine, or
(5) Ponderosa Pine.

Provide sawed timber posts in the grade meeting the following requirements and characteristics:

(1) Stained sapwood,
(2) Splits ¾ of the thickness,
(3) Seasoning checks, single or opposite each other, with a sum total depth equal to half of the post thickness,

(4) Heavy torn grain,
(5) Close grain,
(6) Slope of grain over the full length of post no greater than 1 in 12,
(7) Pitch streaks with medium pitch pockets,
(8) Wane ⅛ of any face,
(9) Shakes ⅓ of the thickness, and
(10) Well-spaced, sound, and tight knots no wider than the following:
(10.1) $1^{3}/_{16}$ in [30 mm] in 5 in [130 mm] posts,
(10.2) 1½ in [40 mm] in 6 in [150 mm] posts, and
(10.3) 2 in [50 mm] in 8 in [200 mm] posts.

For rectangular post sizes, use the wider face to determine the maximum size of the knots permitted.

B.2 Dimensions
Saw the posts and offset blocks to the nominal dimensions as shown on the plans. The Engineer will not require surfacing. Do not allow the sawing dimensions for dry material to vary from the nominal dimensions by greater than −¼ in [6 mm] or +½ in [13 mm].

C Preservative Treatment
Treat posts and offset blocks in accordance with 3491, "Preservatives and Preservative Treatment of Timber Products." Provide treated posts and offset blocks with a dry surface and free of excess preservative.

3412.3 SAMPLING AND TESTING 3491

3413 WOOD FENCE POSTS (TREATED)

3413.1 SCOPE
Provide preservative treated wood posts for fence construction.

3413.2 REQUIREMENTS
A Species of Wood
Provide posts cut from live, growing trees and made from Northern White Cedar or any species of Pine, except Lodgepole Pine.

B Seasoning
Air-season or otherwise condition wood posts to allow penetration of the preservative.

C Manufacture

C.1 Peeling
Shave off inner bark and closely trim knots before treating.

C.2 End Finish
Cut the ends of posts square. If setting the post by driving, the Contractor may cut the larger end to a blunt point with a length no greater than 1½ times the diameter of the pointed end.

C.3 Dimensions
Provide naturally round posts in the length and minimum diameter as required by the contract. The Contractor may provide posts with a diameter at the small end no greater than 2 in [50 mm] greater than the minimum diameter required by the contract.

C.4 Quality
Do not use wood with the following defects:

(1) Knots that impair the post strength,
(2) Short kinks, defined by a line drawn between centers of the butt and tip falling outside the center of the post by more than 2 percent of the post length,
(3) Checks wider than ¼ in [6 mm],
(4) Unsightly and exaggerated winding twists,
(5) Decay, except Northern White Cedar may contain one pipe rot no greater than ¼ in [6 mm] in diameter,
(6) Butt rot and ring rot totaling greater than 5 percent of the butt area in Northern White Cedar, and
(7) Defects that affect the appearance or impair the strength or durability of the post as determined by the Engineer.

D Preservative Treatment
Treat posts in accordance with 3491, "Preservatives and Preservative Treatment of Timber Products."

Cut, trim, and point ends before treatment.

Provide treated posts with a dry surface and free from dripping or excess preservative.

3413.3 SAMPLING AND TESTING 3491

3426 STRUCTURAL WOOD

3426.1 SCOPE

Provide structural wood for dimensional lumber, joists and planks, beams and stringers, and posts and timbers.

A Definitions of Terms ..... ASTM D 9

B Nomenclature ..... ASTM D 1165

3426.2 REQUIREMENTS

A Species of Wood

Use West Coast Douglas Fir or Southern (Yellow) Pine unless otherwise shown on the plans, specified in the special provisions, or specified in the purchase order.

B Standard Sizes

Provide structural wood meeting the dimensions specified for either rough or surfaced stock.

C Preservative Treatment

Provide wood treated in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products," if specified.

D Grading

Provide commercial stress grades of lumber and timber with grade descriptions meeting the stress requirements. The numerical stress values for structural wood required by the contract are the minimum requirements. The Contractor may provide stress graded material meeting grading rules developed from ASTM D 245, Methods for Establishing Structural Grades of Lumber as tabulated by the National Design Specification for Wood Construction (NDS).

The Standard Grading and Dressing Rules of the West Coast Lumber Inspection Bureau, the Standard Grading Rules for Western Lumber of the Western Wood Products Association, and the Standard Grading Rules for Southern Pine of the Southern Pine Inspection Bureau each meet the requirements of ASTM D 245.

3426.3 SAMPLING AND TESTING

Sample and test for preservative treatment in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products."

The Department will make final inspection and acceptance in accordance with the following:

(1) For direct purchases by the Department, at the point of delivery.
(2) For materials provided and installed by a Contractor, at the site of the work.

Lumber, Timber, Piling and Wood Treatment

3457 LUMBER

3457.1 SCOPE
Provide lumber for general building purposes.

Refer to ASTM D 9 for definition of terms.

3457.2 REQUIREMENTS
Use Douglas Fir, Norway (Red) Pine, Ponderosa Pine, White Pine, or Southern (Yellow) Pine.

Provide grade marked lumber graded in accordance with grading rules, adopted by regional associations of lumber manufacturers, in accordance with the requirements of the American Lumber Standards.

Provide No. 1 Grade lumber, unless otherwise specified.

3457.3 SAMPLING AND TESTING 3426

3462 PLANK FOR WEARING COURSE

3462.1 SCOPE
Provide lumber for use as plank for wearing course on bridges.

3462.2 REQUIREMENTS
Refer to ASTM D 9 for the definition of terms and provide plank made from the following species:

(1) Douglas Fir,
(2) Norway (Red) Pine,
(3) Ponderosa Pine,
(4) White Pine,
(5) Southern (Yellow) Pine, or
(6) Northern White Poplar.

Provide plank meeting the following characteristics and requirements:

(1) Sound live-cut timber,
(2) Well seasoned,
(3) Free from pocket rot, dry rot, red heart, cavities, bad checks, loose slivers, loose heart, shakes, splits, any incipient decay, unsound, loose or decayed knots, and ant or worm holes,
(4) Contains no checks in the ends of planks extending greater than 9 in [225 mm] into the piece,
(5) Free from crook,
(6) Contains no corner wane greater than ½ in [13 mm],
(7) Surfaced on one side and one edge (S1S1E) or surfaced on two edges,
(8) Lengths from 6 ft to 16 ft [2 m to 5 m],
(9) Uniform width and thickness through the entire length,
(10) Straight with square-sawed ends, and
(11) Skip on the planed surfaces permitted, not exceeding 15 percent of the surfaced area of any individual plank.

Surface planks with heart center appearing on one side, on the heart side.

For any one bridge, provide planks of the same thickness of at least 1½ in [38 mm] after surfacing.

For any one bridge, the Contractor may provide planks with nominal widths of 6 in [150 mm], 8 in [200 mm], or both. Ensure the widths after surfacing are at least 5½ in [140 mm] for planks with a nominal width of 6 in [150 mm] and 7¼ in [185 mm] for planks with a nominal width of 8 in [200 mm]. Provide planks of each nominal width for any one bridge with the same actual width.

If the contract requires treated plank, provide planks treated with preservative in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products."

3462.3 SAMPLING AND TESTING 3426

3471 TIMBER PILING

3471.1 SCOPE
Provide timber piling for treated and untreated foundation piles below water level.

3471.2 REQUIREMENTS
Provide piling meeting the following requirements:

(1) Capable of withstanding driving without breaking or suffering excessive brooming or splitting,
(2) Cut from sound, live trees, except the Contractor may use fire-killed, blight-killed, or wind-felled trees if no evidence of charred sapwood, wood decay, or insect attachment, and
(3) Free from defects impairing strength or durability.

A Permitted Species

A.1 Untreated Piles
Provide the following types of timber for untreated piles:

(1) Pine,
(2) Tamarack,
(3) Douglas Fir (Coast Region),
(4) Oak,
(5) Elm, or
(6) Hard Maple.

A.2 Treated Piles
Provide the following types of timber for treated piles:

(1) Norway (Red) Pine,
(2) Jack Pine,
(3) Ponderosa Pine,
(4) Southern Yellow Pine, or
(5) Douglas Fir (Coast Region).

A.3 Temporary Structures
If the contract allows untreated timber piling for temporary structures, the Contractor may use any species that will withstand driving to the bearing and penetration required by the contract without damage to the piling.

B Quality of Timber
Provide Douglas Fir, Norway (Red) Pine, and Jack Pine with a sapwood thickness at the butt end of at least ¾ in [19 mm]. Provide Southern Yellow Pine and Ponderosa Pine with a sapwood thickness at the butt end of at least 2 in [50 mm].

Provide untreated trestle piles with a heartwood diameter of at least 80 percent of the diameter of the pile at the butt end.

Do not use timber with checks wider than ¼ in [6 mm].

C Peeling
Peel piles by removing the rough bark and at least 80 percent of the inner bark. Do not leave strips of inner bark greater than ¾ in [20 mm] wide and 8 in [200 mm] long on the pile. Provide at least 1 in [25 mm] of cleaned wood surface between any two strips of inner bark. Provide piles with clean wood on at least 80 percent of the surface circumference at any location on the pile.

D Straightness
Cut piles above the ground swell and provide piles with a gradual taper from the point of butt measurement to the tip.

Ensure that a line drawn from the center of the butt to the center of the tip lies wholly within the body of the pile, and the distance from this line to the center of the pile at any point along the pile is no greater than 1 percent of the length of the pile.

The Contractor may use piles with bends within the upper 75 percent of the pile length, measured from the butt end toward the tip end, if the deviation of the centerline of the pile from a line drawn from the center of the pile above the bend to the center of the pile below the bend is no greater than 4 percent of the length of the bend and is no greater than 2½ in [64 mm]. Do not use piles with bend deviations greater than 1 in [25 mm] if located within the lower 25 percent of the pile length or if located within 10 ft [3 m] from the tip end.

Use piles free of twists greater than half the circumference in any 20 ft [6 m] of length.

Saw off the ends of piles square. Trim knots close to the body of the pile.

E Knots

Do not use piles with unsound knots. The Contractor may use piles with sound knots having diameters no greater than 4 in [100 mm] or 35 percent of the minimum diameter of the pile measured at the knot location. Do not use piles if the sum of the diameters of all knots occurring in a 1 ft [300 mm] length of pile is greater than twice the diameter of the maximum allowable knot size measured at the knot location.

Do not use timber with knot clusters. The Department defines a knot cluster as groups of at least two knots deflecting the fibers of the wood around the entire unit. The Department does not consider a group of single knots, with fibers deflected around each knot separately, as a cluster, regardless of their close proximity.

F Density

Ensure the number of annual rings in any pile, measured at the butt end, averages at least 4 rings per 1 in [25 mm] over the outer 3 in [75 mm] of a representative radial line from the pith. Ensure the outer 1 in [25 mm] within the measured section contains at least 4 rings.

G Dimensions

Provide sound piles with a minimum diameter at the tip end, measured under the bark, in accordance with the following:

Table 3471-1
Minimum Diameter at Tip End

Length of Pile, *ft [m]*	Tip Diameter, *in [mm]*
< 40 [12]	8 [200]
≥40 – ≤74 [12 – 22]	7 [175]
>74 – ≤90 [22 – 27]	6 [150]
> 90 [27]	5 [125]

Provide sound piles with a minimum diameter, measured under the bark at 3 ft [1 m] from the butt end in accordance with the following:

Table 3471-2
Minimum Diameter, 3 ft [1 m] from Butt End

Length of Pile, *ft [m]*	Diameter, *in [mm]*
< 25 [8]	11 [280]
≥ 25 – ≤ 54 [8 – 16]	12 [300]
> 54 [16]	13 [330]

Determine the average diameter of a pile by measuring and dividing the circumference by pi (3.14), or by averaging the maximum and minimum diameters at the locations specified in Table 3171-1 and Table 3171-2 for butt and tip diameters.

Ensure the diameter of the pile, measured at the butt end, is no greater than 20 in [500 mm].

H Preservative Treatment

Treat piling in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products," unless otherwise required by the contract.

3471.3 SAMPLING AND TESTING 3426

3491 PRESERVATIVES AND PRESERVATIVE TREATMENT OF WOOD PRODUCTS

3491.1 SCOPE

Apply wood preservatives and preservative treatment using the pressure process for lumber, timber, piling, posts, poles, plywood, and structural glued laminated members.

3491.2 REQUIREMENTS

A Materials

A.1 Wood Products

Provide timber, lumber, piling, plywood, and posts as required by the contract.
The Department considers Southern Pine the same as Southern Yellow Pine, and Red Pine the same as Norway Pine.

A.2 Preservatives

Provide preservatives listed on the Approved/Qualified Products List and then only for the specific application for which they are approved. Provide preservative meeting the requirements of AASHTO M 133 as modified herein.

B Preservative Treatment

Provide preservative treatment meeting the requirements of AWPA Standard T1and the applicable AWPA Use Category Standards (U1).

B.1 Preparation for Treatment

B.1.a General Requirements

Because difficulty may be encountered in obtaining the specified retention and penetration, ensure the supplier uses wood materials having sufficient sapwood thickness to permit the specified penetration and retention. Ensure suitable conditioning and, for some species, incising prior to the treatment, and the use of treating conditions that do not damage the wood in accordance with AWPA Standards T1, U1, and the applicable AWPA Use Category Standards.

B.1.b BLANK (NOTE: This subsection was moved to 3491.2.G)

B.1.c Incising

Incise the wood to allow penetration of the preservative. Incise lumber and timbers of species difficult to penetrate, including Douglas Fir, Western Larch, Spruce, Hemlock, Redwood, and Jack Pine before treatment such that the incising will not make the material unfit for use. Incise pines if predominantly heartwood. The Engineer may waive the incising requirement if the Contractor can meet penetration and retention requirements without incising.

B.1.d Seasoning

For sawn material treated with an oil-type preservative and used in buildings or other construction where high moisture content or shrinkage would be objectionable, dry to a moisture content no greater than 19 percent before treatment.

Measure the moisture content at a depth equivalent to the required preservative penetration.

Unless the contract requires otherwise, dry lumber no greater than 4 in [100 mm] in nominal thickness and plywood treated with a waterborne preservative to a moisture content no greater than 19 percent before and after treatment.

C Method of Treatment

Unless the contract requires otherwise, the Contractor may use any of the preservative materials listed in this subsection. Use the same preservative on the entire product provided for each contract item, unless the contract requires otherwise.

Use the full-cell process to treat timber products if using with waterborne preservatives.

Field treat cuts, bored holes, and damaged treated areas per the requirements of AWPA M4, except do not use coal tar products, including roofing cement.

D Results of Treatment

Unless the contract requires otherwise, provide preservative retention in accordance with Table 3491-1. Determine the preservative retention meeting the requirements of the AWPA method referenced in Table 2 of the Approved/Qualified Products List for the treatment of timber products.

Provide preservative penetration and other timber product treatments meeting the requirements of AWPA Standard T1 and in accordance with Table 3491-1.

Table 3491-1
Product and AWPA Use Categories

	Product Usage*	AWPA Use Category	AWPA Commodity Specification U1	
			Section	Special Requirements
A	Piles:			
A1	Round	UC4C‖	6E	—
B	Posts: Fence, guide, and sight:			
B1	Round	UC4A‖	6B	—
B2	Sawn four sides	UC4A‖	6A	Subsection 4.3
C	Posts: guardrail and spacer blocks, noise walls:			
C1	Round	UC4B‖	6B	—
C2	Sawn four sides	UC4C‖	6A	Subsection 4.3
D	Poles, lighting:			
D1	Round	UC4B‖	6D	—
E	Lumber and timber:			
E1	Bridges, prefab (nail laminated) panels, other structural members, culverts, and other issues	UC4C‖	6A	Subsection 4.3
E2	Noise wall facing, at or below ground level	UC4B‖	6A	—
E3	Building repair†, at or below ground level	UC4A‖	6A	—
F	Lumber and timber (not in contact with ground or water):			
F1	Handrails, sidewalk plank	UC3B	6A	Subsection 4.3
F2	Noise wall facing, above ground level	UC3B	6A	Subsection 4.3
F3	Building repair†, above ground level	UC3B	6A	Subsection 4.3
G	Glued-laminated structural members: (Treated after gluing)	UC4B‖	6F	—
H	Plywood:			
H1	In contact with ground or water	UC4A‖	6F	—
H2	For use above ground	UC3B	6F	—

* Refer to the Approved/Qualified Products List for information regarding which products may be used on which applications, such as near water, residential, or recreational areas.

‖ For products listed by the AWPA or approved by the International Code Council-Evaluation Service (ICC-ES). Include passing results from the test method AWPA E7. Do not substitute test method AWPA E20.

† Do not use treated wood to construct new buildings or associated components except treated wood may be used as sill plates.

E Handling Treated Products

Care for and handle preservative treated wood products in accordance with the requirements of AWPA Standard M4.

F Product Marking

Hammer, heat brand, dye stamp, or metal tag the treated material marking the species, commercial grade, and type of treatment meeting the requirements of AWPA M1 and AWPA M6, except brand piles on the butt end. Include the charge number in the markings on treated piles.

The Contractor may bundle sawn materials no greater than 2 in [50 mm] in nominal thickness and plywood treated with oil-type preservatives with the tags attached to the bundles. For sawn materials treated with waterborne preservatives, the Contractor may dye stamp the information on the outer pieces of the bundle instead of using bundle tags.

G. Framing (NOTE: This subsection was moved from 3491.2.B1b)

Provide framing with bored holes in accordance with Table 3491-2:

Table 3491-2 Bored Hole Diameter Requirements	
Hardware Types	**Diameter**
Round drift bolts and dowels	Equal to diameter of bolt or dowel
Square drift bolts and dowels	$^{1}/_{16}$ in [2 mm] greater than least dimension of bolt or dowel
Machine bolts	$^{1}/_{16}$ in [2 mm] greater than diameter of bolt
Rods	$^{1}/_{16}$ in [2 mm] greater than diameter of rod
Lag screws	No greater than $^{1}/_{16}$ in [2 mm] of the body diameter of the screw at the root of the thread

3491.3 SAMPLING AND TESTING

Provide for the inspection of materials and treatments meeting the requirements of AWPA M2 by an independent commercial inspection agency. Only use agencies approved by the Materials Engineer for materials provided to Department projects. Engage the inspection agency directly or through the supplier of the treated wood products.

The Department will include the cost of inspection with the relevant contract pay items for treated wood products.

Submit to the Engineer a manufacturer's Certificate of Compliance with each shipment of treated materials. Submit the Certificate of Compliance, the inspection report from the commercial inspection agency, and the treating company's report of treatment to the Engineer.

The Department may inspect treated products upon delivery. Consider the Department's inspection results conclusive and binding.

Paints and Enamels

3501 BASIC REQUIREMENTS FOR PAINTS

3501.1 SCOPE
Provide paints for construction and maintenance.

3501.2 REQUIREMENTS
A Package Stability

Ensure the paint does not cake, liver, thicken, curdle, gel, or show other objectionable properties that cannot be corrected by stirring during 6 months after delivery.

B Colors

Provide paint matching the Federal Standard 595 colors or the Department's standard colors required by the Contract. The Department's standard colors are located at the Materials Laboratory. A paint color is considered to match the specified Standard if $\Delta E \leq 3.0$ when measured according to ASTM D 2244.

C Toxic Metals and Volatile Organic Compounds (VOC)

Provide paints free of toxic metals and meeting the requirements of Federal and MPCA VOC regulations.

D Manufacturing and Packaging

Screen paint while filling containers to remove coarse particles and skins.

Package the paint in new containers marked with the following information:

(1) Name of the manufacturer,
(2) Name of contents,
(3) Specification number,
(4) Date, and
(5) Manufacturer's batch number.

Provide paint in quantities based on the volume or unit mass at 77° F [25° C].

E Drying Time

Ensure drying time for paint meets the requirements of the contract.

F Approval Process

Obtain approval of the paint from the Engineer before use, unless the contract requires the paint selection or it appears on the on the Approved Products List.

3501.3 SAMPLING AND TESTING
Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

Provide a color Draw Down sample on a Leneta chart per ASTM D 2805 to the Materials Laboratory for verification of the finish coat color.

3520 ZINC-RICH PAINT SYSTEMS

3520.1 SCOPE
Provide zinc-rich paint systems.

3520.2 REQUIREMENTS 3501
A Zinc-Rich Primer

Provide multi-component zinc-rich primer capable of being spray-applied in accordance with the manufacturer's instructions and applications guide. After mixing according to the manufacturer's recommendation, strain the primer through a 30-60 mesh screen or a double layer of cheesecloth to remove un-dispersed zinc agglomerates. Formulate the primer to produce a distinct contrast with blast cleaned steel and with the subsequent intermediate coat.

A.2. Pigment

Provide a metallic zinc pigment meeting the requirements of ASTM D 520. Only add inert materials to the pigment for tinting. Ensure the inert materials do not reduce the effectiveness of the galvanic protection.

A.3. Finished Primer

Provide finished primer meeting the requirements in Table 3520-1:

Table 3520-1 Finished Primer Requirements	
Characteristic	**Requirement**
Zinc portion, total solids by weight	≥ 75.0 %
Pot life at 77° F [25° C]	≥ 4 h
Density of VOC	≤ 3.5 lb/gal [420 g/L]
Slip coefficient of cured primer	≥0.33
Cure time for recoating*	per Manufacturer's Product Data Sheet
* When applied at 3 mil [74 µm] dry-film thickness at 77° F [25° C] and 50 percent R.H.	

B Approved Epoxy Zinc-Rich Systems

Provide a zinc-rich paint system listed on the Approved Products List for "Bridge Structural Steel Coatings."

B.1 Epoxy Zinc-Rich System

Provide an epoxy zinc-rich system consisting of an epoxy zinc-rich primer, an epoxy intermediate coat, and an aliphatic urethane finish coat.

B.2 Inorganic Zinc-Rich System

Provide an inorganic zinc-rich system consisting of solvent-based inorganic zinc-rich primer, an epoxy intermediate coat, and an aliphatic urethane finish coat.

B.3 Moisture-Cure Zinc-Rich System

Provide a moisture-cure zinc-rich system consisting of moisture-cure zinc-rich primer, a urethane intermediate coat, and an aliphatic urethane finish coat.

B.4 Two Coat Zinc-Rich System

Provide a moisture cure zinc-rich system consisting of moisture-cure zinc-rich primer and a fast-dry polyaspartic urethane finish coat.

C Color

Provide a semi-gloss finish coat as required by the contract.

D Packaging and Labeling

Provide multi-component paints packaged in separate containers or kits that ensure paint manufacturer's mixing proportions are achieved when using the entire container.

3520.3 SAMPLING AND TESTING

Provide to the Engineer a manufacturer's Certificate of Compliance with each batch, lot, or both for each component of the zinc-rich paint system.

Provide a color Draw Down sample on a Leneta chart per ASTM D 2805 to the Materials Laboratory for verification of the finish coat color.

3532 EXTERIOR POLYURETHANE PAINT

3532.1 SCOPE

Provide exterior polyurethane finish paint for use on steel lighting cabinets, signs, handrails, traffic signal poles and transformer bases.

3532.2 REQUIREMENTS 3501

Provide paint free of toxic metals and meeting the requirements of Federal and MPCA VOC regulations.

Provide an aliphatic polyurethane finish coat listed on the Approved Products List for "Traffic Signal Paint Systems."

Use the finish coat with an intermediate coat or primer and intermediate coat from the same manufacturer.

A Color

Provide the following semi-gloss finish coat in colors chosen from the Federal Standard 595C colors unless otherwise required by the contract:

(1) Dark green: Federal Standard Number 595C Color Number 14062, and
(2) Yellow: Federal Standard Number 595C Color Number 13538.

3532.3 SAMPLING AND TESTING
Sample at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

Provide a color Draw Down sample on a Leneta chart per ASTM D 2805 to the Materials Laboratory for verification of the finish coat color.

3533 ALUMINUM POLYURETHANE PAINT

3533.1 SCOPE
Provide aluminum-filled polyurethane paint for use as a finish coat on bridges, sign posts, traffic signal poles, and luminaire extensions.

3533.2 REQUIREMENTS 3501
Provide paints free of toxic metals and meeting the requirements of Federal and MPCA VOC regulations.

Provide an aluminum polyurethane paint listed on the Approved Products List for Traffic Signal Paint Systems.

Use the finish coat with an intermediate coat or primer and intermediate coat from the same manufacturer.

3533.3 SAMPLING AND TESTING 3501
Sample at the rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

Provide a color Draw Down sample on a Leneta chart per ASTM D 2805 to the Materials Laboratory for verification of the finish coat color.

3584 EXTERIOR MASONRY ACRYLIC EMULSION PAINT

3584.1 SCOPE
Provide acrylic latex paint for coating exterior masonry.

3584.2 REQUIREMENTS 3501
Provide paints free of toxic metals and meeting the requirements of Federal and MPCA VOC regulations.

Provide acrylic latex paint listed on the Approved Products List, meeting the requirements of Federal Specification TT-P-19, and having a vehicle consisting of 100 percent straight acrylic polymer.

Provide paint in the color required by the contract. Only use light fast colorants.

3584.3 SAMPLING AND TESTING 3501
Sample at the rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

Provide a color Draw Down sample on a Leneta chart per ASTM D 2805 to the Materials Laboratory for verification of the finish coat color.

3590 EPOXY RESIN PAVEMENT MARKINGS

3590.1 SCOPE

Provide reflectorized white and yellow two-component, 100 percent solids epoxy resin pavement markings that are free of toxic heavy metals for installation on bituminous and concrete pavement surfaces.

3590.2 REQUIREMENTS

A General

Apply epoxy resin pavement markings including lines, legends, symbols, crosswalks, and stop lines, in accordance with 2582, "Pavement Markings." Use materials capable of producing pavement markings of specified thickness in accordance with 2582.3.B.3, "Thickness Requirements," and retroreflectivity in accordance with 2582.3.C.3, "Retroreflectivity," unless otherwise required by the contract. Provide yellow markings distinguishable from white markings in the dark.

Provide epoxy resin pavement marking systems listed on the Approved/Qualified Products List and as classified by the following types:

(1) Type I: A fast cure material suitable for line applications and, under ideal conditions, may not require coning.
(2) Type II: A slow cure material suitable for all applications of pavement markings under controlled traffic conditions requiring coning. Provide flagging as directed by the Engineer.

Use Slow Dry Type II epoxy material for epoxy pavement markings, unless otherwise required by the contract.

The Department will not require the mixing of individual components before use if stored for no greater than 12 months.

B Epoxy Resin Material

Provide epoxy resin material meeting the following requirements and characteristics:

(1) Composed only of epoxy resins and pigments,
(2) Does not emit or leach solvents into the environment upon application to a pavement surface,
(3) The infrared spectrum for all components shall match the reference sample provided by the manufacturer for the product tested and approved by the Department,
(4) Type II material completely free of Tri-Methyol Propane Tri-Acrylate and other multi-functional monomers,
(5) Free of lead, cadmium, mercury, hexavalent chromium and other toxic heavy metals as defined by the Environmental Protection Agency,
(6) White material no darker than or no yellower than 17778 of Federal Standard Number 595C Colors,
(7) Daytime color of the yellow epoxy meeting the following CIE Chromaticity limits using illuminant "D65/2":

Table 3590-1
Daytime Chromaticity Coordinates (Corner Points) — Yellow

	1	2	3	4
x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

(8) White daylight directional reflectance (Y) of least 83 percent,
(9) Yellow daylight directional reflectance (Y) of at least 50 percent, and
(10) Nighttime color of yellow meeting the following chromaticity limits in ASTM D 6628 Table 2:

Table 3590-2
Nighttime Chromaticity Coordinates (Corner Points) — Yellow

	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

B.1 Adhesion Capabilities

Provide material meeting the adhesion requirements of the American Concrete Institute Committee 403 when tested on portland cement concrete. Apply epoxy resin pavement markings during the test to concrete pavements with a tensile strength of at least 300 psi [2,070 kPa] and ensure the failure of the system occurs in the concrete during testing.

B.2 Abrasion Resistance

Provide material with an abrasion resistance wear index no greater than 82 when tested in accordance with ASTM C 501 with a CS 17 wheel under a load of 1,000 g for 1,000 cycles. The Department defines the wear index as the weight in milligrams of material abraded from the sample under the test conditions.

B.3 Hardness

Provide material with a Type D durometer hardness from 75 to 90 when tested in accordance with ASTM D 2240 after curing for 72 h at 73 °F ±4 °F [23 °C ±2 °C].

B.4 Tensile Strength

Provide material with a tensile strength of at least 6,000 psi [41,370 kPa] when tested in accordance with ASTM D 638 after curing for 72 h at 73 °F ±4 °F [23 °C ±2 °C].

B.5 Compressive Strength

Provide material with a compressive strength of at least 12,000 psi [82,700 kPa] when tested in accordance with ASTM D 695 after curing for 72 h at 73 °F ±4 °F [23 °C ±2 °C].

3590.3 SAMPLING AND TESTING

Test the daylight directional reflectance and the color meeting the requirements of ASTM E 1349.

Provide 1 pt [0.5 L] samples of each manufacturer's lot or batch of material when manufactured to the Department. Provide 1 pt [0.5 L] samples of Part A (yellow/white epoxy resin) and Part B (catalyst) to the Materials Laboratory. Mark the samples with the following information:

(1) Name of manufacturer,
(2) Manufacturer product number,
(3) Lot or batch number,
(4) Date of manufacture,
(5) Color, and
(6) State project numbers for intended material use.

Submit to the Engineer a manufacturer's Certificate of Compliance for all components of the epoxy resin pavement marking system.

Mark containers for epoxy components with the following information:

(1) Name of manufacturer,
(2) Product identification number,
(3) Lot or batch number,
(4) Date of manufacture,
(5) Color, and
(6) Net weight of contents.

3591 HIGH SOLIDS WATER-BASED TRAFFIC PAINT

3591.1 SCOPE

Provide fast-dry white and yellow acrylic latex traffic marking paints for use with drop-on glass beads for application on concrete and bituminous pavements.

3591.2 REQUIREMENTS

A General Requirements

Use paint listed on the Approved/Qualified Products List for High Solids Water-Based Traffic Paint.

A.1 Quality

Provide paint meeting the following requirements and characteristics:

(1) Formulated from first-grade materials,
(2) Capable of being applied by conventional traffic striping equipment at elevated spray temperatures with drop-on glass beads,
(3) Smooth,
(4) Homogeneous, and
(5) Free of coarse particles, skins, or other foreign materials detrimental to the application or appearance of the paint.

A.2 Package Stability

Within 12 months from the time of delivery, if the paint cakes, settles, livers, thickens, skins, curdles, gels, or shows other objectionable properties not correctable with stirring, return the paint to the manufacturer for credit. Ensure the manufacturer adds anti-settling agents, stabilizers, and other additives to ensure proper storage stability.

A.3 Manufacturing and Packaging

Provide paint from a manufacturer capable of producing paint in batches of at least 1,000 gal [3,786 L]. Provide paint screened with a 40 mesh or finer screen to remove coarse particles, skins, or foreign material.

Provide paint packaged in lined, new totes of 55 gal [208 L] or 5 gal [19 L] containers meeting the following requirements and characteristics:

(1) Full removable-head universal drums meeting the requirements of DOT-17H,
(2) Drum covers containing one 2 in [51 mm] fitting and one ¾ in [19 mm] fitting,
(3) Marked with the following information:
  (3.1) Manufacturer's name,
  (3.2) Type of paint,
  (3.3) Batch number,
  (3.4) Date of manufacture,
  (3.5) Gross weight and
  (3.6) Container weight.

To prevent formation of "skins," ensure the manufacturer uses one of the following:

(1) A "float" of ammonia water on the paint surface, or
(2) A "floating type" plastic liner on the top of the filled container.

B Properties of Finished Paint

Provide finished paint with properties in accordance with Table 3591-1:

Table 3591-1
Paint Properties

Parameter	Range
Weight per gallon at 77 °F [25 °C]	≥12.0 lb per gal
Viscosity, Krebs Stormer, at 77 °F [25 °C]	80 KU – 100 KU
Grind, Hegman	≥3
Total solids	≥ 73% by weight
Non-volatile vehicle	≥43% by weight
Pigment	45% – 62% by weight
Titanium dioxide, white paint	≥ 1.0 lb/gal
Dry time, 12 mil [305 µm] WFT at 65% RH	≤ 12 min
Dry through, at 90% RH	≤ 130 min
Daylight directional reflectance, white	≥ 83%
Daylight directional reflectance, yellow	≥ 50%
Contrast ratio	≥ 0.98
Flexibility and adhesion	No cracking or flaking
Water resistance	No blistering or loss of adhesion
Settling	≥ 6 rating
Skinning at 48 h	—
Track free time	≤ 3 min
pH	≥ 9.6

C Specific Requirements

Use a vehicle composed of a 100 percent acrylic polymer.

Use white material no darker than or no yellower than 17778 of Federal Standard Number 595C Colors.

Use yellow paint with a daytime color meeting the following CIE Chromaticity limits using illuminant "D65/2":

Table 3591-2
Daytime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

Use yellow paint with a nighttime color meeting the following chromaticity limits as specified by ASTM D 6628, Table 2:

Table 3591-3
Nighttime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

Use white and organic yellow paints free of the following heavy metals:

(1) Lead,
(2) Mercury,
(3) Cadmium,
(4) Hexavalent chromium, and
(5) Other toxic heavy metals as defined by the United States Environmental Protection Agency.

3591.3 SAMPLING AND TESTING

Provide 1 pt [0.5 L] manufacturer-provided paint samples of each batch and a certification stating that the sample represents the full manufactured batch.

The Department may base acceptance on 1 pt [0.5 L] samples taken at the point of delivery or from the Contractor's supply.

Submit to the Materials Laboratory the manufacturer's certified test results with each batch of paint, including tests for weight per gallon, viscosity, and drying time.

Provide the manufacturer's certified test results, for tests performed annually at the start of paint production, meeting the following requirements:

Table 3591-4
Paint Property Standard

Parameter	Standard
Weight per gallon	ASTM D 1475
Viscosity	ASTM D 562
Grind fineness	ASTM D 1210
Total solids	ASTM D 2369
Total pigment	ASTM D 2371
Titanium dioxide	ASTM D 4563, ASTM D 1394
Dry time, 12 mil [305 µm] wet	ASTM D 711, modified
Daylight directional reflectance	ASTM E 1349
Contrast ratio, 15 mil [381 µm] wet	ASTM D 2805
Bleeding ratio	Federal Specification TT-P-85
Color	ASTM E 1349
pH	ASTM E 70

3592 DROP-ON GLASS BEADS

3592.1 SCOPE

Provide treated glass beads for retro-reflectorizing traffic marking paint.

3592.2 REQUIREMENTS

Provide treated glass beads meeting the following characteristics and requirements:

(1) Listed on the Approved/Qualified Products List,
(2) Made from clean colorless transparent glass,
(3) Smooth,
(4) Spherically shaped,
(5) Free from milkiness, pits, excessive air bubbles, chips, and foreign material,
(6) Capable of being applied by conventional striping equipment,
(7) Produce a retro-reflectorized line when viewed at night with automobile headlights, and
(8) Meet the requirements of AASHTO M 247, Type 1 "Standard Gradation" except with at least 80 percent true spheres.

Provide beads with dual surface treatment meeting the following requirements and characteristics for use with water-based paints:

(1) Moisture resistant silicone treatment meeting the requirements of AASHTO M 247 and as recommended by the paint manufacturer,
(2) Silane adherence surface treatment as recommended by the paint manufacturer, and
(3) Meet the adherence treatment Dansyl Chloride Test of AASHTO M 247.

Provide beads for use with epoxy resins with a moisture resistant silicone surface treatment as recommended by the epoxy resin manufacturer.

Unless otherwise specified, provide beads packaged in moisture-proof, multi-wall shipping bags, and in containers marked with the following information:

(1) Manufacturer name,
(2) Manufacturer address,
(3) Type of moisture treatment,
(4) Batch number, and
(5) Date of manufacture.

Deliver the containers and contents in a dry condition. The Engineer will reject beads not meeting the requirements of this specification.

3592.3 SAMPLING AND TESTING

Provide samples in the rates and sizes meeting the requirements of the Schedule for Materials Control and as required by the contract.

The Engineer will test in accordance with AASHTO M 247, except the Engineer will determine roundness meeting the requirements detailed in the Laboratory Manual.

Stone and Brick

3601 RIPRAP MATERIAL

3601.1 SCOPE

Provide stone and filter layer material for use in random or hand-placed riprap, gabion, and revet mattress construction.

3601.2 REQUIREMENTS

A Stones

A.1 Quality

Provide stone of the quality approved by the Department and meeting the following requirements:

(1) Each individual stone has at least one fractured face.
(2) Is free of soil or other debris before placement.
(3) Contains less than 10 percent of the following by weight:
  (3.1) Stones with defects that could cause rapid or excessive deterioration or degradation during service, such as cracks or seams;
  (3.2) Stones with a width or thickness less than 30 percent of the length.
(4) For carbonate quarry/bedrock material used in total or in part for riprap, the portion of the insoluble residue passing the #200 [75µm] sieve is no greater than 10 percent.

To determine suitable quality of stone, the Department may consider the results of laboratory tests, the performance of the stone under natural exposure conditions, the performance of the riprap from the same or similar geological formations or deposits, or other tests or criteria.

Do not use recycled concrete as riprap unless otherwise allowed by the contract.

A.2 Type

A.2.a Random Riprap.....Table 3601-1

A.2.b Hand-Placed Riprap

Provide individual stones with a weight of at least 50 lb [22 kg]. The Department will not require a minimum weight for smaller stones required for filling in the narrow openings between individual stones (chinking).

A.2.c (Blank)

A.2.d Gabions and Revet Mattresses

Provide well graded stones for filling the baskets, ranging in size from 4 in to 8 in [100 mm to 200 mm] for gabions and 3 in to 6 in [75 mm to 150 mm] for revet mattresses

Table 3601-1
Random Riprap Gradation Requirements

Weight, *lb [kg]*	Size, *in [mm]**	Approximate Percent of Total Weight Smaller than Given Weight				
		Class of Riprap				
		I	II	III	IV	V
2,000 [900]	30 [750]	—	—	—	—	100
1,000 [450]	24 [600]	—	—	—	100	—
650 [300]	21 [525]	—	—	—	—	75
400 [180]	18 [450]	—	—	100	—	—
250 [113]	15 [375]	—	—	—	75	50
120 [55]	12 [300]	—	100	75	50	—
50 [22]	9 [225]	—	75	50	—	—
15 [7]	6 [150]	100	50	—	—	10
5 [2]	4 [100]	—	—	—	10	—
2 [1]	3 [75]	50	—	10	—	—
—	2 [50]	—	10	—	—	—
—	1 [25]	10	—	—	—	—

* Weight to size conversion based on a specific gravity of 2.60 and a volume average between a sphere and cube

B Filter Material

B.1 Granular Filter
Provide granular filter material in accordance with 3149, "Granular Material," and the following gradations:

B.1.a Under Class I Random Riprap 3149.2G

B.1.b Under Other Riprap, Gabion, and Revet Mattress .....Table 3601-2

Table 3601-2
Granular Filter Material

Sieve Size	Percent Passing by Weight
6 in [150mm]	100
3 in [75 mm]	75 – 95
1 in [25 mm]	35 – 75
No. 4 [4.75 mm]	10 – 40
No. 10 [2.0 mm]	5 – 25
No. 40 [425 µm]	0 – 10
No. 200 [75 µm]	0 – 5

B.2 Geotextile Filter.....3733

3601.3 SAMPLING AND TESTING
The Department will inspect the material for compliance to the requirements of this section. Obtain the Engineer's approval of the quality of the stone before delivering the stone to the project. The Engineer will inspect the stone for compliance to the gradation requirements after delivery of the stone to the project.

The Engineer will visually check riprap gradations. If the Contractor disagrees with the results of the Engineer's visual check, the Engineer will test the gradation based on weight. The gradation of random riprap must be within 10 percent of the percentages in Table 3601-1.

If the quantity of riprap for any class is greater than 40 yd^3 [30 m^3], the Engineer may require construction of a control unit consisting of 4 yd^3 [3 m^3] of riprap as a reference for size and quality compliance. Construct the control unit at the source or on the project. When the Engineer requires and approves a control unit for reference, maintain the control unit during riprap construction and incorporate the stones from the control unit as the last stones placed in the riprap construction. Use production stone equivalent to the stone placed in the approved control unit.

If using carbonate quarry/bedrock materials in total or in part for riprap materials, sample and test at the rates specified in the Schedule of Materials Control for the following test(s):

Insoluble Residue Laboratory Manual Method 1221

3602 GABIONS AND REVET MATTRESSES MATERIALS

3602.1 SCOPE
Provide material and construct baskets for gabions and revet mattresses meeting the following characteristics:

(1) Rectangular,
(2) Variable in size, and
(3) Manufactured from double-twisted metallic-coated wire mesh or metallic-coated welded wire fabric.

A Gabion .....Rectangular Basket

B Revet Mattress .....Thin Flat Rectangular Basket

3602.2 REQUIREMENTS
Provide gabions and revet mattresses meeting the requirements of ASTM A 974, for welded wire fabric, or ASTM A 975 for double-twisted wire. Unless otherwise specified, provide welded wire fabric gabions and revet mattresses with a Style 2 coating, and provide double-twisted wire gabions and revet mattresses with a Style 1 coating as listed in the ASTM A 974 and ASTM A 975 specifications, respectively.

3602.3 SAMPLING AND TESTING
Submit to the Engineer a manufacturer's Certificate of Compliance for the wire and basket materials and the construction of gabions and revet mattresses.

3604 PRECAST ARTICULATED CONCRETE

3604.1 SCOPE

Provide manufactured articulated concrete block and mat revetment systems to protect embankment slopes, river channels, spillways, and vehicle accesses where the soil may erode.

3604.2 REQUIREMENTS

A Revetment Systems

Provide articulated block mat and articulated interlocking block systems meeting the requirements of ASTM D 6684-04 and the following material specifications.

Provide Type A, Type B, Type C, Type D, and Type E articulated block mat in accordance with the following and as specified in Table 3604-1.

Provide Type A, Type B, and Type C articulated interlocking block in accordance with the following and as specified in Type 3604-1.

Table 3604-1
Bed Shear Requirements

Type	Minimum Bed Shear, *lb/sq. ft [Pa]*
A	10 [479]
B	15 [718]
C	20 [958]
D	25 [1,197]
E	30 [1,436]

A.1 Articulated Block Mat

Provide closed cell or open cell articulated block mat consisting of blocks cabled together into a prefabricated mat placed on a geotextile fabric. Place the mats side-by-side, and clamp and anchor to provide one homogeneous erosion protection system. Provide blocks for the mats ranging in thickness and weight meeting the bed shear requirements in accordance with Table 3604-1, "Bed Shear Requirements." Determine the type in accordance with Table 3604-1, "Bed Shear Requirements."

A.2 Articulated Interlocking Block

Provide closed cell or open cell articulated interlocking block consisting of hand placed concrete blocks placed on a geotextile fabric and locked together to form a soil protecting paver system. Provide blocks ranging in thickness and weight meeting the bed shear requirements in accordance with Table 3604-1, "Bed Shear Requirements." Determine the type in accordance with Table 3604-1, "Bed Shear Requirements."

Provide open cell units with an open area of at least 20 percent when measured at the bottom of the block in the system. Provide closed cell systems with an open area no greater than 10 percent when measured at the bottom of the block in the system.

B Concrete 2461

Provide blocks meeting the following requirements:

(1) Manufactured in a plant with a Department approved quality control plan,
(2) Design air content of 6.5 percent for wet cast blocks,
(3) Less than 1.0 percent loss in 100 freeze/thaw cycles when tested in accordance with ASTM C 1262 using a distilled water solution or less than 1.0 loss in 50 freeze/thaw cycles when tested in accordance with ASTM C 67, and
(4) Absorption no greater than 7.0 percent when tested in accordance with ASTM C 140.

Provide wet cast concrete blocks with a design strength of at least 4,000 psi [27.6 MPa] when tested at 28 days in accordance with ASTM C 140.

Provide dry cast concrete blocks with a design strength of at least 5,800psi [40.0 MPa] when tested at 28 days in accordance with ASTM C 140.

C Cable

For systems using cables, provide stainless steel or coated high-strength polyester cables compatible with the system and designed to meet a 5:1 factor of safety in accordance with ASTM D 6684. Use stainless steel cable at least $^{3}/_{16}$ in [0.48 cm] thick and use high-strength polyester cable at least ¼ in [0.64 cm] thick.

D Geotextile Filter

Provide geotextile appropriate for the soil conditions in accordance with the manufacture's recommendations and 3733, "Geotextiles." The Engineer will make the final approval of the geotextile type.

E Clamps

Use stainless-steel wire rope clamps and sleeves to secure loops of adjoining mats.

F Anchors

Use anchors with a pull resistance of 4,000 lb [1,815 kg] to secure the top and exposed sides of the mattress.

G Bedding Material

Provide cohesive soil for bedding material meeting the requirements for common borrow in 2105, "Excavation and Embankment," or 3149, "Granular Material."

H Fine Filter Aggregate

Provide fine aggregate bedding sand for bedding in accordance with 3149, "Granular Material," and the grading requirements of 3149.2.J, "Fine Filter Aggregate." Place sand 1 in [25 mm] thick. Spread the sand evenly over the compacted bed, or over geotextile if required by the manufacturer, to place articulated interlocking block or articulated block mat.

3604.3 SAMPLING AND TESTING

Submit to the Engineer a manufacture's Certificate of Compliance for the revetment system and components that meets the requirements of ASTM D 7277 and ASTM D 7276.

3608 CONCRETE ARMOR UNITS

3608.1 SCOPE

Provide manufactured concrete armor units for use in stream bank, riverbank, and lakeshore stabilization, and for soil bioengineering construction.

3608.2 REQUIREMENTS

Use interlocking concrete cross shaped units, each with two individual and symmetrical interlocking halves, to provide concrete armor units. Assemble the units with the two individual halves forming a three dimensional cross with six symmetrical legs. Assemble multiple, identical units into a continuous and flexible interlocking matrix with a 40 percent void space for soil filling and planting.

Use concrete meeting the following requirements to form the armor units:

(1) In accordance with the requirements for Type 3 in 2461, "Structural Concrete,"
(2) Compressive strength of at least 4,000 psi [27.6 MPa], and
(3) Water absorption no greater than 10 lb per cu. ft [160 kg per cu. m].

Ensure each concrete armor unit meets the physical requirements in accordance with the following:

Table 3608-1
Concrete Armor Units Size

Designation	A-24	A-36
Overall dimension (outside of leg to outside of leg)	24 in [610 mm]	36 in [910 mm]
Thickness of each side of leg	3.6 in [93 mm]	5.5 in [142 mm]
Kerf corner reinforcement	1.8 in [46 mm]	2.7 in [92 mm]
Overall weight of assembled unit	78 lb [35 kg]	265 lb [119 kg]
NOTE: Dimensions are nominal dimensions with a 10 percent tolerance.		

3608.3 SAMPLING AND TESTING — (BLANK)

3612 SEWER BRICK (CLAY)

3612.1 SCOPE

Provide brick made from burned clay or shale for the following:

(1) Drainage structures that are part of a sewage, industrial waste, or storm water system; and
(2) Related structures such as manholes and catch basins.

3612.2 REQUIREMENTS

Use sewer bricks meeting the requirements of AASHTO M 91 for the grade shown on the plans. If the plans do not specify a grade, provide Grade MM or higher.

3612.3 SAMPLING AND TESTING

A Compressive Strength and Absorption ..... AASHTO T 32

B Freezing and Thawing ..... AASHTO T 32

C Sample Bricks

The Engineer will select bricks for testing. Provide test specimens from the manufacturer or seller, at no additional cost to the Department.

3613 BUILDING BRICK (CLAY OR SHALE)

3613.1 SCOPE

Provide clay or shale building brick for use in the construction of transportation facilities

3613.2 REQUIREMENTS

Provide clay or shale building brick meeting the requirements of AASHTO M 114. Provide grade SW, unless otherwise required by the contract.

3613.3 SAMPLING AND TESTING

Sample and test in accordance with the Schedule of Materials Control.

3614 BUILDING BRICK (SAND-LIME)

3614.1 SCOPE

Provide sand-lime building brick for use in the construction of transportation facilities.

3614.2 REQUIREMENTS

Provide sand-lime building brick meeting the requirements of ASTM C 73. If the contract does not require a specific brick grade, provide grade MW building brick.

3614.3 SAMPLING AND TESTING

Sample and test in accordance with the Schedule of Materials Control.

3615 BUILDING BRICK (CONCRETE)

3615.1 SCOPE

Provide concrete building brick for construction.

3615.2 REQUIREMENTS

Provide concrete building brick meeting the requirements of ASTM C 55.

3615.3 SAMPLING AND TESTING

Sample and test in accordance with the Schedule of Materials Control.

3616 SEWER BRICK (CONCRETE)

3616.1 SCOPE

Provide concrete brick to construct catch basins and manholes.

3616.2 REQUIREMENTS

Provide concrete brick meeting the requirements of ASTM C 139, as modified by the following:

(1) Provide concrete brick with a compressive strength of at least 4,100 psi [28 MPa] for any individual unit and an average compressive strength of 4,500 psi [31 MPa] for three units, when delivered to the project, and

(2) Use steam or water curing methods to cure the concrete, unless the Materials Engineer approves the use of a sealing membrane or other curing methods. If steam curing, maintain an atmospheric temperature in the curing chamber no greater than 158 °F [70 °C]. Protect the concrete from freezing until the completion of

curing. Continue curing until the concrete develops the compressive strength shown above in item (1) within 28 days.

Use any standard size brick capable of producing the dimensions in the completed structure as shown on the plans.

3616.3 SAMPLING AND TESTING ..... ASTM C 140

Precast Concrete Units

3621 CONCRETE MASONRY UNITS

3621.1 SCOPE

Provide solid, precast, segmental concrete masonry units to construct catch basins and manholes.

3621.2 REQUIREMENTS

Provide concrete masonry units in accordance with 3616.2, "Sewer Brick (Concrete), Requirements," modified to provide units with dimensions as shown on the plans and with wall thicknesses of 8 in ±⅜ in [200 mm ±10 mm].

3621.3 SAMPLING AND TESTING 3616

3622 SECTIONAL CONCRETE MANHOLE AND CATCH BASIN UNITS

3622.1 SCOPE

Provide precast, reinforced concrete manhole/catch basin units consisting of riser sections and appurtenances such as grade rings, base slabs, tops, and special sections to construct sewer or water works.

3622.2 REQUIREMENTS

Provide reinforced concrete manhole/catch basin units meeting the requirements of AASHTO M 199, 3236, "Reinforced Concrete Pipe," and the following.

Notify the Materials Engineer a minimum of 2 weeks before the manufacturer starts production to arrange for inspection.

A Physical Properties

Provide sectional concrete manhole/catch basin units in the dimensions, shape, wall thickness, type, and quantity of reinforcement as shown on the plans.

The Contractor may use alternative spigot-up joint or alternative offset joint. Use the profile or pre-lubricated pipe seal system with the alternative offset joint.

Ensure test results show a compressive strength of at least 4,200 psi [28 MPa] at 28 calendar days and before shipping the product to the project site.

B Manufacture

Provide units true to shape and with smooth, dense surfaces uniform in appearance. As soon as the forms are removed, use mortar to fill minor surface cavities or irregularities not impairing the service value of the unit and capable of being corrected without marring the appearance. Remove forms without damaging the unit.

When the manufacturer provides manholes with block outs or holes, provide additional steel in the remaining unit to prevent cracking. If the unit is cracked, remove the cracked portion and repair with mortar in accordance with the approved repair procedure in the QM Manual and notify the MnDOT inspector for acceptance.

When manufacturing special design rectangular manholes, provide sections meeting the manufacturing requirements of 3238.

3622.3 SAMPLING AND TESTING 3236

3630 PRECAST CONCRETE MEDIAN BARRIERS

3630.1 SCOPE
Provide precast concrete median barriers for use in construction work zones.

3630.2 REQUIREMENTS 3238
Provide precast concrete median barriers manufactured at a precasting plant approved by the Materials Engineer.

A Materials

A.1 Concrete 2461

A.2 Mix Designation 2533

A.3 Reinforcement Bars 3301

B Concrete Finish

If shown on the Plans or required by the Special Provisions, sandblast the precast barrier units and fill the surface imperfections with a grout-containing bonding agent in accordance with 2401.3.F.2.a, "Ordinary Surface Finish." Begin sandblasting and grouting operations after stripping the forms and while the concrete barriers are still warm.

3630.3 SAMPLING AND TESTING 3236

Joint Fillers and Sealers

3702 PREFORMED JOINT FILLERS

3702.1 SCOPE
Provide preformed filler material for joints in concrete construction.

3702.2 REQUIREMENTS
Use preformed joint filler material meeting the requirements of AASHTO M 153 or AASHTO M 213.

Provide the filler for each joint in a single piece for the full depth and width required for the joint unless otherwise approved by the Engineer. For pavement construction, provide filler in lengths equal to the width of the pavement lanes. Where dowel bars are necessary, provide joint filler with properly sized clean-cut punched holes correctly spaced to fit flush with the dowel bars.

Provide fiber or granulated cork bituminous bound-type filler meeting the requirements of AASHTO M 213, unless otherwise required by the contract or approved by the Engineer.

3702.3 SAMPLING AND TESTING — (BLANK)

3719 HOT-POURED, CRUMB-RUBBER TYPE CRACK SEALER

3719.1 SCOPE
Provide hot-poured, crumb-rubber type crack sealer for sealing cracks in concrete and bituminous pavements and miscellaneous structures.

3719.2 REQUIREMENTS
Provide crack sealer material meeting the following requirements:

(1) On the Approved Products List,
(2) Consists of asphalt and crumb rubber blended together by the manufacturer to produce a homogeneous mixture,
(3) When melted, the sealer does not separate or settle, and
(4) Uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

A Physical Requirements

Provide crack sealer meeting the requirements of ASTM D 6690, Type I with the following modifications in Table 3719-1 after one cycle of heating to the manufacturer's maximum heating temperature, cooling, and reheating to the manufacturer's maximum heating temperature.

Table 3719-1
ASTM D 6690, Type I Modifications

Test	Specification
Recycled rubber, mass	≥ 18% of asphaltic components
Bond Test, 50% extension at 0° F [-18° C]*	No adhesion or cohesion bond failure after 5 cycles
Resilience at 77° F [25° C]	≥ 40%
Softening point	≥ 180 °F [82° C]

* Use sawed cement mortar blocks or asphalt HMA blocks prepared using the method found in the Mn/DOT Laboratory Manual.

B Packaging and Marking

Package and ship the sealer material in boxes weighing no greater than 50 lb [23 kg]. Mark the boxes with the following information:

(1) Material name,
(2) Manufacturer name,
(3) Brand name,
(4) Weight,
(5) Batch number, and
(6) Maximum heating temperature recommended by the manufacturer.

3719.3 SAMPLING AND TESTING

A Sampling

Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

The Materials Engineer will perform tests on samples taken from the product proposed for use. Submit to the Engineer a manufacturer's Certificate of Compliance for each sealer batch.

B Methods of Test

Perform tests meeting the requirements of ASTM D 5329, except, perform the bond test using sawed cement mortar blocks or asphalt HMA blocks (consistent with the pavement type) prepared in accordance with the methods in the Laboratory Manual.

3721 PREFORMED ELASTOMERIC COMPRESSION JOINT SEALS FOR CONCRETE

3721.1 SCOPE

Provide preformed polychloroprene elastomeric joint seals for use in sealing joints in concrete pavements, bridges, and other structures.

3721.2 REQUIREMENTS

A Composition and Manufacture

Provide joint seals meeting the requirements of ASTM D 2628 and as specified in this section.

Provide seals that are preformed and manufactured from a vulcanized elastomeric compound using polymerized chloroprene as the only polymer.

B Size and Shape

Provide preformed elastomeric compression joint seals in the size, shape, and dimensional tolerances of the seals as shown on the plans or required by the contract. The Contractor may use alternate shapes, if approved by the Engineer.

C Physical Properties

Unless the contract requires otherwise, provide a $^{13}/_{16}$ in [20 mm] joint seal meeting the physical properties in accordance with ASTM D 2628 and the following table:

Table 3721-1 $^{13}/_{16}$ in [20 mm] Joint Seal Compression-Deflection Requirements	
Property	**Requirement**
Force at 0.65 in [16.5 mm]*	≥ 4 lb/linear inch [0.70 N/mm]
Force at 0.41 in [10.5 mm]*	≤ 20 lb/linear inch [3.50 N/mm]
* Meeting the requirements of ASTM D 2628 and the Compression-Deflection Test Method located in the Laboratory Manual.	

D Identification and Marking

Provide joint seals marked with the following at intervals no greater than 4 ft [1.2 m]:

(1) Manufacturer's name or the manufacturer's trademark,
(2) Lot number, and
(3) Date of production.

For multiple die extrusion machines, identify the seal produced from each extrusion die as an individual sublot, in addition to the list above. Limit individual lot numbers or sublot numbers to one every 8 h shift or every 6,000 ft [1,800 m], whichever results in the smallest lot size. Place a mark on the top surface of the seal at 1 ft [300 mm] intervals, to allow length measurements on each seal after installation.

Provide containers to package joint seals for shipment marked with the following information:

(1) Name of the manufacturer,
(2) Lot number or sublot number, and
(3) Date of manufacture.

E Lubricant-Adhesive

Provide lubricant-adhesive meeting the requirements of ASTM D 2835 to install the seals.

3721.3 SAMPLING AND TESTING

The Engineer in conjunction with the Materials Engineer may sample and test joint seals and lubricant adhesive materials before or after delivery.

The Engineer in conjunction with the Materials Engineer may reject an entire lot or sublot if a test result for that lot or sublot fails.

A Sampling

Provide samples at rates and sizes meeting the requirements of the Schedule for Materials Control or as required by the contract.

B Sample Preparation

The Materials Engineer will prepare test specimens meeting the requirements of ASTM D 2628 and in accordance with the Laboratory Manual.

C Compression Deflection Test

Perform compression deflection testing on two specimens in accordance with the Laboratory Manual.

3722 SILICONE JOINT SEALANT

3722.1 SCOPE

Provide a silicone joint sealant for use in concrete pavement joints and cracks to protect the pavement from intrusion of water and incompressible material.

3722.2 REQUIREMENTS

Provide silicone joint sealant meeting the requirements of ASTM D 5893 and the following:

(1) Primer-less,
(2) Low modulus,
(3) Does not contain solvents or diluents that can cause shrinkage or expansion during curing,
(4) Smooth and uniform in appearance with a consistency that allows application with air pressure guns or hand caulking applicators,

(5) Capable of withstanding repeated joint movement from −50 percent to 100 percent without losing adhesion to the concrete and without cohesion failure, and
(6) Listed on the Approved Products List.

3722.3 SAMPLING AND TESTING

Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

3723 HOT-POURED, ELASTIC TYPE JOINT AND CRACK SEALER

3723.1 SCOPE

Provide hot-poured elastic type joint and crack sealer to seal joints and cracks in concrete and bituminous pavements, bridges, and other structures.

3723.2 REQUIREMENTS

Provide a sealant material meeting the following requirements:

(1) Listed on the Approved/Qualified Products List;
(2) Composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound;
(3) When melted, ensure the sealant does not separate or settle and ensure the sealant does not contain a dispersed or settling component, and
(4) Maintains a uniform consistency to seal joints and cracks without large air holes or discontinuities.

A Physical Requirements

Provide sealant meeting the requirements of ASTM D 6690, Type II and the following modifications:

Table 3723-1
ASTM D 6690, Type II Modifications

Test	Requirement
Cone penetration at 77 °F [25 °C], 150 g, 5 s	60 – 90 dmm
Bond at −20 °F [−29 °C], 3 cycles, 100% extension	No adhesion or cohesion bond failure after 3 cycles
Mandrel bend test at −29 °F [−34 °C], 1 in [25 mm] mandrel	No cracking
Resilience at 77 °F [25 °C]	≥ 40%

B Packaging and Marking

Package and ship the sealant material in boxes no greater than 50 lb [23 kg]. Mark the containers with the following information:

(1) Material name,
(2) Manufacturer name,
(3) Brand name,
(4) Weight,
(5) Batch number, and
(6) Maximum heating temperature, as recommended by the manufacturer.

3723.3 SAMPLING AND TESTING

A Sampling

Provide samples in rates and sizes meeting the requirements of the Schedule of Materials Control, or as required by the contract.

The Materials Engineer will perform tests on samples taken from the product proposed for use. Submit to the Engineer a manufacturer's Certificate of Compliance with each sealant batch.

B Methods of Test

B.1 Bond Test

Perform tests meeting the requirements of ASTM D 5329, except perform the bond test using sawed cement mortar blocks or asphalt HMA blocks (consistent with the pavement type) prepared using the methods found in the Laboratory Manual.

B.2 Mandrel Bend Test ASTM D 522, Method B

The Materials Engineer will perform the Mandrel Bend Test at −29 °F [−34 °C] using a 1 in [25 mm] mandrel, bending the specimen 180° over 5 s. The Materials Engineer will prepare test specimens meeting the requirements of ASTM D 6690, Type II, Flow Test, and condition the specimens at −29 °F [−34 °C] for at least 4 h.

3725 HOT-POURED, EXTRA LOW MODULUS, ELASTIC TYPE JOINT AND CRACK SEALER

3725.1 SCOPE

Provide hot-poured, extra low modulus, elastic type joint and crack sealer to seal joints in concrete pavement, bridges, other structures and rout and seal applications on bituminous pavements.

3725.2 REQUIREMENTS

Provide a sealant material meeting the following requirements:

(1) Listed on the Mn/DOT Approved Products List,
(2) Composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound,
(3) When melted, ensure the sealant does not separate or settle, and
(4) Maintains a uniform consistency to seal joints and cracks without inclusion of large air holes or discontinuities.

A Physical Requirements

Provide sealant meeting the requirements of ASTM D 6690 Type IV with the following modifications in Table 3725-1.

Table 3725-1
ASTM D 6690 Type IV Modifications

Test	Requirement
Cone Penetration at 77° F [25° C], ASTM D 5329	100 – 150 dmm
Cone Penetration at 0° F [-18° C], ASTM D 5329 modified	≥ 25 dmm
Resilience, ASTM D 5329	30% – 60%
NOTE: Ensure the material meets the requirements of Table 3725-1 after heating for 6 h with constant mixing in a laboratory melter at the manufacturer's maximum heating temperature.	

B Packaging and Marking

Package and ship the sealant material in boxes weighing no greater than 50 lb [23 kg]. Mark the boxes with the following information:

(1) Material name,
(2) Manufacturer name,
(3) Brand name,
(4) Weight,
(5) Batch number, and
(6) Maximum heating temperature recommended by the manufacturer.

3725.3 SAMPLING AND TESTING

Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

The Materials Engineer will perform tests on samples taken from the product proposed for use. Submit to the Engineer a manufacturer's Certificate of Compliance with each sealant batch.

Perform tests meeting the requirements of ASTM D 5329, except perform the bond test using sawed cement mortar blocks or asphalt HMA blocks [consistent with the pavement type] prepared using the methods found in the Lab Manual.

3726 PREFORMED GASKET SEALS FOR CONCRETE PIPE

3726.1 SCOPE

Provide preformed gasket seals to construct watertight joints for concrete pipe.

3726.2 REQUIREMENTS

Provide preformed gasket type seals to construct flexible, watertight joints in concrete pipe meeting the requirements of AASHTO M 315 and as shown in the plans for the specific joint design of the pipe.

3726.3 SAMPLING AND TESTING

Sample and test in accordance with the Schedule of Materials Control.

3728 BITUMINOUS MASTIC JOINT SEALER FOR PIPE

3728.1 SCOPE

Provide cold applied, mineral filled, joint sealing compound for joints of bell and spigot or tongue and groove, concrete or clay culvert, sewer, or drain pipe.

3728.2 REQUIREMENTS

Provide a bituminous mastic joint sealer consisting of refined petroleum asphalt meeting the requirements of ASTM D 4586, except for the following modifications:

Table 3728-1
ASTM D 4586 Modifications

Test	Requirement
Grease cone penetration (unworked) 150 g, 77 °F [25 °C], 5 s, ASTM D 217	175 dmm – 300 dmm
Density	≥ 8.75 lb per gal [1.0 kg per L]
Non-volatile content	≥ 65%
Ash content, by ignition	25% – 45%
Cure Evaluation at 77 °F [25 °C]	Tough, plastic coating, free of blisters

Do not use coal tar products.

Provide material exhibiting 100 percent adhesion and cohesion when applied to metal, concrete, or vitrified clay surfaces.

3728.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance.

Apply the bituminous mastic joint sealer in a layer $^{1}/_{16}$ in to $^{1}/_{8}$ in [2 mm to 3 mm] thick on a tinned metal panel. Cure the joint sealer at 77 °F [25 °C] for 24 h. An acceptable bituminous mastic joint sealer will set to a tough, plastic coating, free of blisters.

3731 CAULKING COMPOUND

3731.1 SCOPE

Provide caulking compound meeting the requirements of Federal Specification A-A-272, in the type required by the contract.

3731.2 REQUIREMENTS

Apply the caulking compound in accordance with the manufacturer's recommendations.

Unless the contract requires otherwise, use near white, light gray, or buff colored caulking compound.

3731.3 SAMPLING AND TESTING

Sample and test in accordance with the Schedule of Materials Control.

3733 GEOTEXTILES

3733.1 SCOPE

Provide geotextiles (permeable fabrics) for the typical uses classified as follows:

(1) Type I for wrapping subsurface drain pipe, joints of concrete pipe culvert, or other drainage applications;
(2) Type II. The Department no longer uses this classification. If the contract specifies Type II, use Type III property requirements;
(3) Type III for use under Class I and Class II random riprap, gabions, and revet mattresses;
(4) Type IV for use under Class III and Class IV random riprap and hand-placed riprap on slopes no steeper than 3:1, horizontal to vertical;
(5) Type V for separating materials for stabilization;
(6) Type VI for earth reinforcement;
(7) Type VII for use under Class III and Class IV random riprap on slopes steeper than 3:1, horizontal to vertical, and under Class V random riprap.

3733.2 REQUIREMENTS

A General

Provide geotextiles consisting of woven, nonwoven, or knit fabric of polymeric filaments or yarns, such as polypropylene, polyethylene, polyester, or polyamide, that form a stable network. Knit fabric shall only be used as perforated pipe wrap. Provide geotextile resistant to biological and chemical environments normally found in soils, and that is free of chemical treatment or coating that may significantly reduce porosity or permeability.

Provide geotextile that is uniform in texture, thickness, and appearance, and is free of defects, flaws, or tears that may alter the strength or filtering properties. Repair geotextile as approved by the Engineer.

Deliver rolls of geotextile or geotextile-wrapped perforated pipe with an opaque plastic covering to protect the material from ultraviolet rays or contamination with mud, dirt, dust, or debris. Provide rolled geotextile labeled on the outside wrap and inside the core in accordance with ASTM D 4873 and as follows:

(1) Manufacturer,
(2) Product name, and
(3) Roll number.

Ensure unprotected geotextile is not exposed to sun for more than seven days. Replace contaminated geotextile or geotextile exposed to the sun for more than seven days, if directed by the Engineer.

Provide geotextile meeting the requirements of Table 3733-1 for the type required by the contract.

If using Type 5 or Type 6 geotextile, produce seams meeting the requirements of Table 3733-1, row B3, "Seam Breaking Strength Minimum."

B Physical Properties

Table 3733-1
Geotextile Properties

Geotextile Property	Test Method (ASTM) Units	Type (a) 1 Fabric	1 Knit sock (b)	3	4	5	6	7 (c)
B1 Grab Tensile Strength minimum, each principal direction	D4632 lb [kN]	100 [0.45]	—	100 [0.45]	200 [0.90]	200 [0.90]	(d)	300 [1.3]
B2 Elongation minimum, each principal direction	D4632 percent	—	—	50	50	—	(d)	50
B3 Seam Breaking Strength minimum (e)	D4632 lb [kN]	90 [0.40]	—	90 [0.40]	180 [0.80]	180 [0.80]	(d)	270 [1.2]
B4 Apparent Opening Size (AOS) maximum (f)	D4751 U.S. Std. sieve size [mm]	40 [0.425]	40 [0.425] as applied	50 [0.30]	50 [0.30]	30 [0.60]	20 [0.85]	50 [0.30]
B5 Permittivity minimum (g)	D4491 falling head sec^{-1}	0.7	2.75 relaxed	0.5	0.5	0.05	0.05	0.5
B6 Puncture strength minimum	D6241 lb [N]	—	180 [800]	—	—	—	—	—
B7 Wide Width Strip Tensile Strength minimum each principal direction	D4595 lb/ft [kN/m]	—	—	—	—	—	(d)	—

(a) Minimum Average Roll Values (MARV) based on average of at least three tests per swatch.
(b) Provide socks made of knit polymeric materials and meeting the requirements of ASTM D6707-06, for Type H: fabric. Ensure the sock exhibits minimum snag or run potential, is factory-applied to maintain uniform installed mass, and conforms to the outside diameter of the tubing with a snug fit.
(c) Needle-punched nonwoven. Do not use thermally bonded (heat-set) fabric.
(d) Requirements are site-specific and will be as specified in the contract. The property values for B1 and B3 may not be less than shown for Type 5. If the contract does not specify either B1 or B7, use a default value of 300 lb [1.3 kN] for B1. If the contract does not specify seam strength, use a default value of 270 lb [1.2 kN] for B3.
(e) Adhere to this requirement if the contract requires or allows seams. Strength specifications apply to factory and field seams. Use thread for sewing that has strength of at least 25 lb [110 N]. Sew seams with a Federal Type 401 stitch using a two-spool sewing machine, and install seams facing upward. For seaming with adhesives, see the Approved/Qualified Products List available at the Department's website.
(f) For U.S. sieve sizes, the AOS Number must be equal to or greater than the number specified.
(g) Permittivity: P = K/L, where K = fabric permeability and L = fabric thickness.

3733.3 SAMPLING AND TESTING

A Certificate of Compliance

Ensure the supplier submits to the Engineer a Certificate of Compliance and a document stating the manufacturer's MARV with each shipment of geotextile. MARV are two standard deviations below the mean value of all rolls tested. Provide a copy of the Certificate of Compliance and MARV with each geotextile sample sent to the Materials Laboratory for testing.

B Sampling and Testing

The Department's inspection and test results will determine acceptance of the geotextile, in accordance with 1603.4, "Acceptance." In the presence of the Engineer, randomly select samples in the field at the rates and sample sizes shown in the Schedule of Materials Control. Cut samples across the full width of the roll. Do not sample the first full turn (outside layer) of the roll. Provide seam samples in addition to the regular sample. Use the same machine, or an equal machine to the one on the project, to produce seam samples.

3741 ELASTOMERIC BEARING PADS

3741.1 SCOPE

Provide elastomeric bearing pads for use in bridges and other structures.

3741.2 REQUIREMENTS

A General

The basis of design for all bearing pads is in conformance with Method A of the *AASHTO LRFD Bridge Design Specifications*.

Use a bearing pad supplier listed on the "Approved/Qualified Products List for Bridge Products, Elastomeric Bearing Pads". Test and manufacture elastomeric bearing pads in accordance with AASHTO M 251 except as modified in this special provision.

Provide bearing pads no greater than ½ in [13 mm] thick, fabricated of all elastomer. Plain elastomer pads may be cut from larger sheets cast to the thickness shown on the plans. Avoid heating or damaging the material when cutting. Ensure the cutting produces smooth edges at least meeting the requirements of ANSI 250 finish.

Provide bearings of laminated construction when pads are greater than ½ in [13 mm] thick. Refer to AASHTO M 251 for tolerances, dimensions, and configurations, except provide elastomer to a thickness of ¼ in [6 mm] within a range from $+^{1}/_{8}$ inch to $-^{1}/_{16}$ inch [+3 mm to –2 mm] to cover the top and bottom steel plates.

Provide laminated pads meeting the following requirements or characteristics:

(1) Consisting of alternate layers of elastomer and metal reinforcement integrally bonded together,
(2) Containing reinforcement spaced as shown on the plans, and parallel to the top and bottom surfaces of the pad, and
(3) Including the manufacturer's name or trademark molded into the edge of the pad.

Do not expose the finished laminated pad to temperatures greater than 400°F [205°C].

Cover the edges of metal reinforcement with ¼ in [6 mm] of elastomer.

B Physical Properties

Substitute the requirements of sections 4.1 and 4.2 of AASHTO M 251; comply with B.1 & B.2 in this specification.

B.1 Elastomer

Use elastomer compound containing only virgin crystallization resistant polychloroprene (neoprene) or virgin natural polyisoprene (natural rubber) as the raw polymer. Use only new material with no reclaimed material incorporated in the finished bearing.

Provide elastomer for bearing pads meeting the requirements of AASHTO M 251 with durometer hardness of 60 on the Shore "A" scale. Provide elastomer compounds classified as Low-Temperature Zone D, Grade 4 or 5 meeting the requirements of AASHTO *LRFD Bridge Design Specifications*, Table 14.7.5.2-1, "Low-Temperature Zones and Minimum Grades of Elastomer".

Utilize cotton duck bearing pads (CDP) where MnDOT Bridge Details Part 1 B310 and B354 are included in the plans or when MnDOT Bridge Details Part 1 B311 or B355 utilize plain (non-steel reinforced) elastomeric bearing pads. Test and

manufacture CDP in accordance with Military Specification MIL-C-882E. For CDP, waive additional sampling and testing requirements listed in this specification.

B.2 Properties

Test and accept sampled bearings in accordance with the following:

	Natural Polyisoprene (Natural Rubber)	Polychloroprene (Neoprene)
Durometer	60±5	60±5
Physical properties Hardness (ASTM D 2240)	60±5	60±5
Tensile strength (ASTM D 412)	2250 psi [15.5 MPa]	2250 psi [15.5 MPa]
Ultimate elongation (ASTM D 412), minimum	400%	400%
Heat resistance (ASTM D 573)	158°F [70°C]/168hrs	212°F [100°C]/70hrs
Temperature / Aging Time		
Hardness, maximum Shore "A" points change	+10	+15
Tensile strength, maximum percent change	–25%	–15%
Ultimate elongation, maximum percent change	–25%	–40%
Compression set (ASTM D 395, method B) 22 hrs. at 158°F [70°C], maximum percent	25	N.A.
22 hrs. at 212°F [100°C], maximum percent	N.A.	35
Low Temperature Test (ASTM D 746, procedure B)	No Failure	No Failure
Brittleness at –54.4°F [–48°C]		
Laminated Pad Adhesion Test (ASTM D 429, method B)	40 psi [0.276 MPa]	40 psi [0.276 MPa]
Bond Strength (Peel Test)		

Compressive Strain of Laminated Bearings

Test each sampled laminated pad for compressive strain. The compressive strain in any layer of a laminated pad shall not exceed 9 percent at 1250 pounds per in^2 [8.62 MPa] average unit pressure for the full size laminated pad.

Proof Load Testing

Proof load each bearing pad per AASHTO M 251, Section 8.8.2. Use a compressive load of 1800 pounds per in^2 [12.41 MPa] for laminated pads and 1200 pounds per in^2 [8.27 MPa] for plain elastomeric pads. Reject bearing pads if bulging patterns imply laminate placement does not satisfy design criteria and manufacturing tolerances, or if bulging suggests inadequate laminate bond. Also reject bearing pads if there are three separate surface cracks greater than $^1/_{16}$ in [1.5 mm] wide by $^1/_{16}$ in [1.5 mm] deep.

B.3 Metal Reinforcement

Provide mild steel plates at least $^1/_8$ in [3 mm] thick for use as metal reinforcement.

C Certification

Submit to the Engineer a manufacturer's Certificate of Compliance.

3741.3 SAMPLING AND TESTING

A Manufacturer Sampling and Testing

Sample and test in accordance with AASHTO M 251, Section 8 except as modified in this special provision. Destructive test finished laminated and plain bearing pads at a rate of two full size bearing pads per lot (produced from the same raw material utilizing the same processes and procedures). A lot shall not exceed 100 pads and is not limited to finished sizes or thickness. Destructive testing is defined as any test that renders the product not usable for its intended purpose.

Provide bearing pad test data and certification prior to shipping. Test results of samples must verify compliance to product specifications. Any bearing tested that does not meet the specifications will result in the rejection of the entire lot. When applicable, the supplier shall retain a copy of the passing test results for one year and supply the document with subsequent jobs.

The cost of all bearing pad testing is incidental to the bearing pads.

Concrete Curing Materials

3751 BURLAP CURING BLANKETS

3751.1 SCOPE
Provide burlap cloth for use as a curing cover on portland cement concrete.

3751.2 REQUIREMENTS
Provide burlap cloth meeting the requirements of AASHTO M 182, Class 3 for use as a curing cover on portland cement concrete.

3751.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control.

3753 TYPE 1-D MEMBRANE CURING COMPOUND

3753.1 SCOPE
Provide clear or translucent liquid membrane forming curing compounds with a Type 1-D fugitive dye for spray application on portland cement colored or stamped concrete surfaces, where a finished white surface would mask the decorative finished concrete surface when exposed to the air.

3753.2 REQUIREMENTS
A General
Provide membrane curing compound meeting the following requirements:

(1) All membrane-curing compounds pre-approved by the Department before use. The most current approved lots and batches with product expiration dates are available on the Approved/Qualified Products List,
(2) Meets the requirements of the Department's Curing Compound Manufacturer Approval Program, as listed in the Approved/Qualified Products List, including pre-testing of materials by the manufacturer,
(3) Meets the requirements of ASTM C 309, Type 1-D Curing Compound, and
(4) The Engineer will not allow the use of curing compound that is over 1 year from the manufacture date.

The Contractor may use Type 1-D curing compound in other concrete applications as approved by the Engineer or as shown on the special provisions. Use of any other Type 1 curing compound is at the discretion of the Engineer, in conjunction with the Concrete Engineer.

3753.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control.

Test the material at an application rate of 200 sq. ft per gal [5 sq. m per L].

3754 POLY-ALPHA METHYLSTYRENE (AMS) MEMBRANE CURING COMPOUND

3754.1 SCOPE
Provide poly-alpha methylstyrene liquid membrane curing compounds for spray application on portland cement concrete surfaces exposed to the air.

3754.2 REQUIREMENTS
Provide membrane-curing compound meeting the following requirements:

(1) All membrane-curing compounds pre-approved by the Department before use. The most current approved lots and batches with product expiration dates are available from the Approved/Qualified Products List.
(2) Meets the requirements of the Department's Curing Compound Manufacturer Approval Program, including pre-testing of all materials by the manufacturer.
(3) Meets the requirements of ASTM C 309 for the type required by the contract.
(4) The Engineer will not allow the use of curing compound that is over 1 year from the manufacture date.
(5) White pigmented Type 2, Class B.
(6) Resin is 100 percent poly-alpha methylstyrene and formulated to maintain the specified properties of Table3754-1.

Table 3754-1 Requirements for 3754 AMS Curing Compound	
Properties	**Range**
Total solids, % by weight of compound	≥ 42
% reflectance in 72 h (ASTM E 1347)	≥ 65
Loss of Water, kg/sq. m in 24 h (ASTM C 156)	≤ 0.15
Loss of Water, kg/sq. m in 72 h (ASTM C 156)	≤ 0.40
Settling Test, ml/100 ml in 72 h*	≤ 2
V.O.C. Content, g/L	≤ 350
Infrared Spectrum, vehicle‖	100% α methylstyrene

* Test in accordance with the method on file at the Materials Laboratory.
‖ Match the infrared scan for the dried vehicle from the curing compound to the infrared scan on file at the Materials Laboratory.

3754.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control.

Test the material at an application rate of 200 sq. ft per gal [5 sq. m per L].

3755 LINSEED OIL MEMBRANE CURING COMPOUND

3755.1 SCOPE
Provide extreme service white pigmented, heavy bodied linseed oil emulsion for application as a membrane cure and sealer.

3755.2 REQUIREMENTS
Provide membrane curing compounds meeting the following requirements:

(1) All membrane-curing compound pre-approved by the Department before use. The most current approved lots and batches with product expiration dates are available on the Approved/Qualified Products List.
(2) Meets the requirements of the Department's Curing Compound Manufacturer Approval Program, including pre-testing of materials by the manufacturer.
(3) Composed of a blend of boiled linseed oil and high viscosity, heavy bodied linseed oil emulsified in a water solution meeting the requirements of ASTM C 309, Type 2, except the Department will waive the drying time.
(4) The Engineer will not allow the use of curing compound that is over 1 year from the manufacture date.
(5) Sprayable at temperatures of at least 40 °F [4 °C].
(6) Formulated to maintain the specified properties of Table3755-1.

Table 3755-1 Chemical Requirements of Linseed Oil Membrane Curing Compound (volumes exclusive of added pigment)	
Material Requirements	**Percent by Weight**
Oil phase (50% ± 4% by volume):	
Boiled linseed oil	80
Z-8 viscosity linseed oil	20
Water phase (50% ± 4% by volume)	100

3755.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control.

Test membrane curing compound at an application rate of 200 sq. ft per gal [5 sq. m per L].

3756 PLASTIC CURING BLANKETS

3756.1 SCOPE
Provide white polyethylene sheeting for use as a curing cover on portland cement concrete.

3756.2 REQUIREMENTS
Provide white polyethylene sheeting meeting the requirements of ASTM C 171, "White Opaque Polyethylene Film."

3756.3 SAMPLING AND TESTING
Provide samples for testing meeting the requirements of the Schedule of Materials Control.

3757 MEMBRANE WATERPROOFING SYSTEM

3757.1 SCOPE

Provide a membrane waterproofing system to be used for waterproofing below-grade joints in concrete structures, tunnels, and other below grade applications on concrete structures.

3757.2 REQUIREMENTS

Provide a membrane waterproofing system meeting the following requirements:

(1) Listed on the Approved/Qualified Products List, and
(2) Consists of a primer, a rubberized asphalt membrane on a cross-laminated polyethylene carrier film, an pointing mastic, and a protection course.

A Primer

Provide a solvent-based primer meeting the requirements of Federal and Minnesota Pollution Control Agency VOC regulations and specially formulated for use with the waterproofing system being used.

B Membrane

Provide waterproofing system with a membrane meeting the requirements of Table 3757-1:

Table 3757-1
Waterproofing Membrane Requirements

Property	Specification	Test Method
Thickness	≥ 56 mil [1.42 mm]	ASTM D 3767,Method A
Tensile strength	≥ 250 psi [1.7 MPa]	ASTM D 412, Die C
Elongation	≥ 300%	ASTM D 412, Die C
Composition	Rubber asphalt	Infrared scan

C Carrier Film

Provide membrane waterproofing system with carrier film meeting the requirements of Table 3757-2:

Table 3757-2
Waterproofing Carrier Film Requirements

Property	Specification	Test Method
Thickness	≥ 4 mil [0.1 mm]	ASTM D 3767, Method A
Composition	Polyethylene	Infrared scan

D Composite Membrane

Provide membrane waterproofing system with a composite membrane meeting the requirements of Table 3757-3:

Table 3757-3
Waterproofing Composite Membrane Requirements

Property	Specification	Test Method
Pliability, 180° bend, 1 in [25 mm] mandrel at −25 °F [−32 °C]	Unaffected	ASTM D 146
Permeance	< 0.05 Perms	ASTM E 96, Method B
Peel adhesion	≥ 5 lb/in [kg/mm]	ASTM D 903 Modified*
Water absorption	−0.1%, 72 h	ASTM D 1970

* 90 percent peel after 7 days at 70 °F [21 °C], plus 7 days at 120 °F [49 °C], plus 7 days at 70 °F [21 °C] (dry) (wet). The 180° peel strength is run at a rate of 12 in [300 mm] per minute.

3757.3 SAMPLING AND TESTING

Provide samples in rates and sizes meeting the requirements of the Schedule of Materials Control, or as required by the contract.

The Materials Engineer, may perform tests on samples taken from the product proposed for use or on samples submitted and certified by the manufacturer as representative of the membrane waterproofing system to be supplied.

3760 INSULATION BOARD (POLYSTYRENE)

3760.1 SCOPE

Provide extruded polystyrene insulation board for use on highway insulation applications.

3760.2 REQUIREMENTS

Provide extruded polystyrene insulation board used for highway insulation applications meeting the requirements of AASHTO M 230, except the Department will not apply the requirement for flammability. The contract will identify the selected type of insulation board and the insulation board strength as listed in AASHTO M 230.

3760.3 SAMPLING AND TESTING

Provide samples meeting the requirements of the Schedule of Materials Control.

Electrical Materials

3801 RIGID STEEL CONDUIT (RSC)

3801.1 SCOPE
Provide rigid steel conduit and fittings constructed of galvanized steel for electrical systems.

3801.2 REQUIREMENTS
Use rigid steel conduit listed and labeled by an NRTL, as defined by the U.S. Department of Labor, and meeting the requirements of UL 6 and UL 514B. Use an NRTL listed by OSHA in its scope of recognition for the tests required by this specification.

Hot-dip galvanize the inside and outside surfaces of rigid steel conduit and fittings.

3801.3 SAMPLING AND TESTING
Label each conduit length with the relevant NRTL label.

The Department reserves the right to sample, test, inspect, and accept or reject conduit or fittings based on its own tests.

3802 INTERMEDIATE METAL CONDUIT

3802.1 SCOPE
Provide intermediate metal conduit and fittings for electrical systems.

3802.2 REQUIREMENTS
Use intermediate metal conduit listed and labeled by a NRTL, as defined by the U.S. Department of Labor, and meeting the requirements of UL 6 and UL 514B. Use an NRTL listed by OSHA in its scope of recognition for the tests required by this specification.

Hot-dip galvanize the inside and outside surfaces of intermediate metal conduit and fittings.

3802.3 SAMPLING AND TESTING 3801

3803 NON-METALLIC RIGID PVC AND HDPE CONDUIT

3803.1 SCOPE
Provide rigid polyvinyl chloride (PVC) and high density polyethylene (HDPE) conduit and fittings for electrical systems.

3803.2 REQUIREMENTS

A Rigid PVC Conduit
Use rigid PVC conduit and fittings meeting the following requirements:

(1) Listed by an NRTL as meeting the requirements of UL 514B and UL 651 for underground use,
(2) Gray in color,
(3) Smooth interior and exterior surfaces,
(4) Schedule 80 conduit and conduit fittings, and
(5) With the following marked on the outside:
  (5.1) Manufacturers name,
  (5.2) Size of conduit,
  (5.3) Conduit type, and
  (5.4) NRTL Certification Mark.

B High Density Polyethylene (HDPE) Conduit
Use HDPE continuous-type conduit and fittings meeting the following requirements:
(1) In compliance with ASTM F 2160,
(2) Listed by NRTL as meeting the requirements of UL 651B,
(3) Schedule 80 conduit and conduit fittings,
(4) Red or gray in color,
(5) Smooth interior and exterior surfaces, and
(6) With the following marked on the outside:
  (6.1) Manufacturers name,
  (6.2) Size of conduit,

(6.3) Type of conduit, and
(6.4) NRTL Certification mark.

3803.3 SAMPLING AND TESTING 3801

3804 LIQUID TIGHT FLEXIBLE NON-METALLIC CONDUIT (LFNC-B)

3804.1 SCOPE
Provide liquid tight flexible non-metallic (LFNC-B) conduit and fittings for electrical systems.

3804.2 REQUIREMENTS
Use liquid tight flexible non-metallic conduit meeting the following requirements:

(1) Type LFNC-B,
(2) Listed and labeled by NRTL as meeting the requirements of UL 1660,
(3) Listed for 80°C (176°F) in a dry location,
(4) Listed for 60°C (140°F) in a wet location,
(5) Listed for 70°C (158°F) in an oily location,
(6) Sunlight resistant,
(7) Rated for outdoor use,
(8) CSA certified for use at 75°C (167°F) in dry and oily locations and for minus 18°C (0° F) low temperature applications, and
(9) Shall not have a metallic integral reinforcement within the conduit wall.

3804.3 SAMPLING AND TESTING 3801

3805 PVC COATED HOT DIPPPED GALVANIZED RIGID STEEL CONDUIT

3805.1 SCOPE
Provide NRTL listed PVC coated hot-dipped galvanized rigid steel conduit and fittings with a urethane lined interior for electrical systems.

3805.2 REQUIREMENTS
Use PVC coated hot-dipped galvanized rigid steel conduit listed and labeled by an NRTL, as defined by the U.S. Department of Labor, and meeting the requirements of UL 6. Use PVC Coated fittings listed and labeled in accordance with UL 514B. Use an NRTL listed by OSHA in its scope of recognition for the tests required by this specification.

A PVC COATED HOT DIPPED GALVANIZED RIGID STEEL CONDUIT
Use PVC coated galvanized RSC conduit meeting the following requirements:

(1) Conduits that comply with UL 6, ANSI C80.1, and NEMA RN-1,
(2) Hot-dip galvanize the inside and outside surfaces of rigid steel conduit,
(3) Gray PVC coat exterior of rigid steel conduit and fittings in compliance with NEMA RN-1 standards,
(4) Gray PVC coating shall be nominal 40 mils in thickness continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles or pinholes,
(5) List both PVC and zinc as the primary corrosion protection,
(6) Urethane coat internal parts of conduit and fittings in accordance with NEMA RN-1 "Corrosion Resistant Internal Coatings",
(7) A urethane coating shall be uniformly and consistently applied to the interior of conduit,
(8) Internal urethane coating shall be a nominal 2-mil thickness, and
(9) All male threads on elbows and nipples shall be protected by the application of urethane coating or zinc metalized spray.

B FITTINGS FOR PVC COATED HOT DIPPED GALVANIZED RIGID STEEL CONDUIT
Use PVC coated zinc plated metallic fittings meeting the following requirements:

(1) Fittings that comply with UL 514B,
(2) Suitable for use with PVC coated hot-dipped galvanized RSC conduit,
(3) Zinc plate the inside and outside surfaces,
(4) Gray PVC coat exterior of all fittings,
(5) Gray PVC coating shall be nominal 40 mils in thickness continuous over the entire fitting and be free of blisters, bubbles or pinholes,
(6) With overlapping PVC sleeves on female threaded ends for protecting and covering male threaded joints threaded into the fitting,

(7) List both PVC and zinc as the primary corrosion protection,
(8) Stainless steel hardware,
(9) Urethane coat internal parts of fittings,
(10) A urethane coating shall be uniformly and consistently applied to the interior of the fittings, and
(11) Internal urethane coating shall be a nominal 2-mil thickness.

C HANGERS AND SUPPORTS FOR PVC COATED HOT DIPPED GALVANIZED RIGID STEEL CONDUIT
Use hangers and supports specifically designed for PVC coated galvanized RSC conduit.

3805.3 SAMPLING AND TESTING
Label each conduit length and fitting with the relevant NRTL label.

The Department reserves the right to sample, test, inspect, and accept or reject conduit or fittings based on its own tests.

3810 LUMINAIRES

3810.1 SCOPE
Provide luminaires for lighting systems as specified in contract documents.

3810.2 REQUIREMENTS

A General
Use a complete and operational luminaire of the type and capacity required by the contract.

B Roadway Lighting Luminaire
Use roadway lighting luminaires listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

B.1 Cobra Head Luminaires
Provide HPS cobra head luminaires listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

B.2 LED Roadway Luminaires (40 Foot Mounting Height)
Provide LED roadway luminaires for mounting at 40 feet listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

B.3 LED Roadway Luminaires (49 Foot Mounting Height)
Provide LED roadway luminaires for mounting at 49 feet listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

C Sign Lighting Luminaire
Provide sign lighting luminaires listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

D Underpass Luminaire
Provide underpass luminaires as indicated on the plan.

D.1 Underpass Luminaires HPS
Provide HPS roadway underpass luminaires listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

D.2 Underpass Luminaires LED
Provide LED roadway underpass luminaires listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

E High Pressure Sodium Lamps
Use high-pressure sodium lamps listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

F High Pressure Sodium Self-Starting Extended Life Lamps
Use high-pressure sodium, self-starting, extended-life lamps listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

Do not install luminaires until approved by the District Traffic Engineer or Signing Engineer.

3811 LIGHT POLES

3811.1 SCOPE

Design and provide light poles including poles, mast arms, and base anchorages.

3811.2 REQUIREMENTS

A General

Provide a complete light pole and hardware required for installation as required by the contract and in accordance with the current edition of AASHTO *Standard Specifications of Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. Provide light poles designed with a service life of at least 30 years in accordance with the wind load and fatigue requirements specified in this AASHTO Specification.

Provide breakaway light poles with certification from the manufacturer that the light pole meets the breakaway specifications as specified in the current edition of AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Provide a nominal 2 3/8 inch (60 mm) schedule 40 tenon for slip fit luminaire installation.

Provide a davit or mast arm with an upward angle from horizontal of 3 degrees ± 2 degrees.

The Engineer will reject light poles that do not meet requirements as defined herein.

B Light Pole

Provide mast arm or davit poles designed for a 75 lb [34 kg] luminaire with a projected area of 3.2 sq. ft [0.3 sq. m].

For twin mast arm poles, design for each mast arm to hold a 75 lb [34 kg] luminaire with the projected area of 3.2 sq. ft [0.3 sq. m].

Provide truss arm type poles with a removable, rainproof, ornamental cap for the top of shaft and with a smooth opening in the shaft for cable entry into the mast arm. Provide mast arms fabricated from pipe or tubing, without intermediate splices or couplings, as shown on the plans. Ensure the mast arm to shaft bracket provides a watertight connection.

Unless the contract requires otherwise, provide transformer base type poles. Design and construct the base to provide internal space to accommodate a waterproof frame and a mount for fuses, and ballasts. Provide an access hole, with an opening of at least 100 sq in [0.06 sq. m] on one side of the base. Provide the access hole with a waterproof cover with positive closure. Place the access hole 180° from the mast arm unless otherwise required by the contract.

Finish exposed edges and corners of the light pole base assembly smooth and round the corners so no burrs remain.

Provide breakaway or non-breakaway light poles in accordance with the contract.

Provide each light pole with an electrical grounding lug or threaded hole for attaching a grounding lug with tang. Design and fabricate each light pole to provide electrical continuity to the grounding lug.

Design each pole to stand plumb with the design dead loads in place under a no-wind condition.

Provide light poles with at least the shell thicknesses and shaft diameters required by the contract or the design analysis for the following material types:

B.1 Coated Steel Poles

Provide shafts and transformer bases fabricated from steel meeting the requirements of 3309, "High-Strength Low-Alloy Structural Steel." If the plans show a galvanized coating, the Engineer may approve the use of another weldable steel with a yield point of at least 40,000 psi [276 MPa] after fabrication. Fabricate shafts with only one longitudinal seam unless otherwise allowed.

Provide mast arms made of Schedule 40 pipe meeting the requirements of ASTM A 53, Grade A.

Paint or galvanize component parts of the pole, including hardware and fittings as required by the contract.

Clean, paint, and galvanize in accordance with 2471.3.L, "Coating," and 2478, "Organic Zinc-Rich Paint System."

B.2 Aluminum Alloy Poles

Provide aluminum alloy poles meeting the requirements as follows:

(1) Shafts fabricated from seamless 6063-T6 or 6061 T6 aluminum alloy 0.188 in [4.78 mm] thick tapered tubing.
(2) 10 inch diameter tapered pole shaft.
(3) Mast arms fabricated from 6063-T6 or 6061-T6 seamless tubing.

(4) Aluminum alloy poles with a factory installed vibration dampener and an aluminum wall thickness of 0.188 in [4.78 mm].
(5) Transformer bases for breakaway designs fabricated from cast aluminum alloy 356-T6.
(6) Stainless steel screws, nuts, bolts, washers, and other miscellaneous hardware, except for the anchor rod assemblies, meeting the requirements of 3391.2, "Fasteners, Requirements," for stainless steel fasteners.
(7) Aluminum alloy poles with a nonspecular, natural or sand belted (satin) finish.

B.3 Stainless Steel Poles

Provide shafts, mast arms, transformer bases, and base slip fitters fabricated from material meeting the requirements of ASTM A 240, UNS Designation S20103, or an approved equal, as required by the contract, with a yield strength of at least 50,000 psi [345 MPa]. Provide a slip fitter accommodating the luminaire fabricated from material meeting the requirements of ASTM A 511, Grade MT 304L, Grade MT 316L, or an approved equal, as required by the contract.

Attach the transformer base to the shaft using a slip fitter at least 1½ times the length of the major shaft diameter. Accurately size the slip fitter. Rivet the stainless steel base to the transformer base. Design the light pole so the base to slip fitter circumferential weld and heat affected zone are visible after assembling the shaft and slip fitter.

The Engineer will approve the number and size of the base plate rivets before fabrication. Provide annealed and waxed Type 316 rivets or an approved equal.

Clean the complete pole with a cleaning agent that will not damage the original mill finish.

3811.3 SAMPLING AND TESTING

Within 30 days after contract award, submit the following information to the Engineer as a basis for testing and acceptance:

(1) Material specifications with chemical compositions and mechanical properties for lighting pole and anchorage assembly components,
(2) Dimensioned drawings of the pole and component details,
(3) Manufacturing and assembly data for the pole and the components,
(4) Data supporting the breakaway design features of the pole,
(5) Anchor bolt test specimen that are representative of the designs,
(6) Structural design computations for the lighting pole and components, including design criteria, allowable stresses, fatigue stresses, loading, and designed unit stresses, and
(7) A certification from a registered professional engineer competent in structural design certifying the structural adequacy of the proposed lighting pole.

If the Department previously approved the manufacturer's design and if the manufacturer certifies, in writing that the material, design, structural analysis, manufacturing procedure, and workmanship are the same as previous poles on the project, the Department will not require the data, computations, and certificates for items 3, 4, 6, and 7.

The Engineer will perform final inspection and acceptance at the project, including identification and documentation of the item, type, size, and manufacturer's marking, of the light poles. The Engineer will select random samples from the material delivered to the project or at the source before delivery.

Submit five complete sets of shop detail drawings of the light poles and anchor rods in accordance with 2471.3.B.1, "Shop Detail Drawings, General Requirements," and 2471.3.B.3, "Submittal for Engineer's Review and Approval," to the Engineer for approval by the District Traffic Engineer. Submit final reproducible drawings in accordance with 2471.3.B, "Shop Detail Drawings," for high mast lighting installations. After approval, the Engineer will distribute the drawings to the following:

(1) Contractor,
(2) Contractor's fabricator,
(3) Engineer,
(4) Traffic Electrical Systems Engineer, and
(5) District Traffic Engineer

Obtain the Engineer's approval before installing light poles.

3812 LIGHTING SYSTEM EQUIPMENT

3812.1 SCOPE

Provide miscellaneous lighting equipment required for a complete lighting system.

3812.2 REQUIREMENTS

A Luminaire Wire Holders

Provide luminaire wire holders for lighting systems listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

B Insulated Wire Splice Connector Blocks

Provide breakaway type insulated wire splice connector blocks listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

C Fuse Holders

Provide fuse holders listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

D Photoelectric Controls

Provide photoelectric controls listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

3813 LIGHTING SYSTEM ANCHORAGES

3813.1 SCOPE

Provide foundation anchorages in accordance with 3385 and as required by contract documents.

3813.2 REQUIREMENTS

A Lighting Service Cabinet Cast-In-Place Equipment Pad Anchorages

Provide galvanized embedded concrete "L" shaped anchor rods and nuts for lighting service cabinet installation on cast-in-place equipment pads in accordance with 3385, "Anchor Rods," and meeting the following requirements:

(1) 3385.2A "Type A- Carbon Steel Anchor Rods,"
(2) Sized, type, and quantity as required by the contract, and
(3) one (1) 2in (50.8mm) O.D. stainless steel washer per anchor rod.

Do not use mechanical anchors or concrete wedge anchor bolts.

B Lighting Service Cabinet Precast Equipment Pad Anchorages

Provide stainless steel threaded rod anchors, nuts, and washers for lighting service cabinet installation on precast equipment pads in accordance with 3385.2 D "Stainless Steel Anchor Rods," and meeting the following requirements:

(1) Sized, type, and quantity as required by contract, and
(2) one (1) 2in (50.8mm) O.D. stainless steel washer per anchor rod.

Do not use mechanical anchors or concrete wedge anchor bolts.

C 4 Bolt Anchorages for Light Pole Foundations

Provide anchor rods, nuts, and washers for light pole installation on concrete foundations in accordance with 3385, "Anchor Rods," and meeting the following requirements:

(1) 3385, 2B "Anchor Rods; Type B – Carbon Steel Anchor Rods," and
(2) Sized as required by the contract.

D 6 Bolt Bridge and Barrier Anchor Bolt Clusters

Provide anchor rods, nuts, and washers to make a six (6) anchor bolts cluster foundation for light pole installation on concrete barrier in accordance with 3385 "Anchor Rods" and meeting the following requirements:

(1) 3385.2B, "Type B- Intermediate Strength Anchor Rods" except for bridge and barrier light pole type 12-49 double davit foundations,
(2) Sized as required by the contract, and
(3) Provide two (2) jam nuts in place of one (1) heavy hex nut for top nut.

For bridge and barrier light poles type 12-49 double davit installation provide anchor rods, nuts and washers to make a six (6) anchor bolts cluster foundation meeting the following requirements:

(1) 3385.2C, "Type C- High Strength Anchor Rods,
(2) Mechanical cage only using methods approved by Engineer. Do not weld anchor bolts to cage or other material,
(3) Sized as required by the contract, and
(4) Provide two (2) jam nuts in place of one (1) heavy hex nut for top nut.

E Light Pole Steel Screw-In Foundation and Fasteners

Provide approved steel screw foundations with manufacturer supplied bolts, nuts, and washers listed on MnDOT's Approved/Qualified Products List web under "Roadway lighting" for light pole installation on steel screw-in foundations and meeting the following requirements:

(1) Galvanized in accordance with 3392, "Galvanized Hardware," and
(2) Sized as required by the contract.

Do not install light poles that require shims for leveling on steel screw-in foundations.

3814 EMERGENCY VEHICLE PRE-EMPTION (EVP) EQUIPMENT

3814.1 SCOPE

Provide Emergency Vehicle Preemption (EVP) equipment for traffic control signal systems.

3814.2 REQUIREMENTS

Use EVP systems and confirmatory indicator lights mounted on traffic control signal mast arms and traffic control signal pedestals as required by the contract. Use mounting hardware and attach to mast arms and pedestals in accordance with the contract and as approved by the Engineer.

A EVP Detectors

Use EVP systems listed on MnDOT's Approved/Qualified Products List under "Signals."

Deliver EVP phase selectors to the Department's Central Electrical Services Unit at least 30 working days before the traffic control signal cabinet is required on the project. The Department's Central Electrical Services Unit will approve and install the EVP phase selectors into the Department-provided traffic control signal cabinet.

B EVP Light Emitting Diode (LED) Confirmatory Indications

Only use LED EVP confirmatory indications listed on MnDOT's Approved/Qualified Products List under "Signals."

C EVP Round Outlet Box

Use an EVP round outlet box for wire splicing with the following characteristics:

(1) Nominal 4 in [100 mm] diameter by 1½ in [38 mm] deep,
(2) Cast aluminum,
(3) NRTL listed, for use in wet locations,
(4) Threaded openings at the top, bottom, and two sides, with threaded caps, to support ¾ in [20 mm] conduit,
(5) One threaded opening with threaded cap to support a ¾ in [20 mm] conduit on the back of outlet box,
(6) Galvanized or zinc-plated screw-on cover for wet locations with weather seal, and
(7) Threaded nipples with locking washers sized to fit the round outlet box for attached appurtenances.

D EVP Condulet Outlet Body

Use an EVP condulet outlet body for mounting the EVP detector unit to the EVP round outlet box with the following characteristics:

(1) 90° up from horizontal,
(2) Screw-on cover with weather tight seal,
(3) Male threaded end and female threaded end,
(4) NRTL listed, and
(5) For use in wet locations.

E EVP Confirmatory Indicator Lamp Holder

Use EVP confirmatory indicator lamp holders listed on MnDOT's Approved/Qualified Products List under "Signals."

3814.3 SAMPLING AND TESTING

Confirm and document the listing of the EVP systems and the EVP confirmatory indicator lamp holders on MnDOT's Approved/Qualified Products List under "Signals." Provide this documentation to the Engineer. Obtain the Engineer's approval of the EVP round outlet box or the EVP condulet outlet body before installation.

3815 ELECTRICAL CABLES AND CONDUCTORS

3815.1 SCOPE

Provide electrical cables and individual conductors for use in traffic control signal systems, roadway lighting systems, traffic management systems, sign control systems, automatic traffic recorder systems, and other electrical systems.

3815.2 REQUIREMENTS

A General

Provide copper electrical cables and conductors meeting the following requirements, unless otherwise required by the contract:

(1) Signal control cable listed by a NRTL as defined by the U.S. Department of Labor and tested in a laboratory listed by OSHA in its scope of recognition for the tests specified in this section. The Department will not require NRTL listing of Loop Detector Lead-in cable and EVP cable.
(2) Single stranded copper, 600 V electrical conductors meeting the requirements of ANSI and NEC.
(3) Electrical cable meeting the requirements of ANSI, NEC, ASTM, and ICEA/NEMA Standards Publications.
(4) Wire sizes for electrical conductors based on the American Wire Gauge (AWG).
(5) Electrical cables, except loop detector lead-in cables – IMSA 50-2 and 3/C # 20 EVP Cable, with the following information ink printed on the jacket:
    (5.1) Manufacturer name,
    (5.2) Year of manufacture (date code),
    (5.3) Type of wire or cable,
    (5.4) Size and number of conductors,
    (5.5) Voltage rating,
    (5.6) Conductor insulation rating,
    (5.7) NRTL certification mark indicating that the cable is listed, and
    (5.8) Labeled as sunlight resistant (Sun Res), direct burial (Dir Bur) and oil resistant 1 (Oil Res 1).

Provide signal control cable with the following additional markings:

(1) Traffic signal cable,
(2) Foot markers, and
(3) −31 ºF [−35 ºC] cold bend.

Provide loop detector lead-in cable – IMSA – 50-2 meeting IMSA marking requirements.

Provide EVP detector cable (3/C #20) surface marked in accordance with NEC and with the following additional markings:

(1) Labeled as sunlight resistant (Sun Res),
(2) Labeled as direct burial (Dir Bur),
(3) Year of manufacture (date code),
(4) Conductor insulation rating, and
(5) Foot markers.

Repeat cable markings at intervals no greater than 24 in [609 mm] on the jacket surface.

B Individual Electrical Conductors

B.1 Service, Feeder, and Branch Circuit Conductors

Provide individual conductors in accordance with contract documents and the following:

(1) Individual conductors with a color coded continuous outer finish insulation meeting these color requirements:

    (1.1) Black- line voltage or "hot" conductor,
    (1.2) Red- line voltage or "hot" conductor,
    (1.3) White- neutral or "grounded" conductor, and
    (1.4) Green- equipment grounding conductor (EGC).

(2) Sized as required by the contract and the NEC, and
(3) Type THW, THWN, or XHHW insulation.

B.2 Roadway Loop Detector Conductors

Provide roadway loop detector conductors in rigid polyvinyl chloride (PVC) conduit meeting the following requirements:

(1) 14 AWG,
(2) Stranded copper,
(3) Insulated with Type XLPE, or Type XHHW insulation in accordance with UL 44,
(4) Marked with "XLPE," "XLP," or "XHHW" on the conductor, and
(5) Full compliance with the requirements of International Municipal Signal Association (IMSA) "Official Wire & Cable Specification Manual" 51-3 latest version is required.

Provide conductors for roadway embedded saw-cut loop detectors meeting the following requirements:

(1) 14 AWG,
(2) Stranded copper,
(3) Insulated with filled chemically XLPE, or XHHW insulation in accordance with UL 44, and
(4) Contained in a black polyethylene tubing with an outside diameter of 0.250 in [6.35 mm] ± 10 mils [.25 mm]and a minimum average wall thickness of 30 mils [.76 mm] with no point less than 25 mils [.635 mm],
(5) Marked with "XLPE," "XLP," or "XHHW" on the conductor, and
(6) Full compliance with the requirements of International Municipal Signal Association (IMSA) "Official Wire & Cable Specification Manual" 51-7 latest version is required.
(6.1) No binding of the inner insulated loop conductor and the outer encasing tube is permitted.

B.3 Bridge Deck Loop Detector Conductors

Provide conductors for bridge deck embedded saw-cut loop detectors meeting the following requirements:

(1) 16 AWG,
(2) Stranded nickel or silver plated copper conductors, and
(3) Insulated with at least 0.010 in [0.25 mm] extruded Teflon meeting the requirements of MIL-W-16878D (Type E).

B.4 (Blank)

B.5 Grounding Conductors

Provide equipment grounding conductors (EGC) meeting the following requirements:

(1) Type THW, Type THWN, or Type XHHW,
(2) Green-colored insulated wire,
(3) 6 AWG unless otherwise specified in contract documents, (4) Stranded (7 strands, Class B Stranding), and
(5) Meeting the requirements of ASTM B 8 for stranded wires.

Provide bare solid grounding electrode conductors and bonding jumpers when specified in contract documents meeting the following requirements:

(1) Bare,
(2) Uninsulated solid copper wire,
(3) 6 AWG, unless otherwise specified in contract documents, and
(4) Meeting the requirements of ASTM B 3, "Soft Annealed Copper."

Provide insulated stranded grounding electrode conductors and bonding jumpers when specified in contract documents meeting the following requirements:

(1) Type THW, Type THWN, or Type XHHW,
(2) Green-colored insulated wire,
(3) 6 AWG, unless otherwise specified in contract documents,
(4) Stranded (7 strands, Class B Stranding), and
(5) Meeting the requirements of ASTM B 8 for stranded wires.

C Electrical Cables

C.1 Direct Buried Lighting Cable (4/C #4)

Provide shielded underground cable meeting the following requirements or characteristics:

(1) Listed by a NRTL as defined by the U.S. Department of Labor and tested in a testing laboratory listed by OSHA in its scope of recognition for the tests specified in this section. Provide shielded cable tested by an NRTL and meeting the requirements of UL 44 and UL 1277,
(2) Four conductors 4 AWG,
(3) Class C (19 Strand) soft drawn, bare copper wire conductors meeting the requirements of ASTM B 3 and ASTM B 8,
(4) Suitable for use in cable trays, aerial, or direct buried installations,
(5) Rated for 600 volts,
(6) Heat resistant,
(7) Moisture resistant,
(8) Sunlight resistant,
(9) Insulation acceptable for use in wet and dry locations at 194 °F [90 °C],
(10) Insulated conductors with chemically XLPE insulation,
(11) Individual conductors constructed with circuit identification in accordance with Method 1 of ICEA S-73-532 (NEMA WC-57) Table E-1 (Black, White, Red and Green),

(12) Single thickness copper tape shielding meeting the requirements of ASTM B 152 with a thickness of at least 0.01 in [254 µm] and a spiral overlap of at least 0.25 in [6.35 mm] wrapped around the binder tape and under the outer jacket,
(13) PVC outer jacket with an average thickness at least 80 mils [2.03 mm] and a thickness at any point at least 64 mils [1.62 mm],
(14) Constructed using a tape binder,
(15) Containing non-hygroscopic fillers used in the interstices of the cable where necessary to give the completed cable assembly a circular cross-section. Do not use fillers made of jute or paper,
(16) Containing a rip cord between the copper tape shield and the outer jacket
(17) Containing an outer cable jacket having a substantially circular cross-section as specified in ANSI/ICEA S-73-532 NEMA WC 57 and not convoluted or having a ropey appearance, and
(18) Outer jacket surface ink printed with the following information:
  (18.1) Manufacturer name,
  (18.2) Year of manufacture (date code),
  (18.3) Type of cable,
  (18.4) Size and number of conductors,
  (18.5) Voltage rating,
  (18.6) Conductor insulation rating,
  (18.7) Labeled NRTL listed,
  (18.8) Labeled as sunlight resistant (Sun Res) and direct burial (Dir Bur), and
  (18.9) Foot markers.

C.2 Temporary Overhead Lighting Cable

Provide quadplex cables for the overhead distribution circuits of electrical systems meeting the following requirements:

(1) Thermoplastic-insulated 4 conductor 4 AWG,
(2) Self supporting aluminum cable, and
(3) The fourth conductor that is an ACSR (aluminum conductor, steel reinforced) equipment ground messenger in accordance with the current edition of ANSI/NEMA/ICEA Specification for "Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy" (ANSI/NEMA publication No. WC 70 ICEA publication No. S-95-658,).

C.3 Signal Control Cable (3/C #14, 4/C #14, 6/C #14, 12/C #14)

Provide signal control cable listed by an NRTL as defined by the U.S. Department of Labor and tested in a testing laboratory listed by OSHA in its scope of recognition for tests specified by this section.

Provide cables tested by an NRTL and meeting the following requirements:

(1) UL 44,
(2) UL 1277,
(3) UL 1685,
(4) ICEA T-29-520,
(5) ICEA T-30-520,
(6) ICEA S-73-532 (NEMA WC 57),
(7) Suitable for use at 194 ºF [90 °C] in wet or dry locations,
(8) Suitable for direct burial,
(9) Sunlight resistant,
(10) Rated for 600 Volts,
(11) Rated as a Tray Cable,
(12) XHHW-2 cable designation,
(13) 14 AWG,
(14) Class B (7 strand) soft drawn, bare or tinned copper meeting the requirements of ASTM B 3, ASTM B 8, and ASTM B 33,
(15) Constructed with circuit identification meeting the requirements of Method 1 of ICEA S-73-532 (NEMA WC-57) Table E-1, except as modified below:
  (15.1) 3 Conductor:
    (15.1.1) Black,
    (15.1.2) White, and
    (15.1.3) Green
  (15.2) 4 Conductor
    (15.2.1) Black,
    (15.2.2) White,
    (15.2.3) Red, and
    (15.2.4) Black/red stripe
  (15.3) 6 Conductor:
    (15.3.1) Black,
    (15.3.2) White,

(15.3.3) Red,
(15.3.4) Black/red stripe,
(15.3.5) Orange, and
(15.3.6) Blue

(15.4) 12 Conductor:
(15.4.1) Black,
(15.4.2) White,
(15.4.3) Red,
(15.4.4) Black/red stripe,
(15.4.5) Orange,
(15.4.6) Blue,
(15.4.7) White/Black stripe,
(15.4.8) Red/Black stripe,
(15.4.9) White/Red stripe,
(15.4.10) Orange/Black stripe,
(15.4.11) Blue/Black stripe, and
(15.4.12) Black/White stripe.

(16) Average insulation thickness of at least 30 mil [0.76 mm],
(17) Constructed using a tape binder,
(18) Cable jacket having a substantially circular cross-section as specified in ANSI/ICEA S-73-532 NEMA WC 57, with an outer cable jacket not convoluted or having a ropy appearance,
(19) Non-hygroscopic fillers used in the interstices of the cables where necessary to give the completed cable assembly a circular cross-section,
(20) Fillers not made of jute or paper,
(21) Rip cord between the outer jacket and the tape binder,
(22) May be bare copper or tinned wires,
(23) Outer jacket of the 4 conductor cable having a diameter no greater than 0.480 in [12.19 mm]. Outer jacket of the 6 conductor cable having a diameter no greater than 0.560 in [14.22 mm],
(24) Carries an oil resistance level 1,
(25) Meets a −31 °F [−35 °C] cold bend test,
(26) Cables with a PVC jacket with a low migration grade of PVC,
(27) Cable jacket passes the 7 day [168 h] oven age test at 249.8 °F [121 °C] meeting the requirements of UL 1581, and
(28) Cable carries multiple ratings. If the requirements of different ratings conflict, ensure the cable meets the most stringent specification.

Submit to the Department the NRTL test qualification report, provided by the manufacturer, stating that the submitted cable meets the requirements of this section. The Department will not allow substitutions after the acceptance of a cable, unless otherwise approved by the Department in writing.

C.4 Loop Detector Lead-in Cable (2/C #14)

Provide 14 AWG conductor loop detector lead-in cable meeting the requirements of International Municipal Signal Association, Inc. Specification No.50-2- Polyethylene insulated, Polyethylene Jacketed Loop Detector Lead-in Cable latest version for use in traffic control signal systems and traffic management systems.

C.5 Emergency Vehicle Pre-emption (EVP) Detector Cable (3/C #20)

Provide EVP detector cable for conduit and mast arm pull, direct burial, and exposed overhead installation in traffic control signal systems meeting the following requirements:

(1) Consisting of twisted three-conductor shielded cable with ground drain wire,
(2) Suitable for use at 167 °F [75 °C] in wet or dry locations,
(3) Suitable for direct burial,
(4) Sunlight resistant,
(5) Rated for 600 Volts,
(6) 3/C 20 AWG (7x28) stranded, individually tinned copper, color coded yellow, blue, orange conductors,
(7) 20 AWG (7x28) stranded, individually tinned copper ground drain wire,
(8) Aluminized polyester shield with at least 0.170 in [6.35 mm] overlap,
(9) Black PVC jacket with a 0.04 in [1 mm] nominal wall thickness,
(10) Cable outside diameter, nominal 0.3 in [7.62 mm],
(11) Drain and conductor DC resistance no greater than 11.0 Ω per 1,000 ft [36 Ω per kilometer],
(12) Capacitance from one conductor to other two conductors and shield no greater than 48 pF per foot [157.5 pF per meter], and
(13) Cable marked with the following:
(13.1) Manufacturer name,
(13.2) Year of manufacture (date code),
(13.3) Type of cable,
(13.4) Size and number of conductors,

(13.5) Voltage rating,
(13.6) Conductor Insulation rating,
(13.7) Sunlight resistant (Sun Res) and direct burial (Dir Bur), and
(13.8) Foot markers.

C.6 Telephone Cables

Provide voice grade telephone cable for indoor installation, outdoor installation in conduit, outdoor direct buried installation, and telephone drop wire.

C.6.a Indoor Installation

Provide telephone cable installed indoors in conduit or cable trays utilizing 22 AWG conductors and meeting the requirements of ANSI/ICEA S-80-576.

C.6.b Outdoor Conduit or Direct Buried Installation

Provide telephone cable for direct buried installation or installation in conduit meeting the following requirements:

(1) Gopher resistant,
(2) Grease-filled,
(3) Using 19 AWG conductors, and
(4) Meets the requirements of RUS 7 CFR 1755.390, "RUS Specification for Filled Telephone Cables" and "REA Specification for Filled Telephone Cables" (PE-39), except do not use plastic-coated aluminum-shielded cable with plastic-coated steel-armor (CACSP).

Provide one of the following for cable shielding:

(1) 10 mil [0.25 mm] copper,
(2) 5 mil [0.13 mm] or 6 mil [0.15 mm] copper-clad stainless steel,
(3) 5 mil [0.13 mm] copper-clad alloy steel, or
(4) 6 mil [0.15 mm] or 7 mil [0.17 mm] alloy 194.

Provide cable jacket labeled as meeting the requirements of RUS 1755.390.

C.6.c Telephone Drop Wire

Provide telephone drop wire from the traffic control signal cabinet or other type cabinet to the point of connection with the servicing telephone company conductors meeting the following requirements:

(1) Two-conductor parallel-type drop wire for use on telephone systems,
(2) Meeting the requirements of RUS Bulletin 1753F-204(PE7), "RUS Specification for Aerial Service Wires," and
(3) Approved by the local telephone company.

C.6.d Ethernet Cable (Outside Plant)

Provide shielded Category 5e Ethernet cable for use in outdoor applications from the traffic control signal cabinet or other type cabinet to the point of connection with required equipment in the system meeting the following requirements.

(1) 4 pairs of conductors,
  (1.1) Stranded tinned copper,
  (1.2) 24 AWG 7/32,
  (1.3) Color coded pairs as follows:
    Pair 1: Blue, White/Blue
    Pair 2: Orange, White/Orange
    Pair 3: Green, White/Green
    Pair 4: Brown, White/Brown
(2) H.D. Polyethylene conductor insulation.
  (2.1) Conductor with insulation thickness of a nominal 0.046"
(3) Inner tinned copper braid shielding 38 AWG with a minimum 75 % coverage.
(4) Outer aluminum / Polyester tape (foil in) shielding.
(5) Black Thermoplastic Elastomer outer jacket with a nominal thickness 0f .037 inches.
(6) Cable assembly shall have an overall thickness of 0.301 ± 0.010 inches.
(7) DC resistance maximum of 26.0Ω /1000 feet.
(8) Conductor to conductor capacitance of 13.5pF/ ft @ 1MHz.
(9) Impedance of 100Ω ± 15Ω @ 1- 100 MHz.
(10) A minimum dielectric withstanding of 1500Volts RMS.
(11) A voltage rating of 600 Volts.
(12) Temperature rating of -40°F to 167°F (-40°C to 75°C).
(13) Pass a flex life test of 1 million cycles at 10 times the minimum radius of the outside diameter of the cable.
(14) NRTL certified in accordance with UL 1581, section 1080 (VW-1) and be CMX certified or listed.
(15) RoHS Compliant.

(16) Label the outer jacket in accordance with 3815.2A (5)

RJ 45 terminal ends used when terminating this cable must be in compliance with the cable manufacturer's requirements and recommendations.

C.7 (Blank)

C.8 (Blank)

C.9 (Blank)

C.10 (Blank)

C.11 (Blank)

C.12 (Blank)

C.13 Fiber Optic Cables

Provide fiber optic cable listed on MnDOT's Approved/Qualified Products List under Traffic Management Systems/ITS.

C.13.a Armored Pigtail

Provide armored fiber optic pigtail cables listed on MnDOT's Approved/Qualified Products List under Traffic Management Systems/ITS.

C.14 Microwave and Sonic Detector Cable (4/C #18)

Provide microwave and sonic detector cable and conductors meeting the following requirements:

(1) Listed and tested by an NRTL as defined by the U.S. Department of Labor in a testing laboratory listed by OSHA in its scope of recognition for tests specified by this section and meeting the following requirements:
  (1.1) UL44,
  (1.2) UL1277, and
  (1.3) UL 1685.
(2) Suitable for use at 194 ºF [90 °C] in wet or dry locations,
(3) Sunlight resistant (Sun Res),
(4) Rated for 600 Volts,
(5) Rated as tray cable,
(6) Labeled and rated as oil resistant (Oil Res 1),
(7) Labeled and rated for direct burial (Dir Bur),
(8) Cable designation of TC, PLTC, ITC, CL3,
(9) 18 AWG conductors,
(10) Tinned conductors,
(11) Class B (7X26 strand) soft drawn, tinned copper meeting the requirements of ASTM B 3, ASTM B 8, and ASTM B 33,
(12) XLPE conductor insulation,
(13) Individual conductors constructed with circuit identification meeting the requirements of Method 1 of ICEA S-73-532 (NEMA WC-57) Table E-1 (Black, White, Red and Green),
(14) Non-hygroscopic fillers if used,
(15) Do not use fillers made of jute or paper,
(16) Aluminum/mylar tape shield with an overlap of at least 0.250 in [6.35 mm],
(17) 18 AWG, 7 strand tinned copper drain wire,
(18) Drain wire installed on the outside of the aluminum/mylar tape shield (drain out),
(19) Water blocking barrier tape to allow the cable to be used in underground ducts,
(20) Jacket constructed of polyvinylchloride meeting the requirements of UL 1277,
(21) Black jacket,
(22) Cable jacket having a substantially circular cross-section as specified in ANSI/ICEA S-73-532 NEMA WC 57, with the outer cable jacket not convoluted and not having a ropey appearance, and
(23) Cable markings on the jacket surface ink printed with the following information:
  (23.1) Manufacturer name,
  (23.2) Year of manufacture (date code),
  (23.3) Type of wire or cable,
  (23.4) Size and number of conductors,
  (23.5) Voltage rating,
  (23.6) Conductor insulation rating,
  (23.7) NRTL Certification Mark indicating the cable is listed,
  (23.8) Labeled as sunlight resistant (Sun Res), oil resistant (Oil Res 1), direct buried (Dir Bur), and
  (23.9) Foot markers.

Repeat cable markings at intervals no greater than 24 in [610 mm] on the jacket surface.

3815.3 SAMPLING AND TESTING

The Department reserves the right to sample, test, inspect, and accept or reject all electrical conductors and cables specified in this section.

The Department may require certified test reports covering the physical and electrical properties of the signal control cable in addition to the requirements listed in the specification.

3816 AIR OBSTRUCTION LIGHTS

3816.1 SCOPE

Provide air obstruction lights meeting Federal Aviation Administration (FAA) requirements.

3816.2 REQUIREMENTS

A Air obstruction lights

Provide air obstruction lights listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

3817 NAVIGATION LANTERNS

3817.1 SCOPE

Provide navigation lanterns meeting U.S. Coast Guard (USCG) requirements.

3817.2 REQUIREMENTS

A Navigation Lanterns

Provide navigation lanterns listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

3818 GROUNDING ELECTRODES

3818.1 SCOPE

Provide ground rod electrodes as required by contract documents for use in traffic control signal systems, roadway lighting systems, traffic management systems, sign control systems, automatic traffic recorder systems, and other electrical systems.

Provide plate electrodes when NEC installation requirements for rod electrodes are not practical.
Engineer's approval for use is required prior to installation.

3818.2 REQUIREMENTS

A Ground Rod Electrodes

Provide ground rod electrodes meeting the following requirements;

(1) Listed and labeled by an NRTL in accordance with UL 467,
(2) Meeting the requirements of ANSI/NEMA GR-1,
(3) Diameter of 5/8 inch [15.87mm],
(4) 15 feet long [4.57m],
(5) ASTM-A-1018 cold drawn steel,
(6) Minimum tensile strength of 80,000 psi,
(7) Copper bonded (copper clad) outer coating,
(8) Pointed, and
(9) Non-threaded.

B Plate Electrodes

Provide plate electrodes meeting the following requirements;

(1) Listed and labeled by an NRTL in accordance with UL 96,
(2) Meeting the requirements of NEC and NESC,
(3) 100% copper,
(4) Minimum plate dimensions of 12 inches [304.8 mm] x 24 inches [609.6 mm],
(5) Minimum thickness of 0.06 inches [1.5 mm], and
(6) Solid bare #6 AWG CU x 10 ft. [3.048 m] pigtail connected to the plate with an exothermic weld connection.

3819 HANDHOLES

3819.1 SCOPE
Provide handholes as required by contract documents.

3819.2 REQUIREMENTS

A Handholes Non-Deliberate Heavy Vehicular Traffic
Only use Department-approved handholes listed on MnDOT's Approved/Qualified Products List under "Signals."

Emboss "MnDOT Signals" on the cover for traffic control signal projects.
Emboss "MnDOT Lighting" on the cover for roadway lighting projects.
Emboss "MnDOT TMS" on the cover for ITS projects.

B Handholes Deliberate Heavy Vehicular Traffic
Only use handholes in accordance with Standard Plate 8117 which are in full compliance with Article 314.30 of the NEC. Handholes shall meet the requirements of "AASHTO H-20 Deliberate Vehicular Traffic Applications".
Emboss "MnDOT Signals" on the cover for traffic control signal projects.
Emboss "MnDOT Lighting" on the cover for roadway lighting projects.
Emboss "MnDOT TMS" on the cover for ITS projects.

3831 TRAFFIC CONTROL SIGNAL MAST ARM POLES, MAST ARMS, LUMINAIRE POLE EXTENSIONS, AND LUMINAIRES

3831.1 SCOPE
Provide mast arm pole standards in accordance with Standard Plates 8121, 8123, and 8133 as detailed in the plans for supporting mast arm mounted and pole mounted vehicle and pedestrian signal heads, and supporting luminaires, as part of a traffic control signal system.

3831.2 REQUIREMENTS

A General
Use mast arm pole standards of the type required by the contract including the following:

(1) Transformer base,
(2) Vertical pole shaft,
(3) Traffic control signal mast arm, and
(4) Luminaire vertical pole shaft extension with a luminaire mast arm and luminaire, if required by the contract.

Use mast arm pole standards designed and constructed in accordance with the AASHTO Standard Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals.

B Anchor Rods
Provide anchor rods of the type required by the contract and sized in accordance with MnDOT Standard Plates 8120, 8126, or 8134 as applicable to the foundation being constructed.

C Transformer Base
Use square transformer-type bases with an access hole that provides an opening, as required by the contract, on one side of the base. Provide a cover for the access hole with a positive closure and locking mechanism that is an integral part of the door.

D Mast Arm
Use a ¾ in [19 mm] half-coupling and plug on the top side of the traffic control signal mast arm at the location required by the contract.

If required by the contract, provide swing-away hinges with the traffic control signal mast arm. Obtain the Engineer's approval before installation. Install the swing-away hinges so the traffic control signal mast arm swings away from the intersection.

D.1 Mast Arm Signal Head Mounts
Mount vehicle signal heads on the extended end of traffic control signal mast arms using high-strength cast aluminum angle or straight plumbizer mounts and threaded hub and flange adaptors.
Only use threaded hub and flange pole adaptors listed on MnDOT's Approved/Qualified Products List under "Signals."

If required by the contract, mount vehicle signal heads mid-arm on traffic control signal mast arms using straight plumbizer mounts as specified in this section.
Only use straight mount plumbizers listed on MnDOT's Approved/Qualified Products List under "Signals."

Mount vehicle signal heads on the end of the mast arm using angle mounts as specified in this section.
Only use angle mount plumbizers listed on MnDOT's Approved/Qualified Products List under "Signals."

D.2 Two-way Mast Arm Signal Head Mounts

Mount two-way vehicle signal heads on the extended end of traffic control signal mast arms as required by the contract, using high-strength cast aluminum, two-way plumbizer mounts.
Only use two way mount plumbizers listed on MnDOT's Approved/Qualified Products List under "Signals."

D.3 Vertical Pole Signal Head Mounts

Mount vehicle and pedestrian signal heads on the vertical pole using high-strength cast aluminum angle plumbizer mounts and threaded hub and flange adaptors.
Only use threaded hub and flange pole adaptors listed on MnDOT's Approved/Qualified Products List under "Signals."

If required by the contract, mount vehicle cluster head (dog house) style signal head assemblies on the vertical pole using angle plumbizer mounts with extended threaded pole adaptors.
Only use angle mount plumbizers listed on MnDOT's Approved/Qualified Products List under "Signals."
Only use extended threaded pole adaptors listed on MnDOT's Approved/Qualified Products List under "Signals."

E Luminaire Pole Extension

Provide luminaire pole extensions for luminaires atop mast arm pole standards as required by the contract and meeting the following requirements;

(1) Designed for a 75 lb [34 kg] luminaire with a projected area of 3.2 sq. ft [0.3 sq. m],
(2) A nominal 2 3/8 in [60 mm] schedule 40 pipe slipfitter tenon,
(3) A mast arm with an upward angle from horizontal of 3 degrees ± 2 degrees.
(4) A 9 ft [2.74 m] mast arm unless otherwise specified in contract documents.

E.1 Luminaires

Provide LED Roadway Luminaires (40 foot mounting height) in accordance with 3810 and as shown on the plan.

E.3 Luminaire Wire Holder

Provide wire holders listed on MnDOT's Approved/Qualified Products List under "Signals."

3831.3 SAMPLING AND TESTING

Submit four complete sets of shop detail drawings of the mast arm pole standard, anchor rods, in accordance with 2471.3.B.1, "Shop Detail Drawings, General Requirements," and 2471.3.B.3, "Submittal for Engineer's Review and Approval," to the Engineer for approval. After approval, the Engineer will distribute the drawings to the following:

(1) Contractor,
(2) Contractor's Fabricator,
(3) Engineer, and
(4) District Traffic Engineer.

3832 TRAFFIC CONTROL SIGNAL PEDESTAL

3832.1 SCOPE

Provide 4 inch [100 mm] trade size diameter traffic control signal pedestals that support vehicle signal heads, pedestrian signal heads, and warning flashers.

3832.2 REQUIREMENTS

A General

Provide traffic control signal pedestals in accordance with applicable provisions of MnDOT Standard Plates 8112, 8122, 8129, MnDOT 3832, and contract documents.

Provide traffic control signal pedestals meeting the applicable requirements for structural supports specified in the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Submit shop drawings in accordance with 2545.2A.7 for the pedestal to the Engineer for approval, before procurement.
Provide traffic control signal pedestals with a shaft and a base.

B Pedestal Shaft

B.1 Steel Pedestal Shafts

Provide steel pedestal shafts in accordance with Standard Plate 8122 and the Plans. Clean the inner and outer surfaces of pedestal shafts. Blast clean the outer surface. Paint the inner and outer surfaces of the pedestal shafts with two coats of prime

paint in accordance with 3532, "Exterior Polyurethane Paint." Ensure a total dried primer thickness of 3 mil [76 µm]. Finish paint the outside of the shaft with two coats of yellow paint in accordance with 3532, "Exterior Polyurethane Paint," unless otherwise required by the contract. Ensure a total thickness of the dried primer and finish coats at least 5½ mil [140 µm]. Do not install shafts with scratches or other damages to the paint.

Repair or replace pedestal bases scratched or damaged during installation as approved by the Engineer.

B.2 Aluminum Pedestal Shafts

Provide aluminum pedestal shafts in accordance with Standard Plate 8122 and the Plans.

C Pedestal Base

Provide pedestal bases in accordance with Standard Plate 8122 and the Plans.

C.1 (Blank)

C.2 Ground Connector

Mount one NRTL listed ground wire connector with a single bolt on each adjacent sidewall to the access door, 3 in [76.2 mm] in from the door and 8 in above the base bottom of each sidewall.

Use a cross slot head screw to secure the ground wire to the connector. Ensure the connector accommodates a 6 AWG stranded copper wire. Install the connectors with the connector down. Ensure every device in the pedestal base is constructed from compatible materials.

C.3 Anchor Rods

Provide anchor rods in the size specified on MnDOT Standard Plate 8112. Provide anchor rods, nuts, and washers in accordance with 3385.2.A, "Type A – Carbon Steel Anchor Rods," unless otherwise required by the contract.

Provide pedestal washers meeting the following requirements, unless otherwise required by the contract:

(1) Round-formed, at least Grade 5, hardened steel washers as specified in 3391.2.B, "High Strength Structural Steel Bolts,"
(2) Galvanized by the hot-dip process or by the mechanical process as specified in 3392, "Galvanized Hardware," and
(3) Dimensions in accordance with MnDOT Standard Plate 8129.

C.4 Reinforcing Collars

When required provide pedestal reinforcing collars, wind collars, listed on MnDOT's Approved/Qualified Products List under "Signals".

C.5 Painted Pedestal Base

Shop paint pedestal bases on the inner and outer surfaces with two coats of prime paint meeting the requirements specified in 3532, "Exterior Polyurethane Paint," if required by the contract. Ensure the dried primer is 3 mil [76 µm] thick. Finish paint the outer surface with two coats of green paint meeting the requirements of 3532, "Exterior Polyurethane Paint," or the equivalent manufacture's shop coat paint as specified in 2565.3.T, "Painting." Ensure the combined thickness of the primer and finish coats is 5½ mil [140 µm].

Repair or replace pedestal bases scratched or damaged during installation as approved by the Engineer.

C.6 Pedestal Base Access Door

Provide aluminum pedestal access doors in accordance with MnDOT Standard Plate 8122 and with an anodic coating meeting the requirements of MIL-A-8625 for Type II, Class I Coating.

C.7 Pedestal Cap

Provide aluminum pedestal caps listed on MnDOT's Approved/Qualified Products List under "Signals" and with an anodic coating meeting the requirements of MIL-A-8625 for Type II, Class I Coating.

Provide pedestal caps for each pedestal shaft if using straight mount plumbizers for signal and pedestrian head mounting.

C.8 Pedestal Slipfitter Collar

Provide pedestal slipfitter collars manufactured as specified in MnDOT Standard Plate No. 8111 and with an anodic coating meeting the requirements of MIL-A-8526 for Type II, Class I Coating.

Before ordering from the signal supplier, ascertain from the Engineer the number of required 1½ inch inside threaded hubs (side openings) in the pedestal slipfitter collar.

3832.3 SAMPLING AND TESTING

The Engineer will inspect and approve the pedestal shafts and pedestal bases before installation.

Provide test reports from an FHWA-approved independent laboratory certifying the tests made on pedestal bases showing results that meet AASHTO breakaway requirements.

Submit a certification from the FHWA, provided by the manufacturer, stating FHWA acceptance and approval of tests made on pedestal bases.

3833 ACCESSIBLE PEDESTRIAN SIGNAL (APS) PUSH BUTTONS AND MOUNTING HARDWARE

3833.1 SCOPE

Provide touch-activated Accessible Pedestrian Signals (APS) with information signs and required mounting hardware to detect and instruct pedestrians as shown on the plans.

3833.2 REQUIREMENTS

Locate and mount APS push buttons and information signs on vertical mast arm pole shafts, APS push button stations, traffic control signal pedestal shafts, or similar equipment approved by the Engineer, or on separate mountings, as required by the contract.

A.1 APS Push Buttons

Use APS push buttons listed on MnDOT's Approved/Qualified List under "Signals."

A.2 Accessible Pedestrian Signal Pole Adaptor

Use accessible pedestrian pole adaptors listed on MnDOT's Approved/Qualified Products List under "Signals."

A.3 Accessible Pedestrian Signal Push Button Mounting Spacer

Use accessible pedestrian signal push button mounting spacers listed on MnDOT's Approved/Qualified Products List under "Signals."

A.4 Accessible Pedestrian Signal Push Button Base

Use accessible pedestrian signal push button bases listed on MnDOT's Approved/Qualified Products List under "Signals."

A.5 Accessible Pedestrian Signal Push Button Base Anchorages and Adhesive

(1) Provide a quantity of four (4) 5/8 inch (UNC) stainless steel threaded rods, nuts and washers in accordance with MnDOT 3385.2D.for the anchors.

(2) Rod length = 7 ½ ± ¼ inches.
The top and bottom of the rod must have chamfered (rounded) edges to allow easy installation of the required nut.
Provide 1 nut and washer for each rod.

(3) Provide APS push button base adhesive anchoring systems to secure the stainless steel threaded rods into the concrete.
Only use APS push button base adhesive anchoring systems listed on MnDOT's Approved/Qualified Products List for "Signals."

3833.3 SAMPLING AND TESTING

Confirm and document the listing of the APS units and other components on MnDOT's Approved/Qualified Products List under "Signals." Provide this documentation to the Engineer. Obtain the Engineer's approval of the APS before installation.

3834 VEHICLE SIGNAL HEADS

3834.1 SCOPE

Provide standard traffic control signal heads to control vehicle movements as part of a traffic control signal system or freeway ramp control signal.

3834.2 REQUIREMENTS

A Standard ITE Vehicle Signal Heads

A.1 General

Use standard ITE black polycarbonate vehicle signal housings listed on MnDOT's Approved/Qualified Products List under "Signals," unless otherwise required by the contract.

Use adjustable-type vehicle signal housings capable of 360° rotation about a vertical axis.

Use vehicle signal heads made up of at least three separate vehicle signal sections. Ensure each vehicle signal section consists of a housing, housing door, visor, optical unit, and wiring.

Provide and install the required through-bolts for connecting the individual sections.

Fasten together the signal sections above or below the straight or angle mount by means of a noncorrosive 3-bolt mounting assembly. Use locknuts for the 3-bolt mounting assembly to prevent the assembly from loosening.

Use signal indications for traffic control signal systems of the nominal size as required by the contract.

Arrange vehicle signal sections in a vehicle signal head in accordance with Part IV, "Highway Traffic Signals" of the MN MUTCD.

For each intersection, install standard ITE vehicle signal heads from the same manufacturer.

Install and mount each vehicle signal head at the location shown on the plans.

Always provide vehicle signal heads with provisions to attach a background shield, regardless of the contract requirement for background shields.

A.2 Visor

Provide each signal section of each signal head with a removable visor. Use visors meeting the following characteristics:

(1) Made from black polycarbonate material,
(2) Designed to fit tightly against the housing door to prevent filtration of light between the visor and the housing door,
(3) At least 9½ in [240 mm] long for a nominal 12 in [300 mm] vehicle signal indication, and
(4) At least 7 in [180 mm] long for a nominal 8 in [200 mm] vehicle signal indication.

Mount the visor with twist-on slots and stainless steel screws positioned for vertical or horizontal mounting of the signal section, and with a downward tilt of at least 3.5°.

For traffic control signal system heads, provide tunnel-type visors that enclose 80 percent of the lens circumference.

A.3 Signal Indications

Use LED signal indications listed on MnDOT's Approved/Qualified Products List for "Signals" and as required by the contract.

A.4 Background Shield

Provide and attach background shields to vehicle signal heads unless otherwise required by the contract.

Use black polycarbonate background shields that extend at least 5 in [125 mm] on each side of the vehicle signal head and at least 4 in [100 mm] at the top and bottom.

Do not cut the bottom of a background shield attached to a vehicle signal head, mounted directly above a pedestrian signal head. For this case when using pipe bracketing, install a length of pipe nipple, threaded on both ends above the pedestrian signal head to allow the separate rotation of the vehicle signal head and the pedestrian signal head.

Provide background shields with a nonflective black, dull finish. Attach background shields to vehicle signal heads so no background light shows between the shield and the vehicle signal head.

B Mounting Vehicle and Pedestrian Signal Heads

Mount vehicle and pedestrian signal heads using straight, angle, or two-way plumbizer signal mounts. Provide signal head mounts and required appurtenances for mounting vehicle and pedestrian signal heads to mast arms, vertical pole shafts, and pedestal shafts in accordance with the contract requirements.

Use straight, angle, or two-way plumbizers listed on MnDOT's Approved/Qualified Products List under "Signals."

Provide and install metal support plates on the inside of the signal section at the attachment point of the straight or angle mount plumbizers or signal bracketing.

Provide and install angle and straight mount caps when installing pedestrian indications. Only use angle and straight mount caps listed on MnDOT's Approved/Qualified Products List under "Signals."

Provide four and five-section signal heads and signal head mounting spacers at the point of mounting to the plumbizer.

Use signal head mounting spacers listed on MnDOT's Approved/Qualified Products List under "Signals."

C Signal Brackets and Pipefittings

If the contract requires signal brackets and pipe fittings for mounting vehicle and pedestrian signal heads, provide signal brackets and pipe fittings in accordance with the following:

(1) Use nominal 1½ in [40 mm] diameter standard anodized aluminum pipe signal bracket and pipe fitting for signal brackets and pipe fittings for mounting vehicle and pedestrian signal heads.
(2) Provide signal brackets long enough to provide vehicle and pedestrian signal head alignment, to allow programming of optically programmed vehicle signal heads, or of a length directed by the Engineer.
(3) Provide locknuts, nipples, locknipples, gaskets, washers, and other hardware used to fasten vehicle and pedestrian signal heads to signal bracketing and pipe fittings, fabricated of anodized aluminum and traffic signal industry standard signal hardware.
(4) Mount signal brackets and pipe fittings plumb or level, symmetrically arranged, and securely assembled.
(5) Construct signal brackets and pipe fittings to conceal traffic control signal conductors, watertight, and free of sharp edges or protrusions to prevent damage to the traffic control signal conductor insulation.

3834.3 SAMPLING AND TESTING
Do not install the material specified in this section until approved by the Engineer.

3835 PEDESTRIAN SIGNAL HEADS

3835.1 SCOPE
Provide pedestrian signal heads to direct pedestrian movements as part of a traffic control signal system.

3835.2 REQUIREMENTS

A General
Use standard ITE black polycarbonate pedestrian signal housings listed on MnDOT's Approved/Qualified List under "Signals," unless otherwise required by the contract.

Provide LED modules for pedestrian signal indications with countdown timers listed on MnDOT's Approved/Qualified Products List under "Signals."

B Signal Brackets and Pipe Fittings 3834.2.C

3835.3 SAMPLING AND TESTING 3833
Submit four sets of manufacturer's drawings, warranty information, and the product invoice, to the Engineer for approval.

3836 STAINLESS STEEL WOVEN WIRE CLOTH

3836.1 SCOPE
Provide stainless steel woven wire cloth in pole bases for controlling rodent intrusion from the interior of the pole.

3836.2 REQUIREMENTS
Provide a stainless steel woven wire cloth with the following characteristics:
(1) 0.5 x 0.5 per inch mesh,
(2) 0.041 inch wire diameter,
(3) 0.159 inch opening width, and
(4) 63.2% open area

3837 ELECTRICAL SERVICE EQUIPMENT

3837.1 SCOPE
Provide electrical service equipment for controlling and distributing electrical power, providing over-current protection, and a means to cut-off power to items of electrical equipment as part of a traffic control signal system, roadway lighting system, automatic traffic recorder system, or other electrical system.

3837.2 REQUIREMENTS

A Service Equipment
A.1 General
For electrical service for the traffic control signal system, roadway lighting system, automatic traffic recorder system, or other electrical system, provide and install the following, as required by the contract:

(1) Meter socket,
(2) Disconnecting means,
(3) Two (2) ground rods,
(4) Grounding and bonding materials,
(5) Conduit,
(6) Conduit fittings, and
(7) Service conductors.

In addition, for installations on wood poles, provide and install the following, as required by the contract:

(1) Conduit risers, and
(2) Weather head.

For installations on wood poles, size the service conductors that run above the disconnecting means and through the meter socket to the weather head for the rating of the service disconnect. Ensure these service conductors meet the requirements of the electric utility company and extend beyond the weather head for connection to the service conductors from the source of power.

Provide parts of the service equipment that use copper conductors and have connections that are NRTL listed for use with copper conductors. Refer to NEC article 100 for the definition of the term "Listed."

A.2 Meter Socket

Use a commercial-type meter socket with the following characteristics:

(1) Rated for 200 A, 480 V,
(2) Containing a positive bypass mechanism,
(3) Containing lugs that allow the service conductors to be stripped and laid into the lugs without cutting, and
(4) Approved by the electric utility company.

The electric utility company will provide and install the meter.

A.3 Circuit Breaker Load Center

Unless otherwise required by the contract, provide a disconnecting means meeting the following characteristics:

(1) Three-wire,
(2) Solid neutral,
(3) 100 A, 120/240 VAC,
(4) NEMA 3R rain-tight enclosure for outdoor use,
(5) Circuit breaker load center, and
(6) NRTL-listed for use as service equipment.

Use a load center with a front cover and inner dead front cover capable of easy removal for installation, maintenance, and wiring. Ensure the front cover is hinged at the top with a slip-hinge arrangement that allows the cover to be left in an open position, and a snap closure at the bottom.

Provide lugs for service conductor connections in the load center that are NRTL-listed for use with copper wire. Provide solder-less, set screw-type lugs, sized for the conductors assigned to each lug.

Provide the circuit breaker load center with an isolated, bondable neutral bar with the capacity to accept the number and size of neutral and grounding conductors required by the contract or the NEC. Ensure neutrals bond in accordance with NEC.

Unless otherwise required by the contract, provide and install circuit breakers in the load center as required in contract documents.

Label the circuit breakers with the "on" and "off" positions and with the load carried. Provide circuit breakers and load center enclosures from the same manufacturer.

A.4 General Duty Safety Switch

Use a general duty safety switch with an isolated, bondable neutral bar capable of accepting the numbers and sizes of neutral and grounding conductors required by the contract or the NEC. Ensure bonding of the neutral in accordance with NEC.

If required by the contract, provide a disconnecting means with the following characteristics:

(1) Three-wire,
(2) Fusible,
(3) Two-pole,

(4) Solid neutral,
(5) Single throw,
(6) 60 A, 120/240 VAC,
(7) NEMA 3R rain-tight enclosure for outdoor use,
(8) NRTL-listed for use as service equipment.

Ensure lugs contained in the safety switch are sized for the conductor material and size assigned to each lug. Provide the required fuses.

A.5 Heavy Duty Safety Switch

Install a safety switch to turn off power to the sign lights. Provide a safety switch with the following characteristics:

(1) A NEMA 3R rain tight enclosure for outdoor use made from sheet metal and zinc-coated with a gray finish,
(2) 30 A, heavy-duty, single-throw, fusible with an insulated solid neutral,
(3) Rated for 240 VAC for a 120/240 V sign lighting system and 600 VAC for a 240/480 V sign lighting system,
(4) With two, 20 A cartridge type fuses, and
(5) Three-wire, 2-pole for either switch. For the 600 VAC switch, the Contractor may use 4-wire, 3-pole.

Install the safety switch in a vertical upright position.

A.6 Enclosed Circuit Breaker

If required by the contract, provide and install an enclosed circuit breaker where shown on the plans for cutting power to the electrical system or systems.

Mount the circuit breaker in a NEMA 3R rain-tight enclosure for outdoor use. Provide a circuit breaker with the following characteristics:

(1) Two-pole,
(2) 100 A, 120/240 VAC,
(3) Thermo-magnetic breaker,
(4) NRTL-listed for use as service equipment, and
(5) Clearly marked with "on" and "off" positions and identified with the load it is carrying.

If lugs are necessary to connect the power conductor to the breaker, provide NRTL-listed, solder-less, set screw-type lugs for use with copper wire. Include provisions for a padlock on the rain-tight enclosure.

A.7 Signal Service Cabinet Type SSB

Provide a signal service cabinet with the following characteristics:

(1) A meter socket,
(2) Main and branch circuit breakers,
(3) A luminaire test switch,
(4) Enclosed photoelectric controls, and
(5) Provisions for a battery back-up system.

Use signal service cabinets Type SSB listed on MnDOT's Approved/Qualified Products List under "Signals."

Provide uninterrupted power supplies for signal service cabinets listed on MnDOT's Approved/Qualified Products List under "Signals."

Use batteries for uninterrupted power supplies listed on MnDOT's Approved/Qualified Products List under "Signals."

For signal service cabinets Type SSB, provide anchor rods and nuts in with the following characteristics:

(1) In accordance with 3385, "Anchor Rods," for Type A anchor rods,
(2) Tops stamped AB36,
(3) Do not provide blue top-bolt identification,
(4) With a diameter of ¾ in [19 mm] × 19 in [483 mm] ±0.50 in [13 mm] long before bending a 2 in [51 mm] ell on one end,
(5) With a minimum of 4 in [102 mm] of thread,
(6) Hot-dip galvanize each anchor rod length in accordance with 3392, "Galvanized Hardware.", and
(7) Provide stainless steel washers 2 in [51 mm] in diameter in accordance with 3385, "Anchor Rods."

B Transformer and Circuit Breaker Assembly

B.1 Transformer

Provide an outdoor, general purpose, dry-type transformer meeting the following characteristics:

(1) Primary — 480 V, two 5 percent taps below 480 V,

(2) Secondary — 120/240 VAC,
(3) Rating — 7.5 KVA, single phase, and
(4) Size — 16 in [400 mm] high, 12 in [300 mm] wide, and 10½ in [270 mm] deep.

Provide transformers and related wiring compartments that are NRTL-listed for indoor-outdoor applications, and meeting the requirements of relevant NEMA and IEEE standards. Mount the transformer on the equipment pad as required by the contract and as approved by the Engineer.

B.2 Enclosed Circuit Breaker

Protect the transformer with a circuit breaker mounted in a NEMA 3R rain-tight enclosure for outdoor use.

(1) Provide 2-pole, 20 A, 480 VAC, thermo-magnetic circuit breakers,
(2) If lugs are necessary for power conductor connections to the breaker, provide NRTL-listed solder-less, set screw-type lugs for use with copper wire,
(3) Include provisions for a padlock on the rain-tight enclosure,
(4) Include provisions for a padlock on the rain-tight enclosure, and
(5) Mount the circuit breaker enclosure as required by the contract and as approved by the Engineer.

3837.3 SAMPLING AND TESTING

Submit six sets of manufacturer's drawings and specifications for the proposed transformer and circuit breaker assembly to the Engineer for approval.

After approval, the Engineer will distribute the drawings to the following:

(1) Contractor,
(2) Contractor's fabricator,
(3) Engineer,
(4) Traffic Electrical Systems Engineer,
(5) District Traffic Engineer, and
(6) Traffic Control Signal Cabinet or other pad mount cabinet.

3838 ELECTRICAL JUNCTION BOXES

3838.1 SCOPE

Provide junction boxes as part of a traffic control signal system, freeway ramp control signals, automatic traffic recorder systems, roadway lighting systems, or other electrical systems for the following:

(1) Accessing electrical wiring,
(2) Facilitating installation of electrical wiring, and
(3) Changing from field cable wiring to individual conductors.

3838.2 REQUIREMENTS

A Metal Junction Boxes Attached to a Bridge

Use NRTL listed metal junction boxes attached to a bridge meeting the following characteristics:

(1) NRTL Listed in accordance with UL 50 and UL 50E,
(2) Equipped with a removable cover made of the same material as the box, attached with stainless steel hex-head screws or bolts and containing a composition fiber gasket around the cover perimeter,
(3) Malleable iron with interchangeable side hub plates, stainless steel hardware, composition fiber gaskets for cover and hub plates, for use with rigid steel or intermediate metal conduit,
(4) Triple coated with the following: zinc electroplate, chromate, and epoxy powder coat,
(5) Inside dimensions of 8½ in × 8½ in × 4 in [216 mm × 216 mm × 100 mm] unless otherwise required by the contract,
(6) Equipped with four mounting holes on the inside of the enclosure,
(7) Bossed conduit entrances capable of accommodating the nominal outside diameter of the conduit shown on the plans and threaded to provide five full threads,
(8) Bossed conduit entrances of the following dimensions: ½, ¾, 1, 1-1/4, 1-1/2, 2 inches, and
(9) A field installed drain fitting

B Metal Junction Boxes on Wood Poles

Provide and install metal junction boxes with terminal blocks on wood poles for the following:

(1) Temporary traffic control signal systems;
(2) Flashing beacon systems,
(3) Advance warning flashers, or

(4) Vehicle, pedestrian signal heads, or flashing signal indications.

Use metal junction boxes on wood poles meeting the following characteristics:

(1) Meeting the requirements of NEC,
(2) NEMA, Type 3R,
(3) At least 12 in × 12 in × 6 in [300 mm × 300 mm × 150 mm] deep,
(4) ¼ in [6 mm] drain hole on the bottom side,
(5) Equipped with a cover with a gasket around the perimeter and attached with stainless steel screws, and
(6) Equipped with terminal blocks meeting the requirements of 2565.3.J, "Wiring," for terminating field conductors and traffic control signal conductors, attached to the back of the junction box so the terminal screws of the terminal block face the box opening, and covered with an electrical insulating coating after conductor terminations on the terminal block.

Provide and install liquid-tight flexible non-metallic conduit and conduit fittings in accordance with 3804 and as shown on the plans. Install conduit between the metal junction box and each wood pole-mounted signal bracket.

C Junction Boxes in Rigid PVC Conduit Runs Attached to a Bridge

For junction boxes mounted to bridges, use PVC junction boxes with the following characteristics:

(1) Equipped with a cover attached by stainless steel screws,
(2) At least 6 in × 6 in × 6 in [150 mm × 150 mm × 150 mm] deep,
(3) Attached to the bridge as approved by the Engineer, and
(4) Meeting the requirements of NEC.

D (Blank)

E Junction Boxes for Roadway Lighting Systems

For roadway lighting systems, use NRTL listed metal junction boxes meeting the following characteristics:

(1) NRTL listed and labeled in accordance with UL 50 and UL 50E,
(2) Equipped with a removable cover made of the same material as the box, attached with stainless steel hex-head screws or bolts and containing a composition fiber gasket around the cover perimeter,
(3) Malleable iron with interchangeable side hub plates, brass cap screws, composition fiber gaskets for cover and hub plates, for use with rigid steel or intermediate metal conduit,
(4) Triple coated with the following: zinc electroplate, chromate, and epoxy powder coat,
(5) Inside dimensions of 8½ in × 8½ in × 4 in [216 mm × 216 mm × 100 mm] unless otherwise required by the contract,
(6) Equipped with four mounting holes on the inside of the enclosure,
(7) Bossed conduit entrances that accommodate the nominal outside diameter of the conduit shown on the plans and threaded to provide five full threads,
(8) Bossed conduit entrances of the following dimensions: ½, ¾, 1, 1-1/4, 1-1/2, 2 inches, and
(9) A field installed drain fitting.

3838.3 SAMPLING AND TESTING

Submit three sets of shop drawings of the proposed metal junction boxes and mounting details to the Engineer for approval.

3839 CONDUIT EXPANSION AND DEFLECTION/EXPANSION FITTINGS

3839.1 SCOPE

Provide PVC coated and urethane lined metallic conduit expansion fittings and PVC coated metallic deflection/expansion fittings for PVC coated RSC conduit runs for bridges.

3839.2 REQUIREMENTS

Refer to the NEC, article 100 for the definition of the term "Listed."

A Expansion Fittings

Provide expansion fittings with the following characteristics:

(1) NRTL listed in accordance with UL514 B and CSA certified to C22.2,
(2) NRTL listed for use in wet or dry locations,
(3) Minimum of 8 inches longitudinal movement,
(4) Supports conduit sizes ¾ inch thru 5 inches,
(5) NRTL-listed, PVC coated iron or steel, and protected by galvanizing or plating for use with RMC or IMC , and

(6) Internal tinned copper braid bonding jumper to meet requirements of NEC 250.98.

B Deflection/Expansion Fittings

Provide deflection/expansion fittings with the following characteristics:

(1) Provides for movement of ¾ inch from normal alignment in all directions,
(2) Allows for a deflection of 30 degrees from normal alignment in any direction,
(3) Supports conduit sizes 1 inch thru 6 inches,
(4) PVC coated, zinc plated iron hubs, one female and one three piece coupling (Erickson type union),
(5) Neoprene sleeve,
(6) Internal tinned copper braid bonding jumper,
(7) Tamperproof stainless steel bands,
(8) Watertight, rain tight, concrete tight NEMA 4 rated, and
(9) NRTL-listed in accordance with UL514B and CSA certified to C22.2.

3839.3 SAMPLING AND TESTING
Obtain the Engineer's approval before installing the expansion or the deflection/expansion fittings.

3840 WOOD POLES

3840.1 SCOPE
Provide wood poles for traffic control signal systems, electric lighting systems, and mounting service equipment.

3840.2 REQUIREMENTS
Provide wood poles meeting the following requirements:

(1) ANSI 2051,
(2) The length shown on the plans,
(3) Class II, unless otherwise required by the contract,
(4) The species specified by Table 3491-1, "Bored Hole Diameter Requirements,"
(5) Treated with preservative in accordance with 3491, "Preservatives and Preservative Treatment of Timber Products."

3840.3 SAMPLING AND TESTING 3491

3841 SPONGE RUBBER EXPANSION JOINT

3841.1 SCOPE
Provide AASHTO M 153, Type 1 sponge rubber expansion joint for wrapping electrical conduit expansion and deflection/expansion fittings.

3841.2 REQUIREMENTS
Use AASHTO M 153, Type 1 sponge rubber expansion joint for wrapping expansion and deflection/expansion fittings as defined below.

(1) Compliance with AASHTO M 153, Type 1,
(2) Compliance with ASTM D 1752, Type 1,
(3) Compliance with Corps of Engineers CRD-C 509, Type 1,
(4) Compliance with FAA Specification Item P-610-2.7,
(5) Compliance with Federal Specification HH-F-341 F, TYPE II,
(6) ¼ Inch thick,
(7) Gray in color,
(8) Uniform thickness,
(9) Blown sponge rubber,
(10) Density of not less than 30 lb./ft.^{3}, and
(11) Is easily compressed and has a recovery of 95% or more.

3841.3 SAMPLING AND TESTING
The Department reserves the right to sample, test, inspect, and accept or reject sponge rubber expansion joint based on its own tests.

3850 LIGHTING SERVICE CABINET

3850.1 SCOPE

Provide electrical service cabinets for distributing electrical power, providing over current protection, and providing a means to cut off power to roadway lighting systems.

3850.2 REQUIREMENTS

A General

Use lighting service cabinets and sub-assemblies listed and labeled by a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor.

Ensure the NRTL is listed by OSHA in its scope of recognition for the tests conducted in accordance with this section.

Provide lighting service cabinets meeting the following characteristics:

(1) Complete and operational as required by the contract,
(2) NEMA 3R rated for the enclosure,
(3) Provides electrical service for roadway lighting,
(4) Listed and labeled by the NRTL as in compliance with UL 508 and UL 508A,
(5) Listed and labeled by the NRTL as suitable for use as service equipment,
(6) Listed and labeled by the NRTL as approved for outdoor use, and
(7) With all available branch circuit breakers installed.

B Type L1 Service Cabinet

Use Type L1 service cabinets listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

C Type L2 Service Cabinet

Use Type L2 service cabinets listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

D Type Rural Lighting and Flasher (RLF) Service Cabinet

Use Type RLF service cabinets listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

E Type A Service Cabinet

Use Type A service cabinets listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

F Type B Service Cabinet

Use Type B service cabinets listed on MnDOT's Approved/Qualified Products List under "Roadway lighting."

3850.3 SAMPLING AND TESTING

The Department reserves the right to test, inspect, and accept or reject lighting service cabinets that are not in compliance with requirements as defined in the cabinet specifications posted on MnDOT's Approved/Qualified Products List under "Roadway lighting" for lighting service cabinets

Planting Materials

3861 PLANT STOCK

3861.1 SCOPE

Provide species and varieties of trees, shrubs, vines, and perennials suitable for roadside landscape planting. The Department will use the term "plant" to describe trees, shrubs, vines, or perennials.

3861.2 REQUIREMENTS

Unless otherwise specified as collected stock (wild or grown in other than nursery conditions) or as Department-provided plants, provide plants grown in a nursery for at least 2 years and meeting the requirements of the current edition of the *Inspection and Contract Administration Manual for MnDOT Landscape Projects* (*ICAMMLP*) for grading and accepting plant stock. Provide a Certificate of Nursery Inspection from the Department of Agriculture of the state of plant origin in accordance with 2571.2.A.2, "Plant Stock and Materials Documentation."

A Classification of Plants

The Department will classify trees, shrubs, vines, and perennials for landscaping purposes by species, variety, and size or age as required by the contract.

If the contract requires a dimensional size, provide plants with the minimum range of height, stem caliper, or spread acceptable, meeting the requirements of the current edition of the *ICAMMLP*.

B Plant Names

The Department will specify the botanical and common names of plant materials based on the requirements of *Hortus Third.*

C Plant Hardiness

Provide plant stock hardy to the Minnesota zone that includes the project and meeting the following requirements:

(1) Documented as continuously grown for at least the last 2 years within the acceptable growing range limits as shown on the standard planting detail (A) in the plans, or

(2) If grown outside the acceptable growing range limits, documented as having the seed source or root and graft stock originating from within the acceptable growing range limits as shown on the standard planting detail (A) in the plans.

The Engineer will resolve questions regarding plant stock hardiness or botanical identification.

D (Blank)

E Quality and Condition

Provide a Certificate of Nursery Inspection from the Department of Agriculture of the state of plant origin in accordance with 2571.2.A.2, "Plant Stock and Materials Documentation."

Provide plant species or variety shown on the plans, free of disease, disfiguring knots, sun scald, insect infestations, dead or broken branches, bark abrasions, and other unacceptable conditions as described in the current edition of *ICAMMLP*.

Provide plants that meet all applicable criteria for plant type, size, and age as listed in the current edition of the *ICAMMLP* for each plant shown on the plans.

Provide container grown plants with root systems capable of holding the soil intact after removal from the container. The Engineer will reject nursery grown plants with root systems not consistent with criteria listed in the current edition of the *ICAMMLP*.

The Engineer will reject plants delivered with broken or bruised branches, stems, or canes unless the Contractor prunes the damaged growth without affecting the size or symmetry. The Engineer will reject balled and burlapped plants delivered with broken or disturbed balls. Deliver and install bare root plants in a dormant condition unless otherwise approved by the Engineer. If installing plants that have broken dormancy as approved by the Engineer, the Department will withhold payment for the initial planting operations until the Engineer determines the plant acceptability after the first year of plant establishment.

Provide coniferous trees meeting the dimensional requirements in the current edition of the *ICAMMLP* and containing buds or new growth at the terminal ends of the branches. During the spring planting season, the Contractor may plant coniferous plants with new growth during storage in a holding bin. The Engineer will reject coniferous plants dug after producing new growth. The Engineer will reject coniferous trees not fully branched from bottom to top.

Provide pine trees with a terminal leader bud and terminal leaders no longer than 18 in [500 mm]. Train a new central leader in conifers delivered with multiple or missing leaders.

F Digging and Handling

Dig and handle plants with reasonable care and skill to prevent damage to stems, roots, branches, and the trunk.

For balled and burlapped plants, preserve a firm ball of undisturbed soil around the root system. Provide balled and burlapped plants meeting the requirements of the current edition of the *ICAMMLP*.

Wrap and bound balled and burlapped plants to maintain an intact and solid soil ball during handling, shipment, and planting. Handle balled and burlapped plants by the soil ball and not by the branches or trunk. The Contractor may use wire baskets with balled and burlapped plants unless otherwise specified in 2571.3.F, "Installation of Plants."

G Packing and Shipping

Ship plant material meeting the requirements of the nursery inspection and plant quarantine regulations of the states of origin and destination and the Federal regulations governing interstate movement of nursery stock as administered through each state Department of Agriculture.

Ship plants true to name. Legibly and securely label each bundle, bale, or individual plant with the following information for each species or variety:

(1) Name,
(2) Size, and
(3) Quantity.

Package and ship plants without damage. After digging the plants, cover the roots with a suitable moisture-holding material to protect the roots from drying out. Do not remove the material until delivery to the planting site. Protect roots from the sun, wind, and freezing temperatures. If transporting plants in closed vehicles, provide ventilation to prevent bud break.

3861.3 SAMPLING AND TESTING

The Engineer will inspect plants at time of delivery of plants to the project site. Acceptance requirements for each plant stock and form are described in the current edition of the *ICAMMLP*.

The Engineer may randomly inspect no greater than three balled and burlapped or container plants, of each variety delivered to the planting site for condition and size of the root system. The Engineer may pull back the burlap and wire basket or remove plants from containers. Replace plants becoming unsuitable for planting from the inspection at no additional cost to the Department.

The Engineer will reject plants not meeting dimensional requirements as described in the current edition of the *ICAMMLP*. The Engineer will measure the height of coniferous trees of the pine, spruce, and fir species to the upper limit at the midpoint of the terminal leader.

Remove and replace rejected plants, unless otherwise directed by the Engineer.

3874 FILTER BERM

3874.1 SCOPE

Provide filter berms to slow, filter, and divert storm water runoff and other pollutant water.

3874.2 REQUIREMENTS

Provide the following types of filter berms. Dimensions may vary by the contract:

A Type 1 — Compost

Provide compost berms meeting the following requirements and characteristics:

(1) Compost Grade 2 in accordance with 3890,
(2) Ttrapezoidal shape with 5 feet [1.5 m] base width,
(3) At least 2 ft [0.6 m] high in loose volume, and
(4) 2:1 (V:H) side slopes.

B Type 2 — Slash Mulch

Provide slash mulch berms meeting the following requirements and characteristics:

(1) Type 5 mulch in accordance with 3882,
(2) Trapezoidal shape with 5 ft [1.5 m] base width,
(3) At least 2 ft [.6 m] high in loose volume, and
(4) 2:1 (V:H) side slopes.

C Type 3 — Rock Weeper System

Provide rock weeper systems meeting the following requirements and characteristics:

(1) Type IV Geotextile filter fabric liner in accordance with 3733,
(2) Trapezoid shape with 8.0 feet [2.4 m] base width,
(3) No higher than 2.0 ft [0.6 m]
(4) 2:1 (V:H) side slopes
(5) Front half composed of coarse filter aggregate in accordance with 3149.2.H, and
(6) Back half composed of riprap in accordance with 3601, Class I and 100 percent crushed or quarry run material.

D Type 4 — Topsoil

Provide topsoil filter berm meeting the following requirements and characteristics:

(1) Common Topsoil salvage in accordance with 2105,
(2) Trapezoid shape with 7 feet [2.1 m] base width,
(3) At least 2ft [0.6 m] high, and
(4) 2:1 (V:H) side slopes.

E Type 5 — Rock

Provide rock filter berm meeting the following requirements and characteristics:

(1) Geotextile filter fabric liner in accordance with 3733, Type IV,
(2) Riprap in accordance with 3601, Class II and 100 percent crushed or quarry run material,
(3) Trapezoid shape with 5 ft [1.5 m] base width,
(4) No higher than 2.0 ft [0.6 m], and
(5) 2:1 (V:H) side slopes.

3874.3 SAMPLING AND TESTING

Provide test samples as directed by the Engineer.

3875 WATER TREATMENT

3875.1 SCOPE

Provide water treatment methods to minimize turbid water levels from dewatering practices that discharge to receiving waters.

3875.2 REQUIREMENTS

Provide water treatment methods meeting NPDES, ACOE, DNR, local watersheds, or any other applicable regulatory requirements.

A Passive

Use passive dewatering treatment methods, using time and gravity to settle out sediments, if draining basins, traps, ditches, or sumps to prepare the construction site for the next storm event.

A.1 Rock Weepers

Provide rock weepers for vegetated or impermeable lined channels in accordance with 3874.2.C, "Type 3 — Rock Weeper System."

A.2 Perforated Riser (Standpipe)

Provide a riser pipe in a pond, basin, or trap outlet structure meeting the following requirements or characteristics:

(1) Two-thirds the height of the outlet above the floor of the structure,
(2) Made of perforated PVC or metal pipe of the same diameter as the outlet structure, and
(3) Surrounded by clean rock from 1 in to 2 in [25 mm to 50 mm], for the entire height of the riser pipe.

Install a trash guard on the top overflow.

A.3 (Blank)

A.4 Floating Head Skimmer

Provide a schedule 40 PVC pipe at least 1.5 in [38 mm] diameter for the floating head skimmer. Use a flocculant with a floating head skimmer in accordance with 3898, "Flocculants," to provide additional treatment if shown on the plans.

A.5 Portable Sediment Tanks

Provide prefabricated portable sediment tanks meeting the following requirements and characteristics:

(1) Designed to settle sands, loamy sands, and sandy loams,
(2) Contain 16 cu. ft [0.45 cu. m] of storage per gallon [liter] per minute of pump discharge capacity,
(3) Contain orifice attachment portals for dewatering hoses and sediment cleanout access,
(4) Include weirs and replaceable media filters of slash mulch, excelsior fibers, or other filter media to meet the project pollutant load, and
(5) Used in accordance with 3898, "Flocculants."

Provide additional tanks to meet item (2) above or, if outfall water is not visibly clear.

B Active

Provide pumps, hoses, pressurized tanks, or a combination of these items to depress the water table allowing for construction work to be completed in dry soil conditions.

B.1 Rock Barrel

Provide a 55 gal [200 L] barrel with 12 in [300 mm] slits cut into the base. Install a sleeved 8 in [200 mm] diameter perforated pipe in the barrel. Provide a flocculant sock in accordance with 3898, "Flocculants," and place the sock at the bottom of the barrel and around the base of the perforated pipe. Surround the slits in the bottom of the barrel with clean rock with a diameter from 1 in to 2 in [25 mm to 50 mm]. Place the clean rock on a 1:2 (V:H) slope around the barrel.

B.2 In-line Flocculant Sock

Provide a flocculant in accordance with 3898, "Flocculants," in the hose connecting one containment facility to another. Locate the flocculant sock after the pump.

B.3 In-line Pressurized Filter Systems

Provide a portable water quality monitoring system consisting of sand media, pressurized bags, or cartridges to produce required turbidity or chemical reduction. Use liquid flocculants in accordance with 3898, "Flocculants," if necessary. Provide a portable water quality monitoring system meeting the discharge requirements shown on the plans.

3875.3 SAMPLING AND TESTING

Provide samples for testing meeting the requirements of the NPDES construction permit. Make modifications to the method in accordance with the test results.

3876 SEED

3876.1 SCOPE

Provide seed for planting to establish temporary and permanent vegetative cover.

3876.2 REQUIREMENTS

Provide seed meeting the following requirements and characteristics:

(1) From a vendor listed on the Approved/Qualified Product List and approved to blend or sell the type of mix used;
(2) Meeting the requirements of Minnesota Statutes 21.80-21.91 and any applicable federal regulations, including those governing labeling and weed seed tolerances;
(3) Conditioned to remove all pieces of stem, straw, or other chaff longer than 1½ in [38 mm] so that it can pass through a drill seeder without plugging;
(4) Supplied on a pure live seed (PLS) basis; and
(5) Meeting the tolerance requirements for germination and purity factors of the following Minnesota Seed Law Rules applied to seed lots sampled and tested by the following Association of Official Seed Analysts (AOSA) methods:
    (5.1) 1510.0050,
    (5.2) 1510.0060,
    (5.3) 1510.0070,
    (5.4) 1510.0080,
    (5.5) 1510.0090, and
    (5.6) 1510.0100.

Apply Rhizobial inoculants to legume seed with the rhizobial culture appropriate for the species being inoculated as directed by the manufacturer or as shown on the special provisions.

Apply Mycorrhizal inoculants for native warm season grasses as shown on the plans.

Apply Azospirillum innoculants to grass seed as shown on the plans.

Use inoculants before the expiration date. Provide a label showing the expiration date of the innoculant.

Store seed and innoculant in accordance with 1606, "Storage of Materials," and under controlled conditions. Before planting, maintain seed at or below 70 °F [21 °C] and at or below 10 percent moisture content, and protect seed from rain, direct sunlight, rodents, and insects.

The Department defines PLS as the product of the percent of viable seed ("total germination and hard seed or dormant seed when applicable") multiplied by the percent of pure seed divided by 100 percent.

A (Blank)

B (Blank)

C (Blank)

C.1 (Blank)

C.2 (Blank)

C.3 (Blank)

D Seed Mix Designations

D.1 Standard Seed Mixes

Use seed of the species and germplasm meeting the requirements of the Seeding Manual, and the State Seed Mix Acceptable Substitution Table, or as specified in the special provisions.

Table 3876-1
State Seed Mixes*†

Category & Mix No.	PLS Rate, *lb/acre*	PLS Rate, *kg/ha*	Name
Cover Crop			
21-111	100	112.1	Oats Cover Crop
21-112	100	112.1	Winter Wheat Cover Crop
21-113	110	123.3	Soil Building Cover Crop
Mid-Term Stabilization			
22-111	30	34.2	Two-year Stabilization
22-112	40	44.8	Five-year Stabilization
Non-Native Grassland			
25-121	61	38.4	Sandy General Roadside
25-131	220	246.6	Low Maintenance Turf
25-141	59	66.1	Mesic General Roadside
25-142	45	50.4	Agricultural Roadside
25-151	120	34.5	High Maintenance Turf
Mid-term Stabilization Native			
32-241	38	45.6	Native Construction
Stormwater Facilities			
33-261	35	39.2	Stormwater South and West
33-262	44	49.3	Dry Swale / Pond
33-361	35	39.2	Stormwater Northeast
Wetland			
34-171	5.3	5.9	Wetland Rehabilitation
34-181	5	5.6	Emergent Wetland
34-261	31.5	35.3	Riparian South & West
34-262	14.5	16.3	Wet Prairie
34-271	12	13.5	Wet Meadow South & West
34-361	31.5	35.3	Riparian Northeast
34-371	12.5	14	Wet Meadow Northeast
Native Grassland			
35-221	36.5	40.9	Dry Prairie General
35-241	36.5	40.9	Mesic Prairie General
35-421	11	12.3	Dry Prairie Northwest
35-441	11	12.3	Mesic Prairie Northwest
35-521	12.5	14	Dry Prairie Southwest
35-541	12	13.5	Mesic Prairie Southwest
35-621	11	12.3	Dry Prairie Southeast

Table 3876-1 State Seed Mixes*†			
Category & Mix No.	**PLS Rate, *lb/acre***	**PLS Rate, *kg/ha***	**Name**
35-641	12	13.5	Mesic Prairie Southeast
Woodland			
36-211	34.5	38.7	Woodland Edge South & West
36-311	33.5	37.6	Woodland Edge Northeast
36-411	35.5	39.8	Woodland Edge Northwest
36-711	35.5	39.8	Woodland Edge Central

* Sort mix components by functional group except for footnoted mix tables that identify mix components not required to be bagged separately. Refer to the seeding manual.

† The Department will list components in mix tables by order of predominance within each functional group. Refer to the seeding manual.

D.2 Site Specific Seed Mixes

Provide seed mixes in accordance with *Native Seed Mix Design for Roadsides* if shown on the plans.

E Blending

Provide uniformly blended seed mixes as required by the contract and meeting the requirements of the Seeding Manual. Blend mixes meeting the requirements of the Department's Approved Seed Vendor Agreement.

E.1 Non-native mixes and cover crop mixes

Combine all components of non-native mixes and cover crop mixes

E.2 Native seed mixes

Blend and package components of native seed mixes according to size to allow installation from the appropriate seed box of native seeding equipment and in accordance with the following:

(1) Combine the seeds of sedges and rushes for installation by hand or with the small seed box,
(2) Combine the seeds of small and medium seeded forbs for installation with the small seed box,
(3) Combine the seeds of most grasses and large-seeded forbs for installation with the fluffy seed box, and
(4) Combine large seeds of cover crop species such as oats and winter wheat for installation with the grain box.

F Minimum PLS

Provide seed meeting the minimum purity and germination requirements for certification in accordance with the seed certification standard on file with the appropriate seed certifying agency. If using non-certified seed approved as substitutions, provide seed meeting the minimum PLS requirement listed on the State Seed Mix Acceptable Substitution Table.

G Acceptable Varieties and Origin

Use seed of introduced species that has been certified by the Minnesota Crop Improvement Association (MCIA) or the appropriate seed certifying agency in the seed's state of origin. Use seed of varieties listed in the State Seed Mix Acceptable Substitution Table.

Where native species occur in predominately non-native mixes, use seed varieties as listed in the State Seed Mix Acceptable Substitution Table or seed certified as Source Identified by the MCIA.

In native seed mixtures, use seed of native species certified in the Source Identified class by the MCIA.

In native seed mixtures, use seed of native species with a genetic origin from Minnesota or the following regions of adjacent states:

Table 3876-2 Native Species from Adjacent States	
State	**Counties**
North Dakota	Barnes, Benson, Cass, Cavalier, Dickey, Eddy, Foster, Grand Forks, Griggs, Lamoure, Nelson, Pembina, Ramsey, Ransom, Richland, Sargent, Steele, Stutsman, Towner, Traill, Walsh
South Dakota	Aurora, Beadle, Bon Homme, Brookings, Brown, Clark, Clay, Codington, Davison, Day, Deuel, Douglas, Grant, Hamlin, Hanson, Hutchinson, Jerauld, Kingsbury, Lake, Lincoln, Marshall, McCook, Miner, Minnehaha, Moody, Roberts, Sanborn, Spink, Turner, Union, Yankton
Iowa	Allamakee, Bremer, Buena Vista, Butler, Cerro Gordo, Cherokee, Chickasaw, Clay, Clayton, Dickinson, Emmet, Fayette, Floyd, Franklin, Hancock, Howard, Humboldt, Kossuth, Lyon, Mitchel, O'Brien, Osceola, Palo Alto, Plymouth, Pocahontas, Sioux, Winnebago, Winneshiek, Worth, Wright
Wisconsin	Ashland, Barron, Bayfield, Buffalo, Burnett, Chippewa, Clark, Crawford, Douglas, Dunn, Eau Claire, Grant, Iowa, Iron, Jackson, La Crosse, Lafayette, Monroe, Pepin, Pierce, Polk, Price, Richland, Rusk, Saint Croix, Sawyer, Taylor, Trempealeau, Vernon, Washburn

G.1 Range-Limited seed mixes

If a seed mix is identified on the plans as Range-Limited, supply seed in accordance with the following requirements as specified on the plans:

(1) Range-Limited 150: At least 85 percent of native components have a genetic origin from within 150 miles of the project,
(2) Range-Limited 75: At least 85 percent of native components have a genetic origin from within 75 miles of the project,
(3) Range-Limited 25: At least 85 percent of native components have a genetic origin from within 25 miles of the project.

H Substitutions

The Contractor may substitute species or germplasm listed in the Seeding Manual with corresponding species or germplasm listed in the State Seed Mix Acceptable Substitution Table. Use native species from the State Seed Mix Acceptable Substitution Table only for projects in regions of the state where the substitute species is native in accordance with the State Seed Mix Acceptable Substitution Table. The Contractor may request permission to use alternate substitutions from the Office of Environmental Stewardship, Erosion and Stormwater Management Unit if a species or germplasm on the State Seed Mix Acceptable Substitution Table is not available. Do not make alternate substitutions before approval by the Erosion and Stormwater Management Unit and amendment of the State Seed Mix Acceptable Substitution Table.

The Department will allow substitutions for seed of native species in accordance with the following priority:
(1) Default Source: MCIA certified in the Source Identified class with a genetic origin in the region defined in 3876.2.G, "Acceptable Varieties and Origins,"
(2) Primary Authorized Substitution: Source Identified seed certified by a seed certifying agency other than MCIA and with a genetic origin in the region defined in 3876.2.G, "Acceptable Varieties and Origins,"
(3) Secondary Authorized Substitution: Certified seed of varieties/germplasm listed in the State Seed Mix Acceptable Substitution Table,
(4) Tertiary Authorized Substitution: Wild Type with a genetic origin in the region defined in 3876.2.G, "Acceptable Varieties and Origins." The Department defines "wild type seed" as seed from a local or regional ecotype originating from remnant native stands and not modified by any intentional selection process, and
(5) Other substitutions as approved by the Office of Environmental Stewardship.

3876.3 SAMPLING AND TESTING

A Testing and Viability

Provide seed tested in accordance with the official rules for testing on file with the AOSA and meeting the minimum germination requirements of 3876.2.F, "Minimum PLS," during installation. Plant seed within 12 months of viability testing exclusive of the month the test was completed.

Upon request by the Engineer, provide seed test reports from a registered seed technologist for each lot of seed being used. Take samples of seed lots delivered to the project in accordance with the Schedule for Materials Control for testing and inspection, or more often as requested by the Engineer. The Department will use a tetrazolium test in lieu of a standard

germination test for quality control. If the Department's inspection and testing results disagree with those obtained at the origin, the Department's findings will be conclusive and binding. The Contractor may challenge the Department's seed test results and may request re-testing at no additional cost to the Department.

B Blank

C Labeling

Label each container of seed with the following information (in addition to information required by the Minnesota Seed Law, Section 21.82):

(1) Total PLS weight for the container,
(2) Net weight for the container,
(3) Area covered by the amount of seed in the bag when applied at the rate specified for that mix in Seeding Manual or special provision,
(4) When listing origin of mix components, list county of genetic origin for native species, and
(5) PLS percent.

List the following information for each mix component that is 5 percent or less of the seed mix (include on the label for each container or supply as a separate sheet for each seed mix lot):

(1) Species,
(2) Variety,
(3) Origin (production area for introduced species; county of genetic origin for native species),
(4) Pure seed (percent),
(5) Germination (percent),
(6) Hard (dormant) seed (percent), and
(7) PLS (percent).

When bags of small seeded species are placed inside larger bags of large-seeded species of the same mix, label smaller bags to clearly identify the components contained in the bag and what mix they belong to.

Attach applicable certification tags from appropriate seed certifying agencies to each bag containing certified seed or provide a certification certificate with the certified seed.

Attach a MnDOT Approved Seed Vendor tag to each bag of seed. Ensure that the tag matches the type of mix labeled.

The Department considers the labeling and tags required in this section and by state and federal law as the certificate of compliance for the provided seed.

3877 TOPSOIL MATERIAL

3877.1 SCOPE

Provide topsoil material for use as a medium to establish plant growth for water quality and permanent erosion protection. Provide manufactured soils for use as a medium for treating and filtering stormwater in rain gardens, horizontal filter berms, dikes, bioswales, and bioslopes.

3877.2 REQUIREMENTS

Provide loam to sandy loam topsoil from Type A and/or Type B horizon soils defined in the soil profile section of the Grading and Base Manual, from alluvial deposits, or blended from defined sand, compost, and loam to sandy loam topsoil sources. Manufactured topsoil's in section E, F, G, and H are blended on a volume basis of materials. When the individual components have been verified to meet the appropriate specification, the blended material in the ratio indicated shall meet this specification. In addition to the requirements, any of the topsoil types may require soil conditioners, plant hormones, or root stimulators in accordance with 3896, "Soil and Root Additives."

Aggregate material from sources other than gravel pits and quarries must also meet the minimum contaminants requirements in US EPA 503 or Minnesota Rule 7035.2846 Subp. 6, Sec. A.

A Common Topsoil Borrow

Provide Common topsoil borrow ranging from a silt loam, loam, clay loam, sandy clay loam, or sandy loam soils for general use as a turf growing medium and in accordance with Table 3877-1. Common topsoil borrow material is a blend of Type A and/or Type B horizon soils defined in the soil profile section of the Grading and Base Manual, and is similar to topsoil found adjacent to the project.

Table 3877-1 Common Topsoil Borrow Requirements		
Requirement	**Range**	**Test Method**
Material Passing the ¾ in [19 mm]	100 %	ASTM D 422
Material passing No4 in [4.75 mm]	≥ 85%	—
Clay	5% – 35%	ASTM D 422
Silt	5% - 70%	ASTM D 422
Sand	10% - 75%	ASTM D 422
Organic matter	3% – 15%	ASTM D 2974
pH	6.1 – 7.8	ASTM G 51

B Loam Topsoil Borrow

Provide topsoil borrow consisting mostly of loam ranging into sandy clay loam, sandy loam, silt loam, and clay loam soils as a plant growing medium for landscape and planting beds and in accordance with Table 3877-2:

Table 3877-2 Loam Topsoil Borrow Requirements		
Requirement	**Range**	**Test Method**
Material Passing the ¾ in [19.0 mm]	100%	ASTM D 422
Material passing No. 4[4.75 mm]	≥ 90%	-
Clay	5% – 35%	ASTM D 422
Silt	10% – 60%	ASTM D 422
Sand	15% – 60%	ASTM D 422
Organic matter	3% – 15%	ASTM D 2974
pH	6.1 – 7.5	ASTM G 51
Soluble salts	≤ 0.15 siemens/m [1.5 mmho/cm]	—

C Sandy Clay Loam Topsoil Borrow

Provide topsoil borrow mostly consisting of a sandy clay loam and ranging into clay loam, sandy loam, and loam soils for use as a plant growing medium in critical areas, such as steep slopes and as a top dressing for Turf Reinforcement Mats, and in accordance with Table 3877-3:

Table 3877-3 Sandy Clay Loam Topsoil Borrow Requirements		
Requirement	**Range**	**Test Method**
Screened	—	—
Material passing the ¾ in [19.0 mm]	100%	ASTM D 422
Material passing No.4 (4.75 mm)	≥ 95%	ASTM D 422
Clay	10% – 35%	ASTM D 422
Silt	0% – 40%	ASTM D 422
Sand	30% – 75%	ASTM D 422
Organic matter	3% – 15%	ASTM D 2974
pH	6.0 – 7.5	ASTM G 51
Soluble salts	≤ 0.15 siemens/m [1.5 mmho/cm]	—

D Blank

E Rooting Topsoil Borrow

Provide topsoil borrow consisting of three blended components of sandy loam topsoil, sand, and compost for use as a well-drained course sand medium for vegetative plant restoration, plant preservation, or as a plant growing medium for rooting, water quality, and infiltration. The components consist of the following by volume.

(1) Sixty percent sand in accordance with 3149.2.J, "Fine Filter Aggregate;" or 3149.2K, "sand cover"
(2) Twenty percent Grade 2 compost in accordance with 3890, "Compost;" and
(3) Twenty percent topsoil meeting the requirements of Loam Topsoil Borrow.

Supplement with root additives to stimulate root establishment in water quality treatment facility.

F Boulevard Topsoil Borrow

Provide topsoil borrow containing three blended components consisting of loam soil, sand, and compost for use as structural soil for plant establishment in streetscape boulevards. The components consist of the following by volume:

(1) One-third topsoil meeting the requirements of Loam Topsoil Borrow;
(2) One-third sand accordance with 3149.2J, "Fine Filter Aggregate;" or 3149.2K, "sand cover" and
(3) One-third compost in accordance with 3890, "Grade 2 Compost."

G Filter Topsoil Borrow

Provide topsoil borrow containing two blended components of sand and compost for water quality, plant growing medium, and filtration medium with a filtration rate of at least 4 in/h [10 cm/h]. The components consist of the following by volume:

(1) 60%-80% sand meeting the gradation requirements of 3126, "Fine Aggregate for Portland Cement Concrete" and
(2) 20%-40% compost meeting requirements 3890 Grade 2 Compost.

H Organic Topsoil Borrow

Provide topsoil borrow containing two blended components of topsoil, and compost for a plant growing medium to enhance existing soils. The components by volume consist of:

(1) 50% existing salvaged topsoil, and
(2) 50% compost meeting requirement of 3890 "Grade 2 Compost."

Provide Type 4 fertilizer in accordance with 3881, plant hormones in accordance with 3896.

3877.3 SAMPLING AND TESTING

Provide material from vendors that have been approved by Mn/DOT's Erosion and Storm water Management Unit or submit a list of prospective sources for topsoil material to the Engineer at the preconstruction meeting to allow for inspecting, testing, and approving the sources. Submit preapproval test results to the Office of Environmental Stewardship, Erosion & Stormwater Management Unit. If federal or state chemical or biological requirements conflict, provide material meeting the most stringent requirement.

Test blended topsoil for each individual component before blending.

Conduct fertility testing in accordance with the standard testing procedures of the University of Minnesota Soils Testing Laboratory, Soil Science Department. After placement of soil, perform an Infiltration Test meeting acceptable infiltration rate of infiltration topsoil borrow.

3878 SOD

3878.1 SCOPE

Provide sod for turf establishment, erosion control, energy dissipation of low flow water outfalls, river banks, and channel bottoms.

3878.2 REQUIREMENTS

Provide sod consisting of densely-rooted bluegrass or other permanent grasses and flowers, depending on sod type shown on the plans. Provide material from vendors on the Approved/Qualified Products List.

Cut turf-type sod in uniform strips at least 12 in [300 mm] wide and ¾ in [20 mm] thick. Cut the sod thicker to retain and expose the dense root system in the bottom side of the sod. Cut the sod when it contains sufficient moisture to withstand exposure and handling during the transplant operations. Rake the sod free of debris and trim the top growth to a height from 1 in to 3 in [25 mm to 75 mm].

Do not use sod strips with dry or dead edges upon delivery. Between June 1 and September 15, do not cut sod more than 24 h before delivery.

Provide native sod in the dimensions specified in the plans or by the manufacturer's recommendations for handling immediately before installation.

Before delivery, provide certification from the grower to the Engineer stating the grass varieties contained in the sod. Do not place sod until the Engineer approves the certification. Provide salt tolerant and the netted sods from certified growers as defined by the Minnesota Crop Improvement Association and the Office of Environmental Services. The Engineer will require certification of conformance based on third party inspection and documentation process for all material from certified growers.

A Lawn Sod

Provide lawn sod meeting the following requirements and characteristics:

(1) Soil is moist,
(2) Uniform texture,
(3) Dark green,
(4) Does not contain grass with blade widths greater than 0.2 in [5 mm],
(5) Weed-free,
(6) Contains no greater than 0.2 in [5 mm] of thatch over the base soil,
(7) Consists of a blend of 4 or 5 fine leafed turf grasses, and
(8) At least two-thirds of the grasses, as determined by initial seeding proportions, consist of improved and elite type Kentucky bluegrass varieties as specified in the Seeding Manual.

B (Blank)

C Salt Tolerant Sod

Provide salt-tolerant sod for use along boulevards or in a potential salt environment meeting the following requirements and characteristics:

(1) Low maintenance type,
(2) Fine leafed,
(3) Uniform texture,
(4) Free of noxious, broad-leafed, and grassy weeds,
(5) Contains less than 3 percent coarse grasses, and
(6) Originated from the blend of grass seed of seed components listed by the Minnesota Crop Improvement Association, Minnesota Turf Association, and the Office of Environmental Services.

D Mineral Sod

Provide mineral sod meeting the following requirements and characteristics:

(1) Commercially produced on or harvested from mineral based soils consisting of no greater than 10 percent organic matter by weight,
(2) Fine leafed,
(3) Uniform texture,
(4) Free of noxious, broad-leafed, or grassy weeds,
(5) Contains less than 3 percent coarse grasses,
(6) Consists of a blend of 4 or 5 fine leafed turf grasses, and
(7) At least 35 percent of the grasses, as determined by initial seeding proportions, consist of improved type Kentucky bluegrass varieties as specified in 3876, "Seed."

E Native Sod

Provide native sod meeting the following requirements:

(1) Commercially produced from native grass and flower seed mixtures in accordance with 3876, "Seed," and as shown on the plans, and
(2) Seeded and grown in turf reinforcement mats or natural organic mats for at least 30 days before delivery and installation.

3878.3 SAMPLING AND TESTING

The Engineer will obtain test samples for determination of soil organic matter content of mineral sod from the soil exposed in the bottom side of the sod rolls. The Engineer will test for organic matter content meeting the requirements of ASTM D 2974.

The Department may conduct its own inspection during sod production in the fields or at the project. Provide representative samples of the sod to the Engineer if requested. Do not deliver sod until the Engineer approves the samples.

3879 AGRICULTURAL LIME

3879.1 SCOPE

Provide Agricultural Liming Material (ALM) containing calcium compounds, magnesium compounds, or both, capable of neutralizing soil acidity and providing an increase in soil pH within six months of placement into the soil.

3879.2 REQUIREMENTS

ALM includes the following forms:

(1) Limestone (calcitic or dolomitic),
(2) Burned lime,
(3) Slaked lime, and
(4) Marl.

Gypsum is not a liming product. Provide lime product containing at least 80 percent Total Neutralizing Power (TNP) ground fine to provide the following characteristics:

(1) At least 90 percent, including fine particles obtained in the grinding process, passes through a No 8 [2.36 mm] sieve;
(2) At least 60 percent passes through a No. 20 [850 µm] sieve;
(3) At least 50 percent passes through a No. 60 [250 µm] sieve;
(4) A maximum water content of 10 percent;
(5) ALM with a rating of at least 1,000 lb Effective Neutralizing Power (ENP) per ton [1,120 kg ENP per tonne] of ALM.

Obtain the ALM from a Minnesota Department of Agriculture (MDA) licensed distributor or producer. For ALM supplied in bulk, deliver the ALM to the project with the following information on a billing, delivery invoice or scale ticket label:

(1) Distributor or producer's name, address, telephone number, and source of production or stockpile location;
(2) Customer's name;
(3) Date of sale or transfer;
(4) Type of ALM;
(5) Minimum weight in pounds of ENP per ton [mass in kilograms ENP per tonne], accurate within 3 percent; and
(6) Weight or cubic yards [cubic meters] of ALM distributed and weight per cubic yard [cubic meter].

For ALM supplied in bags or other container types, affix the following information to the bag or container:

(1) Distributor or producer's name and address;
(2) Minimum weight in pounds ENP per ton [mass in kilograms ENP per tonne], accurate to within 3 percent; and
(3) The net weight.

3879.3 SAMPLING AND TESTING

Collect samples in accordance with the MDA Agricultural Lime Official Sampling Methods. Submit samples to MDA or the University of Minnesota testing lab for analysis of the following:

(1) Percent of TNP,
(2) Percent passing the No. 8 [2.36 mm] sieve, No. 20 [850 µm] sieve, and No. 60 [250 µm] sieve,
(3) Percent dry matter, and
(4) The weight in pounds ENP per ton [mass in kilograms ENP per tonne] of ALM rating.

Perform sampling and testing within 90 days before applying the lime material to the land. The weight in pounds ENP per ton of ALM is defined as follows:

$$\left(\frac{2{,}000\ lb(1{,}000kg)}{ton}\right)(ENP)\left(\frac{PDM}{100}\right)=\frac{W}{T}$$

when:

$$\text{ENP} = \left(\frac{FinenessIndex}{100}\right)\times\left(\frac{\%TNP}{100}\right)$$

Fineness Index = $0.2(\%passNo.8-\%passNo.20)+0.6(\%passNo.20-\%passNo.60)+1(\%passNo.60))$

PDM = percent dry matter = 100 − % Moisture
W = weight, lb [kg] ENP
T = Ton [tonne] of ALM

The Engineer may accept material provided in accordance with this section, on the basis of the distributor's or producer's guaranteed analysis. The Department reserves the right to sample, test, inspect, and accept or reject the material based on its own tests.

3881 FERTILIZER

3881.1 SCOPE

Provide fertilizer for use in establishing vegetative cover and landscape plantings.

3881.2 REQUIREMENTS

A General

Provide a manufactured grade of inorganic or organic fertilizer produced in granular or granulated form. The fertilizer shall contain at least the minimum analysis shown on the plans, and shall consist of a blended or homogeneous form containing the specified percentages of total nitrogen, available phosphoric acid (or phosphorous), and water-soluble potash (or potassium), in that order.

If the fertilizer is provided in closed containers, clearly mark the containers with the following information in accordance with Minnesota Department of Agriculture (MDA) regulations:

(1) The weight,
(2) The type of nutrients, and
(3) The manufacturer's guaranteed analysis.

If the fertilizer is provided in bulk, provide the above information in an invoice, delivery ticket, or written form. Include a suitable bill-of-lading with each shipment that contains the information in accordance with MDA regulations.

B Types
Provide fertilizer that conforms to the requirements for one of the following types, as shown on the plans.

B.1 Type 1 — Commercial Fertilizer
Provide commercial fertilizer meeting the following characteristics:

(1) Consisting of dry granulated nutrients produced by mining and manufacturing processes and commonly used in the agricultural or lawn care industries; and
(2) Containing nitrogen, phosphorous, and potassium.

B.2 Type 2 — Phosphorous-Free Fertilizer
Provide commercial fertilizer meeting the following characteristics:

(1) Consisting of dry granulated nutrients produced by mining and manufacturing processes and commonly used in the agricultural or lawn care industries, and
(2) Contains nitrogen and potassium.

B.3 Type 3 — Slow-Release Fertilizer
Provide slow-release fertilizer with the following characteristics:

(1) Specifically processed to release nitrogen at a slow rate over a growing season;
(2) Containing nitrogen, phosphorous, and potassium;
(3) The primary nitrogen sources shall be in a coated, prilled urea form; and
(4) At least 70 percent of the nitrogen component shall be slow-release water-insoluble nitrogen.

B.4 Type 4 — Natural-Based Fertilizer
Provide natural-based fertilizer with the following characteristics:

(1) With at least 50 percent of the mass and at least 50 percent of the macronutrients derived from natural or organic material;
(2) Consisting of dry granulated nutrients with a moisture content of less than 10 percent;
(3) Consisting of granules with an approximate size from No. 7 [2.8 mm] sieve to No. 30 [0.6 mm] sieve;
(4) Derived from aerobically composted feed stock supplemented with ammonium sulfate, ferrous sulfate, and sulfate of potash to meet the ratios shown on the Plans; and
(5) Free of sewage sludge, raw manure, or uncomposted organic matter.

3881.3 SAMPLING AND TESTING
The Department may approve the fertilizer based on the manufacturer's guaranteed analysis, but the Department reserves the right to sample and test the material at the source, or at the project before final acceptance. The Department will perform chemical analysis tests in accordance with the methods established by the Association of Official Agricultural Chemists.

3882 MULCH MATERIAL

3882.1 SCOPE
Provide mulch material for controlling erosion and establishing vegetative cover.

3882.2 REQUIREMENTS
Provide mulch material meeting the requirements of one of the following types, as required by the contract.

A Type 1
Provide Type 1 mulch with the following characteristics:

(1) Grain straw, hay, cuttings of agricultural grasses, and legumes.
(2) Free of noxious weeds as defined by the rules and regulations of the Minnesota Department of Agriculture (MDA);
(3) Free of cattail (*Typha sp*), reed canary grass (*Phalaris arundinacea*), birds-foot trefoil (*Lotus corniculatus*), and crown vetch (*Coronilla varia*), Queen anne's lace (Daucus carota) ; and
(4) In an air-dried condition at the time of delivery.

B (Blank)

C Type 3
Provide Type 3 mulch with the following characteristics:

(1) Clean Agricultural grain straw, (Wheat, Oats, Rye, Barley) or clean straw harvested from native grass production fields, certified by the Minnesota Crop Improvement Association (MCIA) to be free of noxious weeds;
(2) Free of cattail (Typha sp), reed canary grass (Phalaris arundinacea), birds-foot trefoil (Lotus corniculatus), Crown vetch (Coronilla varia); and Queen anne's lace (Daucus carota);
(3) Bales are in an air-dried condition at the time of delivery; and
(4) Attached to each bale is the MCIA inspection tag.

D Type 4

Provide Type 4 mulch with the following characteristics:
(1) Type 1 or Type 3 mulch; and
(2) Hydraulic Stabilized Fiber Matrix , meeting the requirements of 3884.

E Type 5

Provide Type 5 mulch with the following characteristics:
(1) Raw wood slash from hard or soft timber harvested during clearing and grubbing operations on the project;
(2) Product of a mechanical chipper, hammermill, or tub grinder;
(3) Maximum length of individual pieces shall not to exceed 20 in [500mm], and.
(4) Maximum width of individual pieces shall not exceed 2 in [50mm].

Provide mulch from a supplier outside of the Emerald Ash Borer quarantine areas or, if the mulch originates from within the quarantine areas, obtain a Compliance Agreement with the Minnesota Department of Agriculture (MDA). The Department will not allow mulch transported in or through a quarantine area to be transported outside the Emerald Ash Borer quarantine area without approval from the MDA. Contact MDA for more information.

F Type 6

Provide Type 5 mulch with the following characteristics:
(1) Raw wood material from hard or soft timber and that is the product of a mechanical chipper, hammermill, or tub grinder;
(2) Material is free of mold, dirt, sawdust, and deleterious material;
(3) Do not use wood material in an advanced state of decomposition, chipped-up manufactured boards or chemically treated wood; including wafer board, particle board, Chromated Copper Arsenate (CCA), or penta treated wood;
(4) Material is air dried;
(5) Do not allow unattached bark, green-leaf composition to exceed 20 percent by mass;
(6) Maximum length of individual pieces shall not to exceed 12 in [300 mm]; and
(7) Maximum width of individual pieces shall not to exceed 2 in [50mm].

Provide mulch from a supplier outside of the Emerald Ash Borer quarantine areas or, if the mulch originates from within the quarantine areas, obtain a Compliance Agreement with the MDA. The Department will not allow mulch transported in or through a quarantine area to be transported outside the Emerald Ash Borer quarantine area without approval from the MDA. Contact MDA for more information.

G Blank

H Type 8

Provide Type 8 mulch with the following characteristics:
(1) Consisting of prairie hay;
(2) Has not been thrashed to remove seeds so it consists of directly-bailed material;
(3) Harvested from native stands or from native grass fields;
(4) Free of noxious weeds as defined by the rules and regulations of the Minnesota Department of Agriculture (MDA); and
(5) Free of cattail (*Typha sp*), reed canary grass (*Phalaris arundinacea*), birds-foot trefoil (*Lotus corniculatus*), and crown vetch (*Coronilla varia*); and Queen anne's lace (Daucus carota).

I Type 9

Provide Type 9 mulch with the following characteristic:
(1) Consists of naturally occurring mineral materials,
(2) Contains no topsoil or organics, and
(3) Aggregate ranging in size from ⅜ in [9.5 mm] to 2 in [50 mm], with 5 percent by mass passing the ⅜ in [9.50 mm] sieve.

3882.3 SAMPLING AND TESTING

Obtain test samples at a rate in accordance with the Schedule of Materials Control. Test for moisture content in accordance with ASTM D 4444 and sieve analysis in accordance with ASTM D 422.

3884 HYDRAULIC EROSION CONTROL PRODUCTS

3884.1 SCOPE

Provide hydraulically applied Hydraulic Erosion Control Products (HECPs) to control erosion on all soil types and to establish vegetative cover.

3884.2 REQUIREMENTS

Provide HECPs meeting the following requirements and characteristics:

(1) Noncorrosive to hydraulic application equipment,
(2) Nonfoaming or containing mixture enhancers to prevent foaming and mixing problems during agitation in the application equipment, and
(3) Safe to the applicator, adjacent workers, and the environment if properly applied in accordance with the EPA and OSHA.

Apply HECPs with equipment capable of mechanical agitation and slurry bypass.

Provide an Applicator's Certification from the manufacturer before applying the Bonded Fiber Matrix and Fiber Reinforced Matrix.

A Hydraulic Tackifiers

A.1 Natural Tackifier

Provide the following types of natural tackifiers with an erosion control performance no greater than 3 months:

(1) Water soluble natural proteins,
(2) Vegetable gums,
(3) Guar gums; at least 95 percent guar gum by weight and the remaining weight consisting of dispersing and cross-link additives,
(4) Starch; non-ionic, cold-water soluble, pre-gelatinized granular cornstarch,
(5) Psyllium; finely ground muciloid coating of plantago seeds applied as a dry powder or a wet slurry to the surface of the soil,
(6) Pitch; non ionic emulsion with a solids content of at least 48 percent,
(7) Rosin types blended with gelling and hardening agents; consisting of at least 26 percent of the total solids content, or
(8) Water soluble blends of hydrophilic polymers, viscosifiers, sticking aids, and other gums.

Use non-corrosive, water-dilutable emulsion soil stabilizer capable of curing to water-insoluble binding and cementing agent upon application.

A.2 Synthetic Tackifier

Provide synthetic tackifiers with an erosion control performance no greater than 18 months and meeting the following characteristics and requirements:

(1) Consists of polyvinyl acetate emulsion formulations containing at least 55 percent active solids;
(2) Does not contain poly-acrylates or polyvinyl-acrylics;
(3) Water-soluble;
(4) Remains flexible and does not re-emulsify after curing;
(5) Does not inhibit water and oxygen infiltration;
(6) Consists of organic, biodegradable, non-polluting, non-volatile, non-toxic material;
(7) Effective on all soil types with either acid or alkaline condition; and
(8) Air cures within 48 h.

A.3 Polyacrylamide Tackifier

Provide polyacrylamide (PAM) tackifiers meeting the following requirements and characteristics:

(1) Break down within 6 months,
(2) Naturally break down in soil,
(3) Liquid formulation containing PAM as the primary active ingredient and meeting the following requirements:
    (3.1) Linear, anionic copolymer of acrylamide and sodium acrylate,
    (3.2) Residual monomer content of the PAM no greater than 0.05 percent by weight, and
    (3.3) Formulated as a water-in-oil emulsion containing at least 2.6 lb pure PAM per gal [0.31 kg pure PAM per L], and containing at least 30 percent active pure PAM, or
    (3.4) Formulated as a liquid dispersed polyacrylamide (LDP), containing at least 4.4 lb pure PAM per gallon [0.53 kg pure PAM per liter], and containing at least 35 percent active pure PAM.
(4) Available as a prepackaged product and labeled to indicate the Minnesota Department of Agriculture registered and approved as a soil and plant amendment product,
(5) Drying time no greater than 4 h.

B Hydraulic Matrix

B.1 Compost
Provide hydraulic compost meeting the following characteristics and requirements:

(1) Contains plant or livestock manure feedstock finished compost in accordance with 3890, "Compost,"
(2) Contains peat moss, wood cellulose, straw fibers or other organic fibers blend containing humus, enzymes, vitamins, auxins, amino acids, and tackifier,
(3) Suspends with agitation in water,
(4) Includes a tracer dye for contrast against soils for visual metering, and
(5) Contains at least 60 percent compost, and tackifier by weight with the remaining weight composed of additional organic fibers.

B.2 Mulch
Provide hydraulic mulch meeting the following characteristics and requirements:

(1) Contains shredded wood paper fibers, natural fibers, or both containing no germination or growth inhibiting factors,
(2) Contains from 2.5 percent to 5.0 percent tackifier by weight premixed in the bag,
(3) Contains moisture content no greater than 15 percent at the time of delivery,
(4) If washed on a No. 20 [850 µm] sieve, at least 50 percent retained on the sieve, and
(5) Functional for no greater than 3 months after application.

B.3 Stabilized Fiber Matrix (SFM)
Provide stabilized fiber matrix meeting the following requirements and characteristics:

(1) Premanufactured matrix containing defibrated organic fibers with at least one of the following additives:
  (1.1) Soil flocculants,
  (1.2) Crosslinked hydro-colloidal polymers, or
  (1.3) 5 percent Crosslinked tackifiers.
(2) Contains moisture content no greater than 15 percent by weight,
(3) Cures within 48 h, and
(4) Functional for at least of 3 months.

B.4 Bonded Fiber Matrix (BFM)
Provide bonded fiber matrix meeting the following requirements and characteristics:

(1) Composed of wood fibers or wood byproducts,
(2) At least 25 percent of the fibers average 0.4 in [10.16 mm] long and with at least 50 percent retained on No. 25 sieve,
(3) Fibers colored with water soluble, non-toxic dye,
(4) Contains 10 percent $\pm$ 1 percent blended hydrocolloid,
(5) Crosslinker contains slow-release and agricultural based fertilizers or other proprietary chemicals no greater than 2 percent by volume,
(6) Binder and crosslinkers do not dissolve or disperse upon rewetting,
(7) Contains moisture content no greater than 15 percent by weight, and
(8) Functional for at least 6 months.

B.5 Reinforced Fiber Matrix(RFM)
Provide fiber reinforced matrix composed of a chemical and mechanical matrix containing the following:

(1) Organic defibrated fibers,
(2) Cross-linked insoluble or linear hydro-colloidal tackifiers,
(3) Reinforcing natural or synthetic fibers, and
(4) Functional for at least 12 months.

3884.3 SAMPLING AND TESTING
Submit to the Engineer a Manufacturer's Certificate of Compliance. Test for moisture meeting the requirements of ASTM D 4444. Perform particle sieve analysis meeting the requirements of ASTM D 422. Use a standard test board or free liquid quality control before placement of Bonded Fiber Matrix and Reinforced Fiber Matrix to ensure the liquids separate from fibrous solids no greater than 1 in [25 mm] in 1 min as shown on the board.

3885 ROLLED EROSION CONTROL PRODUCTS

3885.1 SCOPE

Provide temporary rolled out products to control erosion, aid the establishment of vegetation, and reinforce vegetation on slopes, ditch bottoms, and shorelines.

3885.2 REQUIREMENTS

A Acceptable Types

Provide acceptable types of rolled erosion control products listed in Table 3885-1.

Table 3885-1
Rolled Erosion Control Products

Category	Acceptable Types
	Blank
0	Wood Cellulose 1S, NT, or Wood Fiber 0S,
1	Blank
2	Blank
3	Straw 2S or Wood Fiber 2S
4	Straw/Coconut 2S or Wood Fiber HV 2S
5	Blank
6	Straw/Coconut 3S or Wood Fiber 3S
7	Blank

The lettering designation is defined as follows:
- 0S – No netting, stitching only
- 1S – Blank
- 2S – Netting on two sides – natural or synthetic as specified
- 3S – More than two nettings forming a three dimensional matrix
- NT – No thread/stitching

B Physical Requirements

Provide blankets that conform to the general requirements listed in Table 3885-2, Table 3885-3, and Table 3885-4.

Table 3885-2 Erosion Control Blanket Criteria			
Criteria		**Category 0**	
		Wood Cellulose Fiber 1S, NT	**Wood Fiber 0S**
mass per yd^2 [m^2] (min) ASTM D 6475		6.0 oz [0.17 kg]	8.0 oz [0.23 kg]
Permissible Shear stress, Minimum (non-vegetated) ASTM D 6460		0.5 lb/Sq. ft. [24 Pa]	0.5 lb/sq. ft. [24 Pa]
Fill	Fiber length, 80% greater than	0.5 in [12.7 mm]	6 in [150 mm]
	Material	100% Wood Cellulose	100% Excelsior
	Service Life	-	-
Netting	Material	Degradable	-
	Netting Opening, Min. (MD x TD)	0.5in x 0.5 in [13mm x 13mm]	-
	Service Life	3 months	-
Stitching	Material	-	Degradable
	Service life	-	3 months
	Max spacing		4 in [100 mm]

Table 3885-3 Erosion Control Blanket Criteria						
Criteria			***Category 3P, Category 3N**		***Category 4P, Category 4N**	
			Straw 2S	**Wood Fiber 2S**	**Straw-Coconut 2S**	**Wood Fiber 2S**
mass per yd^2 [m^2] (min) ASTM D 6475			6.0 oz [0.17 kg]	6.0 oz [0.17 kg]	6.0 oz [0.17 kg]	8.0 oz [0.23 kg]
Permissible Shear stress, (min) (non-vegetated) ASTM D 6460			1.7 lb/sq.ft [84 Pa]	1.7 lb/sq.ft [84 Pa]	2.25 lb/sq.ft. [108 Pa]	2.25 lb/sq.ft. [108 Pa]
Fill	Fiber length, 80% greater than		3 in [75 mm]	6 in [150 mm]	3 in [75 mm]	6 in [150 mm]
	Material		100% Straw	100% Excelsior	70% Straw, 30% Coconut	100% Excelsior
	Service Life		-	-	-	-
Netting	Material		**Degradable Synthetic or Natural	**Degradable Synthetic or Natural	**Degradable Synthetic or Natural	**Degradable Synthetic or Natural
	Netting Opening, (min) (MD x TD)	Synthetic	0.5in x 0.5in [13mm x 13 mm]	0.75in x 0.75in [19mm x 19mm]	0.5in x 0.5 in [13mm x13 mm]	0.75in x 0.75 in [19mm x 19 mm]
		Natural	0.5 x 0.5 in [13mm x 13 mm]	0.75 x 0.75 in [19mm x 19mm]		
	Tensile Strength Synthetic(max)AS TM D 4355	MD	-	-	-	-
		TD	-	-	-	-
	Service Life (max)		9 months	9 months	12 months	12 months
Stitching	Material		**Degradable Synthetic or Natural	**Degradable Synthetic or Natural	**Degradable Synthetic or Natural	**Degradable Synthetic or Natural
	Tensile Strength(max) ASTM D 4355		-	-	-	-
	Service life (max)		6 months	6 months	6 months	6 months
	Max spacing		2 in [50 mm]	4 in [100 mm]	2 in [50 mm]	4 in [100 mm]

* 3P &4P = Synthetic netting, 3N & 4N = Natural netting and natural stitching
** Not Photo Degradable

Table 3885-4 Erosion Control Blanket Criteria		
Criteria	**Category 6**	
	Straw-Coconut 3S	**Wood Fiber 3S**
Min mass per yd^2 [m^2] ASTM D 6475	10.2 oz [0.29 kg]	10.2 oz [0.29 kg]
Fiber Length, 80% greater than	3 in [75 mm]	6 in [150 mm]
Material	70% Straw and 30% Coconut Fibers	100% Excelsior Fibers
Netting and Stitching Service Life (min)	24 months	24 months
Netting and Stitching Material	Black UV Stabilized Polypropylene	Black UV Stabilized Polypropylene

B.1 Material Fiber

Provide fill material with a uniform web of interlocking fibers, with uniform thickness, and with the material fibers evenly distributed over the entire area of the blanket.

B.2 Blank

B.3 Blank

B.4 Anchors

Provide anchors for each category of blanket meeting the requirements in Table 3885-5.

Table 3885-5
Anchor Specification

Blanket Category	Material	Type	Minimum Length, *in [mm]*
0	Biodegradable	Stake	5 [125]
3 and 4	Steel Wire	11 Gauge	6 [150]
6	Steel Wire	11 Gauge	8 [200]
TRM *	Steel Wire	11 Gauge	10 [254]

* Adjust anchor selection to assure RECP is held in place securely.

B.5 Turf Reinforcement Mat

Provide Turf Reinforcement Mats (TRM) made of a three-dimensional matrix of synthetic material, continuously bonded at filament intersections meeting the requirements of Table 3885-6. Fill all Turf Reinforcement Mats (TRM) with soil.

Table 3885-6
Turf Reinforcement Mat Criteria

TRM Category	Minimum Permissible Shear Stress ‖, *lb/sq ft [Pa]*	Minimum Tensile Strength †, *lb/ft [kN/m]* ASTM-D 6818	Matrix Composition ‡
1	2.1 [100]	125 [1.82]	Nylon, Polypropylene, Polyolefin, or Polyester
*2	6 [288]	150 [2.19]	Nylon, Polypropylene, Polyolefin, or Polyester
*3	8 [384]	175 [2.55]	Nylon, Polypropylene, Polyolefin, or Polyester
*4	10 [480]	1370 [20]	Nylon Polypropylene, Polyolefin, or Polyester

* Provide mats with cells at least ⅜ - ¾ in [10-19 mm) in depth to allow soil filling and retention.
‖ ASTM D 6460-07 vegetated.
† Minimum Average Roll Value of either direction.
‡ Minimum thickness of ¼ in [6.4 mm), UV stability ASTM D4355 at 500 hours of 80 percent.

3885.3 SAMPLING AND TESTING

Approved products for this specification are on file on the MnDOT web page in the Materials Engineering Section.

3886 SILT FENCE

3886.1 SCOPE

Provide silt fence to retain sediment.

Provide Machine Sliced (MS) silt fence consisting of a woven geotextile fabric installed by machine and supported by steel posts.

Provide Hand Installed (HI) silt fence consisting of a woven geotextile fabric installed by hand and supported by steel posts.

Provide Super Duty (SD) silt fence consisting of concrete or water filled jersey barriers with fabric wrapped around the front face of the barrier. The Contractor may provide woven or non-woven geotextile fabric or poly/poly-reinforced sheeting.

Provide Pre-Assembled (PA) silt fence consisting of a woven geotextile fabric supported by wood posts pre-attached to the fabric.

Provide Turbidity Barrier (TB) silt fence consisting of a low permeable fabric barrier, installed in water and supported by steel cable and steel posts.

3886.2 REQUIREMENTS

Provide geotextiles for MS and HI silt fences from the Approved/Qualified Products List.

A Fabric

Provide fabric meeting the following requirements and characteristics:

(1) Uniform in texture,
(2) Uniform in appearance,
(3) Contains no defects, flaws, or tears affecting the physical properties,
(4) Contains UV inhibitors and stabilizers providing a minimum service life of at least 2 years during outdoor exposure, and
(5) Meets the requirements specified in Table 3886-1:

Table 3886-1
Silt Fence Requirements

Silt Fence Type	Width, *in [mm]*	Grab Tensile (machine direction), *lb [kg]**	Apparent Opening Size‖	Puncture Strength†	UV Stability, 500 h, *%* ‡	MAX Permittivity #	Flow Rates, *gpm/sq. ft [L/min/sq. m]*
MS, HI woven geotextile §	36 [915]	130 [59]	No. 30 sieve [0.60 mm]	—	70	1.0 s^{-1}	100 [4,073]
PA woven geotextile	36 [915]	100 [45]	No. 30 sieve [0..60 mm]	—	70	0.1 s^{-1}	5 [170]
SD woven or non-woven geotextile **	36 [915]	100 [45]	No. 30 sieve [0.60 mm]	—	70	—	—
TB polyester or polyvinyl Fabric	60 [1524]	200 [91]	—	90 lb [41 kg]	70	impervious	—

Values in table are Minimum Average Roll Values (MARV)
* ASTM D 4632
‖ ASTM D 4751 Maximum average roll value.
† ASTM D 4833
‡ ASTM D 4355
\# ASTM D 4491
§ Provide MS, HI woven geotextile with monofilament in both directions. Do not make substitutions.
** The Contractor may use poly/poly-reinforced sheeting with a thickness of at least 6 mil [0.152 mm] or an equivalent.

B Fasteners

Provide fasteners with a tensile strength of at least 50 lb [22 kg]. Use plastic zip ties to fasten geotextile to posts on MS, HI and TB applications. Use wire ties or plastic zip ties to fasten geotextile to anchor points on SD applications.

C Supports

Provide steel posts for MS, HI, and TB silt fence types in accordance with 3403, "Hot-Rolled Steel Fence Posts," and the following:

Table 3886-2
Steel Silt Fence Post Requirements

Characteristic	Requirement
Type	T-post
Weight	0.95 lb/ft [1.4 kg/m]
Length	≥ 5.0 ft [1.5 m]
Embedment	≥ 24 in [610 mm]
Post spacing	≤6.0 ft [1.8 m]

Provide wood posts for PA silt fence type meeting the following requirements:

Table 3886-3
Wooden Silt Fence Post Requirements

Characteristic	Requirement
Type	Hardwood
Size	≥ 2 in × 2 in [50 mm × 50 mm]
Length	≥ 4.0 ft [1.25 m]
Embedment	≥ 18 in [460 mm]
Post Spacing	< 5.0 ft [1.5 m]

D Portable Precast Concrete Jersey Barriers

For SD, use portable precast concrete barriers in accordance with 2533, "Portable Precast Concrete Barrier," for main support and strength. If placing the barrier adjacent to traffic, provide a barrier with a shape meeting the requirements of the standard plates design designation shown on the plans. The Contractor may use barriers meeting obsolete standard plate designs in non-traffic areas.

E Portable Water Filled Jersey Barriers

For SD, provide main support strength of at least 1,200 lb [544 kg] when filled with water. Provide a plastic, water-filled barrier. If placing the barrier adjacent to traffic, provide a barrier with a shape meeting the requirements of the standard plates design designation shown on the plans.

F Steel Cable

Provide a top line for TB made of a $^{5}/_{16}$ in [8 mm] galvanized steel cable with a breaking strength of at least 9,800 lb [40.0 kN].

3886.3 SAMPLING AND TESTING

Provide the following to the Engineer with each shipment of geotextile:

(1) A manufacturer's Certificate of Compliance, and
(2) Document stating the manufacturer's minimum average roll values (MARV) and maximum average roll values for the geotextile.

The Department defines MARV as two standard deviations below the mean value of the rolls tested.

3887 FLOTATION SILT CURTAIN

3887.1 SCOPE

Provide flotation silt curtain to contain suspended sediment and floating debris in open water.

3887.2 REQUIREMENTS

Provide floatation silt curtains meeting the following requirements and characteristics:

(1) Made of fabric fastened to a flotation carrier,
(2) Weighted along the bottom edge,

(3) Depth as shown on the plans and referring to the dimension of the curtain fabric extending below the flotation portion of the curtain, and
Table 3887-1, "Flotation Silt Curtain Requirements."

Table 3887-1
Flotation Silt Curtain Requirements

Characteristic	Type	
	Light Duty	**Heavy Duty**
Curtain fabric material type	Impermeable, vinyl-nylon laminate	Impermeable, vinyl-coated nylon
Weight *oz per sq. yd [kg per sq. m]*	18 [0.6]	0.22 [0.75]
Grab tensile strength, *lb [kN]**	300 [1.3]	500 [2.2]
Depth of curtain**	2 ft – 10 ft [0.6 m - 3 m]	2 ft – 10 ft [0.6 m - 3 m]
Flotation, *in [mm]*	6 [150] diameter marine quality expanded polystyrene	8 [200] diameter marine quality expanded polystyrene
Net buoyancy, *lb per ft [N per m]*	13 [200]	20 [300]
Top load carrying components	Fabric only	Fabric plus $^{5}/_{16}$ in [8 mm] galvanized steel cable at least 9,800 lb [40 kN] break strength
Ballast	≥0.7 lb per ft [1.0 kg per m] enclosed ¼ in [6 mm] galvanized chain	≥1.1 lb per ft [1.6 kg per m] enclosed $^{5}/_{16}$ in [8 mm] galvanized chain
Connection between sections	Laced grommets	Aluminum collar reinforced quick disconnects

* Minimum average roll value meeting the requirements of ASTM D 4632
** As required by the contract.

Remove the curtain upon completion of work. Do not allow re-suspension of sediment or loss of trash and oil into the water during the curtain removal.

3887.3 SAMPLING AND TESTING
Submit to the Engineer a manufacturer's Certificate of Compliance for the floatation silt curtain and components.

3888 POLY COVERINGS

3888.1 SCOPE
Provide poly coverings for temporary soil stabilization.

3888.2 REQUIREMENTS

A Poly Sheeting
Provide plastic sheeting meeting the following requirements;
- Minimum thickness of 6 mil (0.15 mm), and
- Reinforced Polyethylene sheeting, Woven Geotextile sheeting, or reinforced polyester tarps.

B Anchors
Provide Anchor system consisting of non-puncture type anchor weights or sand bags with cords or ropes of adequate strength to support the weights on the slope, new or used chain link fence, metal posts, rebar or wood stakes sufficient to keep plastic sheeting from lifting from soil surface, or riprap.

3890 COMPOST

3890.1 SCOPE
Provide compost material for soil amendment for landscape planting or turf establishment.

3890.2 REQUIREMENTS
Provide material from vendors listed on the Approved/Qualified Products List.

Provide compost meeting the US Composting Council Seal of Testing Assurance Program and requirements for animal or plant based feedstocks or the following

(1) Consists of a natural humus product derived from the aerobic decomposition of organic wastes.
(2) Considered mature and useable when 60 percent decomposition has been achieved as determined by an ignition-loss analysis test method and any one additional test method including the Solvita test value of equal to or greater than 5. This means that the compost product has no offensive smell, no identifiable organic materials, and will not reheat to more than 20 °F [11 °C] above the ambient temperature.
(3) Produced by a process to further reduce pathogens (PFRP) and weed seeds, and the process is verified by fecal coliform or *Salmonella sp*. tests, where applicable.
(4) Compost foreign particle restrictions up to 3 percent at 0.16 in [4 mm] apply to the shredded pieces from the plastic bags used to transport feedstocks to the composting facility, but will be considered acceptable if visible in the finished product.
(5) Meets the Minnesota Pollution Control Agency requirements for allowable levels of inherent contaminants (Minnesota Rules Chapter 7035.2836 subp. 6 Sec A), or the Code of Federal Regulations, Title 40, section 503.13(b)(3), amended for mercury.

Provide compost that is registered for sale with the State of Minnesota. Do not mix the compost with materials that do not comply with the Minnesota Rules Chapter 7045 (Hazardous Waste). Compost used in MnDOT transportation systems must not exceed 10 percent of the Minnesota Pollution Control Agency's Superfund residential soil cleanup guidelines, termed Soil Reference Values or SRVs (i.e. 10% of individual chemical or chemical mixture Hazard Index, Hazard Quotient, or acceptable cancer risk level). No chemical contaminant, including pesticides, can be present in concentrations that would result in toxic effects to soil organisms, plants, or animals that reside in or on the composted soil areas or use the treated area for food or shelter. At the time of delivery to the project, the compost shall be in a condition considered safe for exposure to dusts during handling.

A Grade 1 Compost

Provide Grade 1 compost for use in turf establishment meeting the following requirements and characteristics:

(1) Nutrient rich type,
(2) Derived from the decomposition of animal material,
(3) Texture similar to a highly organic soil, and
(4) Meeting the requirements of Table 3890-1.

Table 3890-1
Grade 1 Compost Requirements

Requirement	Range
Organic matter content	≥ 30%
C/N ratio	6:1 – 20:1
NPK ratios*	2:2:1 – 4:4:2
pH	5.5 – 8.0
Moisture content	35% – 55%
Bulk density	700 lb per cu. yd – 1,600 lb per cu. yd [415 kg per cu. m – 950 kg per cu. m]
Inert material	≤ 3% at 0.15 in [4 mm]
Soluble salts	≤ 10 mmho per cm
Germination test ‖	80% – 100%
Screened particle size	≤ ¾ in [19 mm]

* To obtain the nitrogen, phosphorus, or potassium levels specified, the compost may be fortified with commercial fertilizer.
‖ Germination test must list the species of Cress or lettuce seed used.

B Grade 2 Compost

Provide Grade 2 compost as a landscape planting medium and meeting the following requirements:

(1) Humus-rich type,
(2) Derived from the decomposition of leaves and yard wastes,
(3) Texture similar to a shredded peat, and
(4) Meeting the requirements of Table 3890-2:

Table 3890-2 Grade 2 Compost Requirements	
Requirement	**Range**
Organic matter content	≥ 30 %
C/N ratio	6:1 – 20:1
pH	5.5 – 8.5
Moisture content	35% – 55%
Bulk density	700 lb per cu. yd – 1,600 lb per cu. yd [415 kg per cu. m – 890 kg per cu. m]
Inert material *	< 3% at 0.15 in [4 mm]
Soluble salts	≤ 10 mmho per cm
Germination test ‖	80% – 100%
Screened particle size	≤ ¾ in [19 mm]
* Includes plastic bag shreds. ‖ Germination test must list the species of Cress or lettuce seed used.	

Do not use manure at any stage of decomposition.

C Grade 3 Compost

Provide Grade 3 as a blend of Grade 2 compost and no greater than 10 percent Grade 1 compost.

3890.3 SAMPLING AND TESTING

Before delivery of the compost to the project, submit to the Engineer certified test reports and a manufacturer's Certificates of Compliance.

If federal or state chemical specific requirements conflict, provide compost meeting the most stringent requirement.

3892 TEMPORARY SLOPE DRAIN

3892.1 SCOPE

Provide material for temporary slope drains to intercept, direct, and convey surface runoff or ground water down an embankment to control erosion.

3892.2 REQUIREMENTS

A General

Provide temporary slope drains consisting of the following:

(1) Non-perforated, corrugated polyethylene pipe (HDPE) meeting the requirements of AASHTO M 252,
(2) Corrugated metal pipe, or
(3) Heavy duty flexible tubing.

Provide each slope drain with the same diameter pipe over the entire length of the drain. Size temporary slope drains in accordance with Table 3892-1.

Table 3892-1 Slope Drain Sizing	
Drainage Area, *acres [ha]*	**Pipe Diameter, *in [mm]***
0–0.5 [0–0.2]	12 [300]
> 0.5–1.5 [0.2–0.61]	18 [450]
> 1.5–2.5 [0.61–1.01]	21 [525]
> 2.5–3.5 [1.01–1.42]	24 [600]
> 3.5–5.0 [1.42–2.02]	30 [750]

Place slope drain in conjunction with diversion mounds or dykes.

B End sections

B.1 Inlet end

Use a watertight connection to attach the flared end section to the inlet end of pipe. Construct dikes to direct storm water runoff into the temporary slope drains. Construct the top of the earth dike over the inlet pipe and the tops of dikes carrying water to the pipe least 1 ft [0.3 m] higher than the top of the inlet pipe.

B.2 Outlet end

For a pipe slope drain with an outlet into a sediment trapping device, construct the discharge at the riser crest or weir elevation. Use a riprap apron or energy dissipation devise below the pipe outlet for discharging clean water into a stabilized area.

C Joints

Use watertight connecting bands to connect pipe sections.

D Anchors

Anchor the slope drain with stakes in accordance with the following characteristics and requirements:

(1) Nominal 2 in × 2 in [50 mm × 50 mm] cross-section,
(2) At least 3 ft [1 m] long,
(3) Pointed end, and
(4) Spacing between the stake installations no greater than 8 ft [2.5 m].

E Bedding

Hand tamp the soil around and under the entrance section in 4 in [100 mm] layers to the top of the earth dike to prevent piping failure around the inlet.

3892.3 SAMPLING AND TESTING

The Engineer will visually inspect temporary slope drains.

3893 SANDBAGS

3893.1 SCOPE

Provide material for sandbags to dike-off construction areas or serve as temporary erosion control installations.

3893.2 REQUIREMENTS

Use sandbags consisting of a woven polypropylene fabric sewn together with double stitching. Provide polypropylene fabric in accordance with Table 3893-1:

Table 3893-1
Polypropylene Fabric Properties

Property	Test	Minimum Tolerance
Grab Tensile Strength	ASTM D 4632	420 N
UV Stability	ASTM D 4355	70%

Provide sandbags with an overall size of at least 14 in × 26 in [350 mm × 650 mm].

3893.3 SAMPLING AND TESTING — (BLANK)

3896 SOIL AND ROOT ADDITIVES

3896.1 SCOPE

Provide soil and root additives to improve soil or root stock to stimulate growth, and improve the health of plant stock or seed.

3896.2 REQUIREMENTS

Provide soil and root additives registered and approved for sale in Minnesota by the Department of Agriculture (MDA), listed on the Approved/Qualified Products List by the Department's Erosion and Stormwater Management Unit, and meeting the following requirements as required by the contract:

A Plant Hormones

Provide rooting hormone powder or liquid to stimulate rooting of plant cuttings, bare root stock, and perennial plant material. The material shall contain known root hormones including any of the following:

(1) Indole-3-butyric acid (IBA),
(2) Indole acetic acid (IAA), or
(3) Cytokinins.

Provide powder that does not contain inert ingredients that are harmful to the environment.

B Hydrophilic Polymers

Provide super-absorbent polymer or hydrophilic compound meeting the following requirements and characteristics:

(1) Organic,
(2) Made of fully biodegradable cross-linked polymer or other hydroscopic compound with water-binding groups,
(3) Minimum life span of at least 60 days in the soil.
(4) Consists of the following:
  (4.1) Potassium polyacrylate/polyacrylamide copolymer,
  (4.2) Sugar alcohols,
  (4.3) Polysaccharides,
  (4.4) Humates, and
  (4.5) Alpha-hydroxypropionic acid or other documented hydrophilic compound.

Apply the hydrophilic polymers at the rate recommended by the manufacturer.

C Mycorrhizal Inoculum

Provide mychorrhizal inoculum meeting the following requirements and characteristics:

(1) Contains microorganisms symbiotic with and beneficial to plant roots;
(2) Capable of being applied to the soil or base of a plant as a liquid, powder, or pellet; and
(3) Contains defined live spore count.

When known, use Minnesota origin materials. Apply the mycorrhizal inoculum as recommended by the manufacturer for new plantings. Provide a mycorrhizal inoculum that does not contain antagonistic pathogens or at trace levels as defined by the MDA.

C.1 Type 1

Type 1 is for use with native grass plantings. Provide species of Endomycorrhizal fungi containing at least 3 species of glumos fungi. Additional species of *Gigaspora, Scutellospora, Entrophospora, Acaulospora*, or *Sclerocystis* may also be present. Ectomycorrhizal species of *Pisolithus* or *Rhizopogon* can also be present.

C.2 Type 2

Type 2 is for use with plant stock, such as shrubs, trees etc. Provide species of ectomycorrhizal fungi containing species of Rhizopogon fungi and other cold tolerant species.

D Iron Sulfate

Provide ferric sulfate or ferrous sulfate in pellet or granular form containing at least 18.5 percent iron expressed as metallic iron to lower pH. The Engineer will accept the product based on information contained on its label.

E Activated Charcoal

Provide activated charcoal to neutralize or deactivate residual organic pesticide or chemical contaminants in the soil meeting the following requirements:

(1) Finely ground to increase absorptive surfaces, and
(2) Electrically charged to attract the molecules of organic chemicals.

F Rhizobium Innoculum

Provide rhizobium inoculum as a delivery system of living organisms to address atmospheric nitrogen when part of native and non-native legume plant roots and meeting the following characteristics and requirements:

(1) Sterilized carbon based carrier (lignite/charcoal, peat, or compost) of legume specific rhizobium strains;
(2) Capable of being applied with a sticking agent to legume seeds or broadcast during seeding and some fertilizing operations;
(3) Within 1 pH unit of neutral;
(4) Particles size based on manufacturer recommended application and installation method;
(5) Low level of measurable contaminates based on Pikovskave, SS Malate Medium; and
(6) Capable of maintaining appropriate moisture and air content for living nitrogen fixing organisms.

Store rhizobium inoculum at temperatures from 40 °F to 77 °F [4 °C to 25 °C] and away from direct sunlight. Use the rhizobium inoculum per the manufacturer's recommendations. Do not use pesticides, some seed treatments, and typical chloride-based fertilizers.

Provide non-native legume rhizobium inoculum for clovers and alfalfa crop species on lignite or charcoal carriers.

Provide native legume seed rhizobium inoculum for seeds of native legumes of Amorpha, Astragalus, Chamaecrista, Dalea, Desmodium, and Lespedeza species seed-applied on peat or compost carrier.

Provide native legume-broadcast rhizobium inoculum for native legumes of Amorpha, Astragalus, Chamaecrista, Dalea, Desmodium, and Lespedeza species broadcast on a peat or clay carrier in a pelletized form.

G Compost Tea

Provide commercially produced compost tea produced from compost in accordance with 3890 and containing the following biological organisms based on certified test results:

(1) Active bacteria: At least 15 µg per gram of compost,
(2) Total bacteria: At least 150 µg per gram of compost,
(3) Active fungi: At least 15 µg per gram of compost,
(4) Total fungi: At least 150 µg per gram of compost,
(5) Average fungal hyphal diameter: At least ⅛ in [3.5 mm],
(6) Individual fungal hyphal diameter: At least $^{3}/_{32}$ in [2.5 mm],
(7) The following types of protozoa:
  (7.1) At least 8,000 flagellates per gram of compost,
  (7.2) At least 8,000 amoebae per gram of compost, and
  (7.3) Zero ciliates per gram of compost.

Aerobic nematodes are acceptable if present.

Anaerobic root nematodes or nematode feeding nematodes are not acceptable.

The Contractor may choose to modify the Compost Tea by one of the two following methods:

G.1 Bacteria-Dominated Compost Tea

Provide bacteria-dominated compost tea consisting of the following:

(1) High-nitrogen feedstocks, and
(2) Green materials including the following:
  (2.1) Manure,
  (2.2) Grass clippings,
  (2.3) Legumes including alfalfa, peas, clover, and bean plant residues,
  (2.4) Additional green feedstock materials containing sugars and proteins may include any green plant debris, plant based food scraps, and coffee grounds.

Use bacteria-dominated compost tea as a foliar spray for herbaceous plants and turf grass to prevent foliar diseases.

G.2 Fungi-Dominated Compost Tea

Provide fungi-dominated compost tea consisting of the following:

(1) Animal manure,
(2) Green plant material, and
(3) Shredded wood material including the following:
  (3.1) Wood chips,
  (3.2) Saw dust, and
  (3.3) Paper products.

Use fungi-dominated compost tea to suppress woody plant diseases and to introduce beneficial fungi for root development immediately after tree planting.

H (Blank)

3896.3 SAMPLING AND TESTING — (BLANK)

3897 SEDIMENT CONTROL LOG

3897.1 SCOPE

Provide sediment control logs for slowing water velocities, filtering sediment, and diverting storm water runoff.

3897.2 REQUIREMENTS

A Straw

Provide straw logs meeting the following requirements and characteristics:

(1) Type 3 mulch in accordance to 3882, "Mulch Material",
(2) Encased in photodegradable synthetic or natural netting with a service life from 6 months to 9 months and with openings ½ in × ½ in [13 mm × 13 mm],
(3) Diameter from 8 in to 9 in [200 mm to 225 mm],
(4) Consisting of at least 80 percent of the fiber material at least 3 in [150 mm] long, and
(5) Dry weight of 2 lbs to4 lbs. per cu. ft [32 kg per cu. m]

B Wood Fiber

Provide wood fiber logs with the following requirements and characteristics:

(1) Excelsior wood fibers,
(2) Encased in a photodegradable synthetic or natural netting with a service life from 6 to 9 months and with openings ½ in × ½ in [13 mm × 13 mm],
(3) Diameter from 6 in to 9 in [150 mm to 175 mm],
(4) Consisting of at least 80 percent of the fiber material at least 6 in [150 mm] long, and
(5) Dry weight from 1.4 lb per cu. ft to 5.7 lb per cu. ft [22 kg per cu. m to 58 kg per cu. m]

C Blank

D Wood Chip

Provide wood chip logs meeting the following:

(1) Type 6 mulch in accordance to 3882, "Mulch Material"
(2) Encased in a photodegradable synthetic or natural fiber casing with 1/8 to 3/8 [3- 10 mm] openings with a service life from 12 months to 24 months, and
(3) Diameter of 8 in to 10 in [200 mm to 250 mm].

E Compost

Provide compost logs meeting the following characteristics and requirements:

(1) Consisting of the following blend of compost and partially decomposed wood chips;
  (a) From 30 percent to 40 percent, Grade 2 compost in accordance with 3890, "Compost" with at least 70 percent compost retained on the ⅜ in [10 mm] sieve,
  (b) From 60 percent to 70 percent, partially decomposed Type 6 mulch in accordance to 3882, "Mulch Material",
(2) Encased in photodegradable synthetic woven or natural fiber casing with 1/8 to 3/8 [3 mm to 9 mm] openings, with a service life from 12 to24 months, and
(3) Diameter of 7 in to 9 in [180 mm to 230 mm].

F Rock

Provide rock logs meeting the following requirements and characteristics:

(1) Washed, 3/4 in to 1 ½ in [2 mm to 4 mm], Class A, B, C, or D rock in accordance with 3137 "Coarse Aggregate for Portland Cement Concrete",
(2) Encased in a geotextile material with a minimum grab tensile strength of 130 lbf [575 N] ASTM D6818 and a minimum Mullen Burst Strength of 175 psi [1,200 kPa], and
(3) Diameter from 4 in to 6 in [100 mm to 150 mm].

G Coir

Provide coir logs meeting the following requirements and characteristics:

(1) Coir fibers placed in coir netting,
(2) service life of at least 5 years,
(3) Diameter of at least 8 in, and
(4) Dry weight of at least 5 lb per cu. ft [7.5 kg per cu. m]

H Wood Fiber and Blanket

Provide Wood fiber log placed on top of an Erosion Control Blanket meeting the following requirements;
(1) Meet requirements of 3897.2B, wood fiber log ,

(2) Meet Requirements of 3885.2 Category 3B, erosion control blanket, minimum blanket roll width of 6 feet (1.8 m) , and
(3) Blanket staple pattern every 1 ft [300 mm]

I Anchoring

Provide wood stakes for A, B, D, and G with the following dimensions; 1 in × 2 in [25 mm × 50 mm] and 22 in – 24 in [550 mm – 600 mm] long with a pointed end.

3897.3 SAMPLING AND TESTING

Provide samples and sample sizes meeting the Schedule of Materials Control.

3898 FLOCCULANTS

3898.1 SCOPE

Provide naturally derived additives for coagulating dispersed clays, and reducing turbidity in storm water runoff and use flocculants as part of a designed storm water treatment system.

3898.2 REQUIREMENTS

Use environmentally benign flocculants that are biodegradable and consist of natural origin biopolymers to improve water quality and protect aquatic biota.

Use flocculants meeting the following requirements detailed by each type.

A Liquid Flocculant

Store the flocculant in a concentrated liquid state. Ensure the manufacture's label is affixed to the container and lists the percent of concentration in the container and the application dose rate. Obtain the Engineer's verification of the dose rate calculations before applying to the treatment system.

B Flocculant Sock

Use flocculant in a gelatin-like state, packaged in individual compartments of the encasing sock material. Ensure the encasing material allows water to flow through it so the water comes in contact with the gelatin-like flocculant material.

Use a Flocculant Sock with attachment anchor cords or grommets for use in pipes, sediment control filter systems, and ditch bottoms.

Provide a Flocculant Sock capable of treating at least 250,000 gal [945 cu. m] of the water flowing through it.

C Granular Flocculant

Store the flocculant in a granulated state. Ensure the manufacture's label is affixed to the bag or container and states the purity of the product and the application mixing rate. Obtain the Engineer's verification of the dose rate calculations before applying the treatment system.

3898.3 SAMPLING AND TESTING

Before delivery and use on the project, submit to the Engineer a Certificate of Compliance and MSDS for approval.

Miscellaneous Materials

3902 FORM COATING MATERIAL

3902.1 SCOPE
Provide form coating material that will prevent bonding between a form, dowel, or other object and concrete.

3902.2 REQUIREMENTS
Provide form coating material listed on the Approved/Qualified Products List and meeting the following requirements:

(1) Made of a chemical release agent that does not contain ordinary lubrication oil, conventional form oil, fuel oil, or kerosene, and has a flash point of at least 149 °F [65 °C] when tested in accordance with ASTM D 92;
(2) Prevents bonding to concrete;
(3) Does not penetrate, stain, or leave a residual film on the concrete surface; and
(4) Does not attract dirt or other deleterious matter.

Apply the form coating material at a rate recommended by the manufacturer to provide a smooth surface free of dusting action caused by reactions of the chemical release agent.

As a substitute for a form coating material listed on the Approved/Qualified Products List, the Contractor may provide epoxy coated dowel bars utilized in dowel bar baskets and dowel bar retrofits (DBR) coated with a factory applied, Department-approved petroleum, paraffin based lubricant with a manufacturer stated use as a bond breaker.

3902.3 SAMPLING AND TESTING — (BLANK)

3906 WATER FOR CONCRETE AND MORTAR

3906.1 SCOPE
Provide water for use in mixing and curing portland cement concrete and mortar.

3906.2 REQUIREMENTS
Provide water approved by the Engineer and meeting the following requirements for mortar or concrete:

(1) Not salty or brackish
(2) Clean, and
(3) Free of injurious quantities of deleterious substances such as oil, acid, alkali, and organic matter.

The Engineer will allow potable water without testing.

The Engineer may conduct testing to determine allowable use of a Contractor proposed water source. The Engineer will reject the water, if any of the test results in accordance with AASHTO T 26 show the following:

(1) Unsoundness
(2) Change in time of setting greater than 1 h earlier or greater than 1½ h later, or
(3) A reduction of greater than 10 percent in the 7-day mortar strength.

Before using clarified wash water for concrete and mortar, submit a request to the Engineer for review and approval by the Concrete Engineer.

3906.3 SAMPLING AND TESTING
Provide representative samples of water in clean containers to the Engineer for testing as required by the Schedule of Materials Control.

3910 ROCK SALT

3910.1 SCOPE
Provide rock salt for use as a deicer for road construction and maintenance purposes.

3910.2 REQUIREMENTS
Provide rock salt meeting the following requirements at the time of delivery:

(1) ASTM D 632 for Type 1, Grade 1 material;

(2) Free of lumps, aggregations, and foreign matter; and
(3) With no greater than 1.5 percent moisture content.

3910.3 SAMPLING AND TESTING

The Engineer may sample and inspect the rock salt at the supplier's unloading and storage facilities or at the point of delivery.

The Engineer, in conjunction with the Materials Engineer, will perform the following:

(1) Sampling meeting the requirements of ASTM D 632, as modified by the Laboratory Manual;
(2) Moisture testing in accordance with the Laboratory Manual;
(3) Sieve analysis meeting the requirements of ASTM C 136 for Sieve Analysis of Fine and Coarse Aggregate, as modified by the Laboratory Manual; and
(4) Chemical analysis for determination of sodium chloride content meeting the requirements of the Rapid Test Method for Sodium Chloride by Silver Nitrate Potentiometric Titration or the Reference Method for Chemical Analysis of Sodium Chloride as modified by the Laboratory Manual.

3911 CALCIUM CHLORIDE

3911.1 SCOPE

Provide liquid and solid calcium chloride for use in dust control, accelerating the hardening of concrete, and other purposes.

3911.2 REQUIREMENTS

Provide liquid or solid calcium meeting the requirements of AASHTO M 144 for the type and grade required by the contract. Unless the contract requires otherwise, provide liquid calcium chloride with at least 38 percent anhydrous $CaCl_2$ by weight. Provide liquid calcium chloride that is clear and free of solid matter.

3911.3 SAMPLING AND TESTING

Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

Perform sampling in accordance with ASTM D 345.

The Materials Engineer will perform tests meeting the requirements of ASTM D 345.

3912 MAGNESIUM CHLORIDE SOLUTION

3912.1 SCOPE

Provide magnesium chloride solution for dust control or other purposes.

3912.2 REQUIREMENTS

Provide magnesium chloride solution meeting the following characteristics and requirements:

(1) Water clear,
(2) Free of deleterious substances,
(3) Consists primarily of magnesium chloride,
(4) Anhydrous magnesium chloride content of at least 28 percent by mass,
(5) SO_4 sulfate content no greater than 3.5 percent by mass, and
(6) Alkali chlorides content no greater than 5 percent by mass.

3912.3 SAMPLING AND TESTING

A Sampling

Provide samples at rates and sizes meeting the requirements of the Schedule of Materials Control or as required by the contract.

B Testing

The Materials Engineer will perform testing meeting the following requirements:

B.1 Magnesium chloride, $MgCl_2$ ..... Laboratory Manual

B.2 Sulfate, SO_4 ..... Laboratory Manual

B.3 Alkali chlorides, as NaCl ..... ASTM E 449

Traffic Management Center

3973 BURIED CABLE SIGNS

3973.1 SCOPE

Provide buried cable signs to mark the route of underground fiber optic cables.

3973.2 REQUIREMENTS

A Buried Cable Sign

Install aluminum signs meeting the following requirements and characteristics:

(1) In accordance with 3352, "Signs, Delineators, and Markers," and 2564, "Traffic Signs and Devices;"
(2) Meeting the requirements of Standard Signs Manual;
(3) 8 in × 12 in [200 mm × 300 mm]; and
(4) Black legend on a non-reflective orange face.

Before purchasing the buried cable signs, obtain the Engineer's approval of the sign design.

Install the ground mounted signs to 2.6 lb per ft [3.8 kg per m] galvanized steel fence posts in accordance with 3401, "Flanged Channel Sign Post." If installing the signal mounted signs to the Ramp Control Signal, use stainless steel bands and fittings.

B Legend and Logo Size

Provide an 8 in × 12 in [200 mm × 300 mm] aluminum buried cable sign with black legend silk screened on an orange face meeting the requirements of the Standard Signs Manual and the following:

Table 3973-1
Buried Cable Sign Legend

Line Number	Line Text	Character Size and Color, *in [mm]*	Background Size and Color, *in [mm]*
1	CAUTION	1.1875 [30], orange	1.5 × 7 [50 × 180], black*
2	BURIED	0.9375 [24], black	—
3	FIBER OPTIC	0.9375 [24], black	—
4	CABLE	0.9375 [24], black	—
5	BEFORE DIGGING	0.65625 [17], black	—
6	CALL	0.65625 [17], black	—
7	GOPHER STATE ONE CALL	0.5 [13], black	—
8	811	0.90625 [23], black	—
9	MnDOT LOGO‖	—	—

* Center the information on the background
‖ The MnDOT logo is a circle with a diameter of 1.03125 in [26 mm] and the phrase "MINNESOTA DEPARTMENT OF TRANSPORTATION" in black letters in the margin with an orange background. The left half of the logo inside the margin has an orange silhouette of the left one half of a coniferous tree on a black foreground. The right half of the logo inside the margin has an orange five point star silhouette inside a black foreground.

C Sign Placement

Place the signs no greater than 500 ft [150 m] apart, and at each change of direction, along the route of direct buried fiber optic cable.

3973.3 SAMPLING AND TESTING 2550

END