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Structural Metals

2471.1 DESCRIPTION

This work consists of manufacturing, fabrication, and coating structural metals.

2471.2 MATERIALS

The Fabricator shall give the Engineer a copy of all purchase orders and certified mill test reports. Copies of purchase orders shall be furnished at the time orders are placed. Certified mill test reports shall be furnished prior to the start of fabrication of material.

Mill test reports shall show the required chemical analysis and physical test results for each heat of steel used in the work. Where domestic material is required, mill test reports shall show that material was melted and manufactured in the U.S.A. If there is insufficient information on the mill test report, necessary test results shall be provided before material is accepted.

All materials used in this work shall be new and shall conform to the referenced Specification as listed below. Unless otherwise specified in the Contract, structural steel to be used in bridges shall be 3309 and structural steel for all other structures shall be 3306.

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2471.3 FABRICATION REQUIREMENTS

A General

Engineer as used herein shall mean the Department's Bridge Construction and Maintenance Engineer unless otherwise indicated.

Fabricator shall mean the manufacturer or supplier to the Contractor of fabricated structural metals. In the event fabrication work is done by the Contractor, the term shall also mean the Contractor or the Contractor's agent.

The requirements contained herein will not be waived, nor shall they be modified to conform to any set of rules that any Fabricator has adopted as its standard, unless so authorized in writing by the Engineer.

For the fabrication of rolled beam bridges having a pay quantity for structural steel of less than 136 000 kg (**300,000 pounds**), pedestrian bridges, modular expansion joints, overhead signs, pot bearings, or steel diaphragms having a pay quantity of more than 1500 m (**5,000 feet**), the Fabricator shall be certified under AISC Quality Certification Program Category, Simple Steel Bridge Structures (Sbr).

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For the fabrication of rolled beam bridges having a pay quantity for structural steel of 136 000 kg (**300,000 pounds**) or greater and for the fabrication of welded girders, tubs, boxes, trusses or any other items designated by the Engineer, the Fabricator shall be certified under AISC Quality Certification Program Category, Major Steel Bridges (Cbr).

If Simple Steel Bridge Structures (Sbr) or Major Steel Bridges (Cbr) certification is specified and painting is performed at the fabrication shop, the Fabricator shall be certified under the Sophisticated Paint System Endorsment (P) Category of the AISC Quality Certification Program.

For each separate Project, the Contractor shall furnish the Engineer with a complete list showing the names and addresses of all Fabricators and the items to be supplied.

The ordering of materials or performance of shop work prior to the Engineer's final approval of shop drawings shall be at the Fabricator's risk.

When fabricated components will be installed on a previously constructed structure, the Contractor shall measure field dimensions as specified in 2433.3A3.

B Shop Detail Drawings

B1 General Requirements

Shop detail drawings shall consist of detailed plans showing the dimensions and sizes of materials, such other details and information as may be necessary for fabrication, bolt lists for shop and field erection, blocking and camber diagrams, a match marking diagram, a radiographic diagram showing weld locations and identification in accordance with 2471.3C3, and a complete field erection plan showing piece marks. Welding symbols shall conform with ANSI/AWS A2.4 standard symbols for welding, brazing, and nondestructive examination.

The Fabricator shall place weld procedure specification numbers in the tail of the arrow.

The Fabricator shall furnish shop detail drawings for the complete fabrication of all structural metals required by the Contract. When it is specified in the Contract that the Department will furnish standard detail drawings, the Fabricator shall make additions and revisions to the detail drawings as necessary to produce a finished shop detail drawing.

Shop drawings shall note all dimensions measured in the field.

When reference is made in the Contract to a "Standard Plate" the Fabricator will not be required to re-detail these plates except for the purpose of indication of fit at connections to other structural members, or for changes required by the Plan, or for the purpose of complete detailed information to the shop or the material supplier.

B2 Format

Shop detail drawings shall be prepared in a neat and legible form on media from which clear, sharply defined prints can be made for the Engineer's approval and inspection purposes.

The size of the sheets for the drawings shall be 559 mm (**22 inches**) wide by 864 mm (**34 inches**) long with a 13 mm (**1/2 inch**) border on all edges except the left 559 mm (**22 inch**) edge shall have a 50 mm (**2 inch**) border. Each sheet shall have a title in the lower right corner giving the Department's structure number, Project number, the Federal Project number when applicable, the Fabricator's name, the Fabricator's Contract number, the detailer's and checker's initials, the date of preparation, and a brief description of the details shown on each sheet. The height of letters and numerals on the drawing shall be not less than 3.5 mm (**0.14 inch**). The text, details, lines, and dimensions shall be of such quality that when they are reduced to 280 by 432 mm (**11 x 17 inch**) size or when they are projected in full enlargement of microfilm (that has been reduced in ratio of 24 to 1) they will be clearly readable. Bolt lists may be furnished on the Fabricator's own standard sheets.

Each detail sheet shall have a complete bill of material that lists the individual pieces with piece marks and quantities. All material shown and billed on a detail sheet shall be completely detailed and dimensioned on that sheet.

Detail shop drawings for materials furnished by each supplier shall have consecutive sheet numbers. The first drawing of the shop details shall contain a schedule of sheet numbers, including a brief description, for reference purposes.

B3 Submittal for Engineer's Review and Approval

The Fabricator shall submit prints of all required shop detail drawings to the Engineer for review and approval, and any details at variance with the Plans shall be set forth in writing directed to the Engineer's attention. The Fabricator shall deliver two sets of prints to the Engineer for review. One of these sets will be returned bearing the Engineer's comments.

Only checked drawings in complete collated sets shall be submitted for approval; however, details such as ice-breakers, anchorages, bearing plates, and castings, may be submitted separately to avoid delay in construction.

The Engineer may require the Fabricator to furnish a schedule showing dates the shop drawings will be sent for approval. The schedule shall be arranged to avoid delay in completing the work. Where the structure is composed of several units, consideration must be given for completing the detail drawings for the separate units in proper order to expedite the checking and final approval of the details. This

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notice shall also contain information relating to the anticipated dates for shop fabrication.

When changes on submitted drawings are requested by the Engineer, or when the Fabricator makes additional changes, other than those requested, attention shall be called to the changes on the revised prints submitted for approval by encircling, underscoring, or otherwise marking all changes to clearly distinguish them from unchanged details or dimensions.

After all corrections have been made on the shop detail drawings, they will receive approval. The Fabricator shall, without direct compensation therefor, furnish to the Engineer six sets of prints of the corrected drawings and such additional prints as may be required by the Contract or requested by the Engineer. The shop drawings as approved by the Engineer shall become part of the Contract. No changes shall be made in any approved drawing without the written authorization of the Engineer.

The Engineer's approval of shop drawings will not relieve the Contractor of full responsibility for the submission of complete and accurate shop drawings and for the accurate assembly and fitting of all structural members.

B4 Submittal for Completed Work

After all shop work has been completed, the Fabricator shall deliver to the Department detailed shop drawings in the form of permanent reproducible duplicate tracings. These tracings shall include all approved shop drawings with the exception of components shown on Standard Plates or Standard Details where the drawings showing such components are not part of a sequential submittal. The tracings shall accurately reflect the actual configuration of all structural members and components including modifications after delivery to the Project made under the Fabricator's direction.

Any alterations or corrections made on copies that are submitted to the Department shall be made with waterproof drawing ink.

Translucent tracings, intermediate media or duplicates used for making reproductions shall be free of dirt, opaqueness, "graying in," unnecessary lines, watermarks, folds, or any other property that might impair the transparency. They shall be suitable for making copies on standard reproduction equipment. All duplicate reproducible shall be photographic silver halide fixed line positives or archival-quality xerographic positives on polyester base with matte drafting surfaces on both sides. Either option must have a distortion accuracy of plus or minus 1 percent. The minimum line density shall be 1.3 on a standard 18-percent gray card. Opaquing of the optional intermediate negatives and bleaching of the final reproducible may be required to obtain reproducible of microfilm quality. The film base shall be 76 to 102 μm (**0.003 to 0.004 inch**) in thickness. The sheet size shall be 280 by

432 mm (**11 x 17 inches**). For railroad bridges, two sets will be required, one of which shall be 280 by 432 mm (**11 x 17 inches**) and the other shall be sized as required by the railroad.

All material and solutions used for making duplicates shall be fresh stock that has not deteriorated or aged beyond the manufacturer's recommended processing life period.

C General Shop Practice

General shop practices, structural fabrication, welding, and assembly shall be governed by ANSI/AASHTO/AWS (1996) D1.5 Bridge Welding Code for Major Structural Components and/or ANSI/AWS (1998) D1.1 Structural Welding Code for Minor Structural Components, except as modified by this Specification. Work quality and finish shall be equal to that which can be produced by skilled workers using modern tools in a modern structural shop.

Prior to fabrication, the Fabricator shall supply a quality control plan that must be acceptable to the Engineer. The quality control plan shall describe in detail the methods, equipment, Non Destructive Testing (NDT), and frequency of testing used to ensure that requirements of this Specification are met. If the Engineer determines that fabrication work is not being monitored according to the quality control plan or that approved fabrication procedures are not being followed, the Fabricator shall immediately correct the procedure, conduct additional tests, and submit written reports containing all data the Engineer requires to ensure compliance with the quality control plan. All costs of required additional testing shall be at no cost to the Department.

The Fabricator shall submit fabrication progress reports on forms approved by the Engineer at the end of each month.

C1 Prefabrication Conference

Prior to starting fabrication the Engineer may schedule a conference with the Fabricator to discuss pertinent Specifications, procedures, and requirements of the job. The Engineer will, in consultation with the Fabricator, decide the location, date, and agenda items for this conference.

C2 Identification of Materials

Before fabrication begins, the Fabricator shall furnish certified test reports or other documentation satisfactory to the Engineer indicating that materials meet physical and chemical requirements of these Specifications. If the Engineer determines that documentation is incomplete for some or all of the materials to be used, the Fabricator shall sample and test materials as directed by the Engineer and all work shall be done at no cost to the Department. When requested by the Engineer, the Fabricator shall furnish scale weights of individual members or sections.

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During each stage of fabrication, the Fabricator shall provide and maintain identification sufficient to establish the heat of material from which any component is fabricated. Material that loses its identity shall be rejected unless identity can be reestablished to the satisfaction of the Engineer. Identifying and re-establishing the identity of such material shall be at no cost to the Department.

The Fabricator shall maintain a list that shows heat numbers referenced to the material incorporated into each component. The Fabricator shall furnish a copy of this list to the Engineer.

Wide flange beams, flanges, webs, splice plates, welded cover plates, and fracture critical members shall have identification numbers placed on each individual piece of material. Identification numbers shall be referenced to the corresponding heat number.

Identification coding of material shall be done using non-oil-based markers or low stress die stamps.

C3 Weld Identification System

For purposes of identifying welds subject to radiographic and/or ultrasonic testing, the fabricator must use the Mn/DOT standard weld identification system (as identified in section C3a) or an alternate system approved by the Engineer prior to implementation. The traceability system shall have a unique identification assigned to all welds being examined, and shall not be repeated. The identification number shall be documented on the shop detail drawings and shall be traceable back to the original member examined.

C3a Standard Weld Identification System

(1) Piece Mark

The fabricators piece identification from the approved shop detail drawings.

(2) Splice Plane Number

For purposes of this document a splice plane is defined as a 1 m (**3 foot**) wide vertical section of a piece that contains a full penetration welded splice in any component of the piece. Any other full penetration welded splice in any component of the piece within the 1 m (**3 foot**) vertical splice plane is in the same splice plane.

The number of the splice plane on the piece starting from the left end of the piece is shown on the radiographic diagram.

(3) Piece Components Code

- 1 Bottom Flange
- 2 Web - single web or near side (NS) web if there are two webs
- 3 Top Flange - single top flange or NS flange if there are two flanges
- 4 Web - far side (FS) web if there are two webs

5 Top Flange - FS flange if there are two flanges

Film identification numbers/location marks (only on film) - per AWS D1.5. Start from NS edge for flanges and bottom edge for webs.

(4) General Notes

All radiographic and ultrasonic testing of welds shall be done in accordance with AWS D1.5 except as modified by these notes.

The center line of the weld shall be established on the components of the piece before welding by placing punch marks 300 mm (**1 foot**) back from the center line of the weld and 25 mm (**1 inch**) from the edge of the plate.

Image Quality Indicators (wire penetrameters) may required as directed by the Engineer.

For joints that are radiographically inspected less than 100%, the untested areas shall be included in the Film Identification Number scheme.

C4 Storage of Materials

Material shall be stored above ground on platforms, skids, or other supports. Material shall be protected from dirt, oil and other foreign matter and shall be properly drained. Material that has been damaged shall be replaced with new material or shall be repaired to the satisfaction of the Engineer.

D Structural Components

D1 Definitions

D1a Minor Structural Components

Minor structural components shall mean 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), piles and appurtenances, drainage systems, guardrail connections, railings, fencing, conduit systems, and protection angles.
- (2) Electric lighting, traffic signs, and signal systems.
- (3) Pedestrian Bridges.
- (4) Any other system or component that is designated by the Engineer as a minor structural component.

D1b Major Structural Components

Major structural components shall mean all components other than minor structural components.

D2 Welded Stud Shear Connectors

Stud shear connectors on the top flange may be welded in the fabrication shop only if approved in writing by the Project Engineer. If

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shop welded, shop detail drawings shall include notations for stud shear connectors. Shear studs shall not be welded on splice plates.

Studs that do not show a full 360 degree flash shall be repaired or replaced. The placement of studs shall not vary from the location shown in the drawings.

D3 End Connection Angles

The finishing of end connection angles is not required except to correct a faulty assembly. The thickness of the finished angle shall not be less than 10 mm (**3/8 inch**) and original thickness shall not be reduced by more than 3 mm (**1/8 inch**). Portions of members extending beyond the face of the connection angles shall be ground flush. No portion of a web of a connecting member shall be recessed more than 10 mm (**3/8 inch**) from the face of the connection angles.

D4 Bolts

All bolts shall be High Strength Structural Steel Bolts except that common Structural Steel Bolts may be used for connections in expansion and deflection devices and in hand railings. Structural bolts shall project through the nut not less than 3 mm (**1/8 inch**) nor more than 10 mm (**3/8 inch**).

Extra bolts shall be furnished without direct compensation in the amount of five bolts plus 5 percent of the actual number of field bolts required.

D5 Pins and Rollers

Pin and roller finish shall be 1.6 μm (**75 micro inch**).

Pin threads shall conform to American Standard Coarse Thread Series Class 2, free fit as specified in ANSI B1.1. Pin ends and nuts having a diameter of 35 mm (**1-3/8 inches**) or more shall be threaded 6 threads per 25 mm (**inch**). The nuts shall be made of structural steel (3306, 3309, or 3310) and be recessed, hexagonal in shape, and galvanized per 3392. The grip face of the nut shall be machined square to the axis of the pin. Pins and nuts shall be accurately made so that the recessed face of nuts will bear uniformly against the end face of the pin when the nut is turned up tight. The threaded portion of the pin shall project at least 6 mm (**1/4 inch**) through the nut after assembly. Where a recessed cut is made between the threads and the shoulder of the pin, it shall not be wider than 6 mm (**1/4 inch**) nor deeper than the base of the thread.

D6 Shims

Shims shall mean all metal plates that are not required by the Plans and that bring metal surfaces of members into contact or bring the structure to the required grade or alignment.

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Shims 3 mm (**1/8 inch**) or more in thickness shall be made of structural steel. Shims thinner than 3 mm (**1/8 inch**) may be made from sheet steel or sheet brass.

Shims shall be provided by the Contractor at no cost to the Department.

E Structural Fabrication

E1 Cutting

Steel plates and splice plates for major structural components shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile or compressive stresses.

All metals shall be neatly and accurately cut to required size with proper allowance being made to provide for necessary or required finishing operations. Maximum permissible deviation from true lines shall be 2 mm (**1/16 inch**). True lines shall mean theoretical lines exactly corresponding to and used to transfer Plan dimensions to materials for cutting, drilling, and fitting.

When flange plates or other members are cut to a curve, the cut shall be to a true curve. A series of straight cuts approximating the curve is not acceptable.

E1a Thermal Cutting

Thermal cutting shall mean a cutting process using an oxy-fuel flame or a plasma arc.

Carbon steel above 0.25 percent carbon, high alloy steels, heat treated steel, wrought nonferrous metals, and plated metals shall not be thermal cut unless corrective treatment is provided that will eliminate delamination, over-hardened edges, and cracking.

The roughness of thermal cut surfaces shall be 25 μm (**1000 micro inch**).

When material is cut to final size by thermal cutting, sufficient grinding or milling shall be done to remove any cracked or overhardened thermal cut surface.

E1b Re-entrants

All interior and re-entrant corners shall have a minimum radius of 25 mm (**1 inch**). Filleted corners less than 25 mm (**1 inch**) in radius shall be formed by drilling.

E1c Shearing

Shearing shall not be used for the purpose of cutting nonferrous metals where the thickness is greater than 13 mm (**1/2 inch**).

E2 Machining

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E2a General

Any required heat treatment shall be done prior to final machining. Heat treatment shall mean any method of intentionally and systematically applying heat at a temperature below the melting point to any ferrous castings, weldment, or other component.

E2b Machining Tolerances

The standard machining tolerances for all members requiring machine finish shall be plus or minus 760 μm (**0.03 inch**). This tolerance shall apply to the following and all similar dimensions:

- (1) Spacing between bearing assembly pintles and pintle holes.
- (2) Depth of pintle holes and height of pintles after welding.
- (3) Thickness of each individual plate that makes up a bearing assembly.

E2c Machine Lubricant

Machine lubricant used on structural material requiring machine work or drilling shall be such that it can be completely removed, by approved methods, to a thoroughly clean and dry surface.

E2d Edge Finishing

All metal edges shall be smooth, uniform, and free from distortion, ragged areas, fins, tears, cracks, and other discontinuities.

Sheared edges of major structural components more than 13 mm (**1/2 inch**) in thickness shall be machined or thermal cut to a depth of not less than 6 mm (**1/4 inch**). All corners of edges to be painted shall be rounded a minimum of 2 mm (**1/16 inch**). When material is cut to final size by thermal cutting, sufficient grinding or milling shall be done to remove any cracked or overhardened thermal cut surface. For major structural components, corners of thermal cut edges not to be welded shall be rounded 2 mm (**1/16 inch**).

E2e Finishing

Warped or deformed plates or flanges shall be machine finished or straightened by an approved method to provide the proper fit. Surfaces of weldment that will be in contact bearing with other structural parts shall be machine finished.

When only the term "finish" or "machine finish" is specified, the required finish shall be 3.2 μm (**125 micro inch**).

E3 Bending

Bending shall be done with the bend line perpendicular to the direction of rolling. Before bending, the corners of the plates shall be rounded to a radius of 2 mm (**1/16 inch**) throughout the portion of the plate at which the bending is to occur. Metals shall be bent prior to coating and required heat treatment. Bending shall not cause fractures, kinks, reduced section, or other defects in the material.

E3a Cold Bending

Minimum bend radii for structural steel, measured to the concave face of the metal shall be as shown below:

<u>Thickness</u>	<u>Minimum Bend Radii</u>
up to 6 mm (1/4 inch).....	2 x thickness
more than 6 to 13 mm (1/4 to 1/2 inch)	3 x thickness
more than 13 to 19 mm (1/2 to 3/4 inch)	4 x thickness
more than 19 mm (3/4 inch).....	do not bend cold

When Plan details make it necessary to form sections from plates such that the bend will be parallel to the direction of rolling, the minimum bend radius shall be increased by 50 percent.

Flanges for welded girders shall not be bent cold to conform to the shape of the girder web if the radius of the bend is less than 40 times the plate thickness.

E3b Heat Bending

When hot bending is essential, the plates shall be bent hot between 600°C (1110°F) and 650°C (1200°F) or at a temperature designated by the Engineer. Heated material shall be slowly cooled in still air after the bending operation.

E4 Cambering and Curving

Heat curving rolled beams and welded girders and heat cambering rolled beams shall be done by methods approved by the Engineer.

The temperature of the steel shall not exceed 650°C (1200°F). The girder shall be slowly cooled in still air or by other methods acceptable to the Engineer.

Metals shall be cambered and curved prior to coating.

Vertical camber and horizontal curvature shall be measured for final acceptance after all welding and heating operations are completed and the flanges have cooled to uniform ambient temperature. Horizontal curvature shall be checked with the girder in the vertical position.

Over hardening, fractures or other defects due to improper heating shall be cause for rejection of materials.

E4a Girder Cambering

Girder webs shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving.

E4b Attachments

Connection plates, longitudinal stiffeners and bearing stiffeners shall be located and attached after curving. Cover plates shall not be attached to rolled beams before curving if the total thickness of flange plus cover plate exceeds 64 mm (2.5 inches) or the radius of curvature is less than 305 m (1000 feet).

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E5 Straightening Material

Material shall be straightened by methods that will not shear, fracture, stress, or damage the bolts, welds or base metal. Heat straightening shall be done by methods approved by the Engineer. Any material damaged during straightening operations shall be replaced with new material at no cost to the Department.

If, in the opinion of the Engineer, members cannot be properly straightened as an assembly, bent material shall be removed, straightened and re-assembled.

E6 Dimensional Tolerances

Maximum variation from flatness for fascia beam webs shall be one half the limit given in the "ANSI/AASHTO/AWS D1.5 Bridge Welding Code".

F Structural Welding

F1 General

No welding including weld repair will be permitted unless shown in the Plans or approved by the Engineer.

Weld procedure specifications (WPS's) shall be submitted with shop detail drawings. WPS format shall be subject to approval of the Engineer and fabrication shall not begin until WPS's have been approved. Testing may be required of any particular weld detail described in a Fabricator's WPS to ensure the Engineer that proper welds can be made. Testing shall be as described by the Engineer.

The Fabricator must submit test information or procedure qualification records demonstrating, to the satisfaction of the Engineer, that proposed welding procedures will meet requirements of the Contract. Procedure qualification records, once accepted are valid indefinitely.

It shall be the Fabricator's responsibility to provide advance notification so that the Engineer can witness welding or testing or both.

When the Engineer is unavailable to witness qualification or certification welding or testing, the Fabricator shall arrange and bear all costs of having an approved third party as a witness.

All testing of qualification and certification welds shall be conducted at a laboratory accredited by the American Association for Laboratory Accreditation (A2LA) or an approved equal. The Fabricator shall bear all costs of material, testing, and associated work.

F1a Welded Flange Splices

Welded flange splices shall be at least 300 mm (**12 inches**) from web splices. For welded girders having radii less than 580 m (**1900 feet**), additional splices will be permitted only on individual flanges that are uniform in thickness and greater than 12 m (**39 feet**) in length. The

splices will be permitted in addition to the required splices shown on the Plans. No flange shall contain more than two additional splices.

Additional splices shall be located near the third points of individual flange plates; approximately midway between adjacent diaphragm connections; at least 300 mm (**12 inches**) from transverse stiffeners and welded connection plates; and not less than 3 m (**10 feet**) from field splices, bearing points at piers, and flange groove welds that are required by the Plans. The final locations of additional welded splices shall be approved by the Engineer.

F2 Welding Processes and Electrodes

F2a Processes

Welding of major structural components shall be limited to the shielded metal arc (SMAW) or submerged arc (SAW), or flux cored arc (FCAW) welding processes. For minor structural components, welding may be done with other processes and shielding media subject to approval of the Engineer.

F2b Electrodes for Shielded Metal Arc Welding

Field welding of major structural components with E7018 electrodes shall be done with moisture resistant electrodes that shall be received in hermetically sealed containers that bear the additional diffusible hydrogen designator R or H4R. Use of shielded metal arc electrodes for welding of other steels and alloys shall be subject to approval of the Engineer.

F2c Electrodes and Fluxes for Submerged Arc Welding

Wire for submerged arc welding shall be clean, bright, and free of all moisture, rust, grease, and other deleterious substances.

Flux for submerged arc welding shall be stored in the shipping container until needed and shall be baked in a flux oven maintained at a temperature of not less than 120⁰C (**250⁰ F**) for a minimum period of 2 hours prior to use. Flux shall not remain in the oven if the temperature is reduced or the oven is shut off. Flux shall be used within 24 hours after it is removed from an oven.

F2d Electrodes and Shielding Gas for Flux Cored Arc Welding

Wire for flux cored arc welding shall be clean, bright and free of all moisture, rust, grease and other deleterious substances. The welding wire shall be formulated to operate with an Argon rich shielding media. The shielding gas shall be a mixed gas with a minimum Argon composition of 75 percent.

F3 Welder Certification

F3a General

For shop or field welding of minor or major structural components, welders and welding operators must pass the Department Standard Certification Test before they will be certified to weld. A welder or

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welding operator must be certified for each welding process they will use during fabrication or repair.

F3b Welding Operator Experience Requirement

Before being certified, welding operators shall demonstrate to the satisfaction of the Engineer that they have experience using the welding machine and can properly operate and adjust all controls on the machine they are being certified to operate.

F3c Certification by Engineer

The Engineer will issue a written certificate to all welders and welding operators who meet the experience requirements and pass the Department tests. Production welding is not acceptable as a substitute for standard tests.

F3d Proof of Certification

Welders and welding operators shall have their appropriate Department certificate in their possession at the time of welding and shall show it to the Engineer upon request.

F3e Period of Effectiveness

Welders and welding operators shall be certified for a period of 1 year. Welders and welding operators will be re-certified based on the following conditions:

For each year after the welder and welding operator is certified, the Fabricator shall provide the Engineer a welding record that has been verified and signed by a Department inspector, or a third party acceptable to the Department, who witnessed the welding done during that year. This list shall contain the names of the welder or welding operator who welded during the year, item welded, the date of welding, and all code controlled or State DOT approved weld procedure specifications used.

If satisfactory information is furnished, the welder or welding operator will be re-certified for an additional 1-year period for the machine and process used. If welders and welding operators certified to weld on major structural components have only welded on minor structural components during a 1-year period, they will only be re-certified to weld on minor structural components.

F4 Production Welding

The Fabricator shall use only Department certified welders for production welding on Department work. Work done by non-Department certified welders is subject to rejection.

F5 Preparation of Base Metal

Members or parts that have been coated (including metalizing and galvanizing) shall have all of the coating removed from the area which will be affected by the heat of welding so that the weld or base metal is not contaminated.

F6 Conditions for Welding

Preheat shall be applied in a manner that does not produce visible moisture in the weld joint prior to welding.

Temperature limits and location for preheating, interpass temperature, or post-heating are subject to approval by the Engineer.

F7 Technique

Weld run off tabs shall be used at terminal ends of flange and web groove welds and web-to-flange fillet welds. The minimum length of weld to be cut off shall be 100 mm (**4 inches**) for fillet welds and 25 mm (**1 inch**) for groove welds. Terminal ends of all other fillet welds for major structural components shall be subject to approved nondestructive testing (NDT) at no cost to the Department.

Final grinding of all welds and surfaces shall be in the direction of primary stress. All groove welds shall be finished flush. All weld spatter shall be removed without damage to the weld or base metal.

F8 Repair Welding

Repair welding is subject to all requirements of these Specifications and must be approved by the Engineer prior to beginning work. Documentation of all repairs for major structural components including cause for repair, repair location and procedure and NDT report shall be made and submitted to the Engineer.

G Fracture Critical Members

Requirements of the AASHTO/AWS Fracture Control Plan for Fracture Critical Bridge Members shall apply to fracture critical members as modified by these Specifications.

Fracture critical members shall be those members that are designated fracture critical in the Plans. Welds in designated members not subject to tension forces will be exempted from these requirements if written approval is obtained from the Engineer.

No welding or drilled holes for temporary attachments to rolled beams or girders will be permitted.

G1 Fabricator Certification

Fabricators shall be certified under AISC Quality Certification Program Category, Major Steel Bridges (Cbr) with Fracture Critical Members endorsement (F).

G2 Qualification and Certification Testing

Side-bend testing of test welds is not required.

H Hole Forming Operations**H1 Bolt Holes**

All holes for bolts shall be drilled full size from the solid except where punching is allowed by this Specification. Subpunching or

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subdrilling of holes will not be permitted unless written permission is obtained from the Engineer.

Except for field connections and field splices, material forming parts of a member composed of not more than five thicknesses of metal may be punched 2 mm (**1/16 inch**) larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than 19 mm (**3/4 inch**) for structural steel, 16 mm (**5/8 inch**) for high strength steel or 13 mm (**1/2 inch**) for quenched and tempered alloy steel and non-ferrous metals.

Holes shall be clean cut without sharp, torn, or ragged edges. Holes shall be drilled after any required bending, cambering, curving or heat treating of the member.

H1a Special Assembly

When Special Assembly is specified in the Contract, the connection holes in flange and web splices shall be drilled full size in the assembled position. Connection holes in secondary members, including diaphragms, diaphragm stiffeners, lateral bracing, and lateral bracing connection plates, shall be drilled oversized to facilitate alignment. Pre-drilled splice plates may be used as a template only once. Hardened washers conforming to ASTM F 436 shall be placed over both sides of the oversized holes.

H1b Full Assembly

When Full Assembly is specified in the Contract, all bolt holes for field connections in all members and component parts of each structural unit shall be drilled from the solid to specified size while assembled. Pre-drilled splice plates may be used as a template only once.

H1c Punched Bolt Holes

The diameter of the die shall not exceed the diameter of the punch by more than 2 mm (**1/16 inch**). If any holes must be enlarged to admit the bolts, such holes shall be reamed.

H1d Field Connection Bolt Holes

Holes for floor beam and stringer field end connections and 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 shall be drilled full size to a steel template while assembled.

Holes for field splices of rolled beam stringers continuous over floor beams or cross frames and all holes for floor beams, cross frames or bent plate diaphragms may be drilled full size unassembled to a steel template.

Drilling full size of field connection holes through a steel template shall be done after the template has been located to proper position and angle and firmly bolted in place. Templates used for drilling matching

members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts shall be so accurately located that the parts or members are duplicates.

H2 Boring Pin Holes

The final surface of pin holes shall be produced by a finishing cut. The diameter of the pin hole shall not exceed that of the pin by more than 0.5 mm (**1/64 inch**) for pins 127 mm (**5 inches**) or less in diameter, or by 0.8 mm (**1/32 inch**) for larger pins.

The distance outside to outside of end holes in tension members and inside to inside of end holes in compression members shall not vary from that specified more than 0.8 mm (**1/32 inch**). Boring of pin holes in built-up members shall be done after the member has been assembled.

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J Shop Assembly

All fabrication work, including weld inspection, nondestructive testing and necessary repairs, shall be completed before any component is placed in the assembly. The Fabricator shall furnish to the Engineer upon request a written record of each shop assembly setup. These records shall show the following assembly dimensions, both theoretical (as shown on blocking diagram) and actual measurements:

- (1) Elevations at bearing points, field splice locations, and Plan ordinates closest to mid span.
- (2) Span lengths.
- (3) Alignment offsets.

Temporary bolts shall be drawn sufficiently tight to bring the required parts into bearing and to preclude loosening of the nut. Permanent bolt assembly shall be in accordance with 2402.3G2.

Assembled pieces shall be taken apart if necessary to remove burrs, shavings, or other irregularities produced by the operation. The members shall be free from twists, bends, and other deformation.

J1 Special Assembly

Unless otherwise required by the Contract, major structural components shall be assembled at the fabrication shop. Beams or girders shall be line assembled with a length no shorter than the length supported by three adjacent points of bearing and with all indicated and included pieces completely assembled.

Drilling in any of the field connections or field splice materials shall not be done until each assembly unit has been adjusted to the true field position with respect to alignment, camber, grade, and skew as shown in the Plans. The angular rotation of the assembly from true field position with respect to grade shall be permitted provided shop detail drawings showing elevations at all points of bearing and the relative position of webs of main members with respect to true field position are

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furnished by the Fabricator. The Fabricator shall furnish calculations to support the information shown in the drawings.

Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together before drilling or bolting.

J2 Full Assembly

When Full Assembly is specified in the Contract, the following additional requirements shall apply. The main members shall be assembled for the length as set forth in the Contract and the width of the assembly shall be the full width of the structural unit. The assembly shall include all such components as diaphragms, brackets, laterals, wind frames, links, and transverse floor systems. The assembly need not include components such as expansion and deflection devices and bearings.

J3 Match Marking

Connecting parts assembled in the shop to assure proper fit in the field shall be match-marked before disassembly.

The match marking system used shall be one that clearly indicates the exact location in the structure, without continual reference to detail drawings, by using a series of letters and numbers for this purpose. Shop piece marks shall not be used as a match marking scheme. All pieces or parts to be assembled at a point shall be marked with the same mark so that no rotation of pieces can occur.

Material used for match marking shall be removable without damage to the appearance of any surface, painted or unpainted, which is visible in the completed structure.

K Uncoated Weathering Steel Surfaces

For uncoated 3309 or other types of weathering steel specified in the Plans, all foreign matter such as oil, grease, dirt, and concrete spatter shall be removed from the steel in accordance with the Solvent Cleaning (SSPC-SP 1).

Steel not to be coated, including all contact areas of bolted structural connections, shall be blast cleaned in the shop or field in conformance with Near-White Blast Cleaning (SSPC-SP 10/NACE No. 2).

L Coating

Coating shall be interpreted to mean any protective barrier including paint, galvanizing, and metalizing.

Coatings shall not be applied until material has been approved by the Engineer. Coatings shall not be applied to a part until all fabrication work and inspection of the part has been completed and approved by the Engineer. Any material coated prior to the Engineer's approval shall be subject to rejection or removal of all coating.

L1 Galvanizing

All galvanizing shall be done in accordance with 3392 or 3394 as applicable and the requirements given herein.

Welded overlapping or contacting surfaces shall be completely seal welded and all material for rolled or folded joints shall be degreased before forming.

No closed or blind sections of pipe are to be galvanized and material to be galvanized shall be free of paint, lacquer, crayon markings, etc.

Ferrous castings, weld areas, and 3309 and 3310 steel shall be blast cleaned in conformance with Near-White Blast Cleaning (SSPC-SP 10/NACE No. 2) before pickling.

All components of ornamental railing, except for fasteners and rail post anchorages, shall be thoroughly cleaned by blast cleaning in conformance with Commercial Blast Cleaning (SSPC-SP 6/NACE No. 3) before pickling.

Malleable iron castings shall be heat treated and large gray iron castings of non-uniform thickness shall be normalized before pickling.

Galvanized items that have undergone warpage or distortion shall be straightened to fabrication tolerances or as otherwise specified or directed by the Engineer.

Material that has been rejected due to improper galvanizing, shall be replaced or stripped and regalvanized at no cost to the Department.

Repair of galvanized surfaces shall be done in accordance with ASTM A780, Annex A1. Materials used for repair shall be applied according to the manufacturer's instructions.

L2 Metalizing

Metalizing shall be done in accordance with AWS C2.18-93 (Metalizing with Aluminum and Zinc for Protection of Iron and Steel) and the requirements given herein. Surfaces shall be grit blasted, cleaned, and metalized in accordance with the metalizing manufacturer's recommendations that shall be approved by the Engineer before metalizing.

Zinc metalizing wire or powder of a purity equal to that required in the Federal Specification MIL-W-6712 (99.9 percent zinc) shall be used. Surfaces shall be clean, dry, and free of oil, grease, and corrosion products before metalizing and the surface of the sprayed coating shall be of uniform texture, free of lumps, coarse areas, loosely adherent particles and shall show no signs of chipping or coating failure after metalizing. The total thickness of the coating shall be an average of 254 μm (**0.010 inch**) with a minimum of 190 μm (**0.0075 inch**).

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Metalizing processes shall not be attempted when temperature is below 10°C (50°F) unless parts are preheated and kept above 10°C (50°F) during the process. Heat treated base metal shall not be preheated above 93°C (200°F) .

L3 Painting

All surface preparation and painting shall conform to 2478 unless otherwise specified in the Contract. The Fabricator is to provide a quality control log that attests to: correct environmental controls; correct pre-paint surface profile; and correct dry film thickness for each coating application.

M Fabricator Inspection

The Fabricator shall have quality control personnel present as required by the approved quality control plan and this Specification.

M1 Nondestructive Testing (NDT)

The Fabricator shall do NDT in all areas designated in the Contract. Performance of NDT shall be done by trained personnel who have minimum qualification and 2 years experience as an American Society for Nondestructive Testing (ASNT) NDT Level II operator, per SNT-TC-1A, current edition. A final written report of all NDT shall be submitted to the Engineer with interim reports of tests submitted as performed.

For NDT of bridge components, tension areas are defined as follows: The top half of the rolled beam or girder in zones designated in the Plans as "Area A". The bottom half of the rolled beam or girder in zones outside of "Area A". Any location in a rolled beam or girder where superstructure curvature is more than 4 degrees.

All NDT of groove welds shall be completed and the results accepted by the Engineer before the groove welded parts are welded to other parts of the member.

Repair welding shall be followed by NDT of the repair area. NDT of repairs shall be at no cost to the Department.

The Engineer has the right to require NDT of areas not designated in the Contract for such inspection. In such cases, if the inspection shows the area to be defective, the cost of the inspection shall be borne by the Fabricator, but if the inspection shows the area to be satisfactory, the Fabricator may request compensation in accordance with 1403. In addition, when NDT of an area designated in the Contract for inspection shows defects, the Engineer has the right to require NDT of adjacent areas at the Fabricator's expense to determine the extent of the defective area.

M1a Visual Inspection

Visual inspection shall be made during the welding process and again after the weld is placed, cooled and completely cleaned by removal of all slag and residue.

M1b Dye Penetrant Testing

All edges of complete penetration groove welds on major structural components shall be checked by dye penetrant inspection for 75 mm (**3 inches**) to either side of the centerline of the weld or 25 mm (**1 inch**) beyond either side of the weld area, whichever is greater. Magnetic particle testing may be substituted with written permission of the Engineer.

M1c Magnetic Particle Testing

At least 300 mm (**12 inches**) of every 3 m (**10 feet**) length of all fillet welds in major structural components shall be magnetic particle tested except that all bearing stiffener welds shall be 100% tested. These tests shall be located at random areas of a weld but at least 20 percent of all weld terminations shall be tested. Base plate and gusset plate welds for overhead signs and high mast light poles shall be magnetic particle tested 100 percent. The prod method shall not be used unless designated or authorized by the Engineer.

M1d Radiographic Testing (RT)

One hundred percent of each groove weld in tension areas and 25 percent of each groove weld not in tension areas shall be radiographically tested. All developed radiographic film shall have a density between 2.5 and 3.5 and shall be furnished, to and become the property of, the Department.

During radiographic testing, steel edge blocks equal to the thickest part of the weld shall be in place against weld ends with a maximum spacing between the edge block and weld end of 2 mm (**1/16 inch**). In addition, lead vees shall be in place at the edge of the plates where the weld ends to delineate the top edge on the radiograph.

M1e Ultrasonic Testing (UT)

Ultrasonic testing shall be performed as directed by the Contract documents and/or the applicable welding code. Ultrasonic testing may be used in lieu of Radiographic Testing only with approval of the Engineer. For UT that reveals a defect, the Fabricator shall immediately notify the Engineer and provide a hard copy printout of the ultrasonic trace of the defect. All repaired areas shall be ultrasonically tested and a hardcopy trace provided.

N Department Inspection**N1 General**

All structural steel, metal railings, and other similar metallic products will be inspected by the Engineer prior to being incorporated

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in the work. This may involve inspection at the mill, foundry, or fabrication shop, and in the field, as considered necessary by the Engineer, depending on character or importance of the work.

The purpose of Department plant inspection is to establish compliance with those test requirements and process controls that must be met

at the time of production. Plant inspection is not intended to supplement or replace the supplier's own system of quality control, nor shall it relieve the Contractor of responsibility for the correction of errors and faulty workmanship or for the replacement of imperfect materials.

No charge will be made to the Fabricator for plant inspection by Department personnel.

The Fabricator shall be responsible for providing Department inspectors with suitable hard hats, face and hand shields, glasses, respirators, and other equipment necessary for their safety during inspection.

The Fabricator shall give the Engineer at least 5 working days notice of the beginning of work so that inspection may be provided. No material shall be manufactured or work done before the Engineer has been so notified. Any work that has been done without notice shall be subject to additional NDT or rejection of the work at no cost to the Department.

The Inspector shall have authority to reject materials or workmanship that do not fulfill the requirements of the Contract. In cases of dispute, the Fabricator may appeal to the Engineer, whose decision shall be final.

Material delivered to the project site without a Department inspection tag will be considered unacceptable until inspection can be accomplished to the satisfaction of the Engineer. The acceptance of any material, work, or finished members by the Engineer shall not be a bar to their rejection if subsequently found defective. Rejected materials and workmanship shall be replaced or corrected by the Contractor as soon as possible and at no additional cost to the Department.

N2 Facilities for Inspection

The Contractor shall furnish an office and any needed tools and assistance to the inspector for a period of 30 days prior to work being started until 30 days after the work is finished.

The Inspector's office shall:

- (a) Have a minimum floor space of 9.3 m² (**100 square feet**).
- (b) Contain a minimum of two desks, or a desk and a table, and a file case and other necessary furniture.
- (c) Be clean, modern, and have adequate lighting, heating, and ventilation.

- (d) Be separated from the fabricator's activities by being a completely partitioned area provided with a separate door.
- (e) Have telephone service, and a dedicated modem line.

In addition, the Inspector shall have access to a computer printer.

The cost of furnishing, maintaining, repairing, or replacing inspection facilities shall be considered incidental to the cost of Steel Bridge Construction.

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P Marking and Shipping

Prior to shipment, all material shall be legibly marked according to the field erection plan using methods approved by the Engineer. For fascia beams on a bridge, markings shall be placed on the "inside" of the beams. Duplicate pieces shall be marked unless otherwise authorized by the Engineer.

Loose connection plates for a member shall be bolted in position for shipment. Pins, bolts, nuts and washers shall be shipped in suitable weather proof containers not exceeding 230 kg (**500 pounds**). Pins shall be shipped with nuts in place. Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately or packed as an assembly. A list and description of all contained material shall be plainly marked on the outside of each shipping container.

Railing panels shall be stacked with suitable spacers and securely bound. Rail posts shall, unless crated or packed in cartons, be loaded in an upright position and securely fastened at the top and bottom with wire to prevent shifting or tipping.

The loading, transporting, unloading, handling, and storage of material shall be carefully conducted so that the material will be kept clean and free of damage. Coated material shall be padded during these operations to the extent necessary to prevent damage of the coating. All beams and girders shall be shipped in an upright position unless otherwise approved. Material shall be securely blocked in a manner that will prevent permanent buckling, warping, or twisting from stresses developed during transportation. Cambered members shall be securely blocked so as to prevent loss of camber.

2471.4 METHOD OF MEASUREMENT..... 2402

2471.5 BASIS OF PAYMENT 2402

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2472

Metal Reinforcement

2472.1 DESCRIPTION

This work shall consist of the furnishing of metal reinforcement of the type, shape and size specified, and its satisfactory placement at the locations required by the Contract, in concrete structures other than concrete pavement and concrete base.

2472.2 MATERIALS

A	Reinforcement Bars	3301
B	Steel Fabric	3303
C	Spiral Reinforcement	3305

2472.3 CONSTRUCTION REQUIREMENTS

A Bending

Bars shall be bent to the shapes shown in the Plans and may be bent cold. Hot bent bars shall not be heated above the dull cherry-red range (a maximum of 650°C (1200°F)) and shall not be quenched.

Bar bending details shall conform to the American Concrete Institute 315, unless otherwise shown or noted in the Plans. Dimensions shall be out to out. The bar bend diameters shall be those indicated as "Recommended" in the American Concrete Institute 315.

After bending epoxy coated reinforcement bars, any bond loss or coating damage shall be repaired. Before patching, the damaged areas shall be cleaned to remove loose or deleterious material. Any rust shall be removed by blast cleaning. Hairline cracks without bond loss or other damage need not be repaired. The repairs shall be performed as soon as possible, before visible oxidation appears.

B Storage and Protection

Metal reinforcement shall not be stored in a manner that will cause, induce or accelerate corrosion or contamination of the metal. Storage at the site of the work shall be in a manner that will permit visual inspection and allow checking of the various types of reinforcement for conformance with Plan dimensions. Bars of the same type shall generally be stored together, and all reinforcement bars shall be clearly identified with tags bearing the identification symbols used in the Plans.

All systems for handling epoxy coated reinforcement bars shall have adequately padded contact areas where ever possible. All bundling bands shall be padded and all bundles shall be lifted with a strong back, multiple supports, or platform bridge so as to prevent bar-to-bar abrasion from sags in the bar bundle. Bars or bundles shall not be dropped or dragged. Bars or bundles shall be adequately supported in transit in a manner that will prevent damage to the coating.

When epoxy-coated reinforcing steel delivered to the project site or storage yard is, or is expected to be, exposed to the weather for more than 60 days, the reinforcement shall be covered to protect against sunlight and weather exposure. Provisions shall be made for air circulation around the reinforcement to minimize condensation under the protective covering.

C Placing, Supporting, and Tying Bar Reinforcement

C1 General Requirements

Before placing concrete in a unit, the reinforcement bars shall be in the condition defined in the CRSI Recommended Practices Manual for Placing Reinforcing Bars, Chapter VII -- Unloading, Storing, and Handling Bars on the Job. The bars shall be placed to comply with the section on Tolerances in Placement, Chapter X -- General Principles for Bar Placing, Splicing and Tying, of that same manual.

Reinforcement bars shall be firmly supported and securely tied in their proper position. All peripheral intersections shall be tied, and a sufficient number of intermediate intersections shall be tied to ensure that no shifting or displacement of the bars will occur during subsequent operations. Wire used for tying shall be black, soft iron wire, not lighter than 1.5 mm (**16 gauge**). Welded ties shall not be used. Concrete shall not be placed for any unit until the placement, support system, and tying of the reinforcement bars has been inspected and approved.

Steel wire supports for reinforcement bars that will bear on the falsework sheathing for concrete surfaces that will be exposed in the completed structure shall:

- (a) Be fabricated from stainless steel, or
- (b) Have hot-dip galvanized or plastic coated tips extending at least 12.5 mm (**1/2 inch**) above the sheathing.

The wire coating shall not chip, peel, crack, or deform under ordinary job conditions and temperatures.

C2 Special Requirements for Bridge Slabs

In addition to the General Requirements, supporting and tying reinforcement bars for bridge slabs shall be governed by the maximum spacing requirements of 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 as necessary for holding and supporting bars firmly in their correct position.

For bridge slabs, the primary support for the bottom transverse reinforcement bars shall be Slab Bolsters, as shown and defined under Bar Support Specifications and Standard Nomenclature in the CRSI manual. The bolsters shall be placed on the falsework sheathing in continuous lines approximately parallel to the beams, girders, or

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centerline of the roadway, at locations that will permit supports for the top transverse reinforcement bars to be placed directly over them on the bottom transverse bars.

The support system for the top transverse reinforcement bars shall be continuous lines of upper continuous high chairs (with wire runners), placed to transfer load to the bottom bolsters without causing deflection in the bottom transverse bars. Individual type high chairs shall be used only as supplemental support or for sections where the use of continuous type high chairs may be impracticable and substitution is approved by the Engineer.

The top mat of bridge slab reinforcing shall be tied down with tie wires to the in-place beam stirrups or shear connectors at a spacing not to exceed 1.5 m (**5 feet**), measured longitudinally along each beam.

For slab span bridges or other special designs where the above defined support system would be impracticable, the Contractor may propose an alternative support system. The Contractor shall furnish Working Drawings to the Engineer showing the proposed support system.

**TABLE 2472-1
MAXIMUM SPACING OF SUPPORTS AND TIES
FOR BRIDGE SLABS**

Bar Size Number	Maximum Spacing for Slab Bolsters & Continuous Type High Chairs	Maximum Tie Spacing	
		Bottom Mat	Top Mat
10 & 13	900 mm (3 feet)	900 mm (3 feet)	600 mm (2 feet)
16, 19 & 22	1200 mm (4 feet)	1200 mm (4 feet)	900 mm (3 feet)

The bottom layer of longitudinal reinforcement bars for cast-in-place concrete girders, beams, struts, and similar sections shall be supported on beam bolsters or heavy beam bolsters commensurate with the mass to be supported. Subsequent layers of longitudinal bottom reinforcement, except for those bars which can be tied to vertical bars, shall be supported by upper beam bolsters or upper heavy beam bolsters. Any deviation from these requirements shall be subject to approval by the Engineer.

When the Contractor has completed placement and tying of the reinforcement bars for a section of bridge slab, and before concrete delivery has been ordered for that section, the strike-off rails or guides shall be set to correct elevation. The Contractor shall then notify the Engineer that the section is ready for a final check, and shall, in the presence of the inspector, operate the strike-off device over the entire section. A filler strip, 6 mm (**1/4 inch**) less in thickness than the minimum concrete cover requirement, shall be attached to the bottom of the strike-off during this check as a means of detecting areas where the top reinforcement may encroach on the required clearance. Placement of concrete for a bridge slab without having first afforded the Engineer the opportunity of checking the reinforcement as defined above shall be subject to 1512.

C2a Special Requirements for Epoxy Coated Bars

The top mat of epoxy coated reinforcement bars shall be tied at every transverse bar intersection along each continuous row of longitudinal bars. The bottom mat of reinforcement bars and non-continuous rows of top mat bars, as a minimum, shall be tied at every second transverse bar intersection. The ties for the bottom mat shall be staggered along adjacent rows of longitudinal bars. Tie wires shall be plastic or nylon coated.

Wire bar supports shall be epoxy coated. The coating shall be well bonded and resist abrasion. Epoxy coating for bar supports shall be at least 127 μm (**0.005 inch**) in thickness and shall meet requirements of 3301. Wire bar supports that will bear on falsework sheathing for concrete surfaces that will remain exposed in the completed structure shall have plastic coated tips or additional epoxy coating on the legs of the supports. This additional material shall extend at least 13 mm (**1/2 inch**) above the sheathing, but it shall not include portions of the supports other than the legs. The total coating thickness of the 13 mm (**1/2 inch**) portion, including the initial 127 μm (**0.005 inch**) of epoxy coating, shall be a minimum of 2.5 mm (**3/32 inch**), and the color shall be gray. Plastic material shall be incompressible and abrasion resistant.

Damage caused during shipment of epoxy coated bars or by the installation procedures need not be repaired in cases where the damage area is 6 by 6 mm (**1/4 by 1/4 inch**) or smaller and the sum of all damaged areas in each 300 mm (**1 foot**) length of bar does not exceed 2 percent of the bar surface area. All damages larger than 6 mm (**1/4 inch**) square shall be repaired as recommended by the manufacturer and all bars with total damage greater than 2 percent of bar surface area shall be rejected and removed. The total bar surface area covered by patching material shall not exceed 5 percent.

D Splicing Metal Reinforcement

Reinforcement shall be furnished in the lengths indicated in the Plans. No splices, except those shown in the Plans, will be permitted

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without authorization from the Engineer, except as noted hereinafter for spiral reinforcement. When field splices are authorized by the Engineer, the location and details of the splice shall be subject to the approval of the Engineer.

Unless otherwise indicated in the Plans, bar reinforcement shall be lapped at least 36 diameters for No. 22 bar and smaller and at least 40 diameters for No. 25 bar through No. 36 bar. If not shown in the Plans, splices for No. 43 and No. 57 bars shall be approved by the Engineer. Wire mesh reinforcement shall be lapped at least the width of one full mesh plus 50 mm (**2 inches**) for transverse laps or one full mesh plus 50 mm (**2 inches**) plus 2 end overhangs for longitudinal laps.

E Spiral Reinforcement

Spiral reinforcement for circular columns may be made up in either rigid or collapsible cages. Each column spiral shall be finished at the ends with one and one-half turns of the wire.

The spiral cages may be made rigid by tying the vertical column bars to the spiral wires at their intersections, or by the use of metal spacer strips. The number of intersections tied, or the number of spacer strips used, shall be sufficient to ensure a rigid noncollapsible cage with properly spaced loops when the cage is in its final position. Tack welding will not be permitted.

Spiral reinforcement cages shall preferably be furnished full length but may be furnished in two pieces with sufficient added stock to provide for lapping the two adjoining ends not less than one and one-half turns.

If the spacer strip option is used with epoxy coated spiral reinforcement, the spacer strip must also be epoxy coated.

2472.4 METHOD OF MEASUREMENT

A Reinforcement Bars

Reinforcement bars, including those in bar mats, will be measured by the mass incorporated into the structure, based on the Table 2472-2. The quantity measured will include only those splices that are shown in the Plans. Bar supports and tie wires will not be measured for payment.

**TABLE 2472-2
REINFORCEMENT BARS
THEORETICAL MASSES**

NOMINAL DIMENSIONS		
Bar Size Designation Number*	Diameter mm (inches)	Mass kg/m (lb/ft)
10	9.5 (0.375)	0.560 (0.376)
13	12.7 (0.500)	0.994 (0.668)
16	15.9 (0.625)	1.552 (1.043)
19	19.1 (0.750)	2.235 (1.502)
22	22.2 (0.875)	3.042 (2.044)
25	25.4 (1.000)	3.973 (2.670)
29	28.7 (1.128)	5.060 (3.400)
32	32.3 (1.270)	6.404 (4.303)
36	35.8 (1.410)	7.907 (5.313)
43	43.0 (1.693)	11.380 (7.650)
57	57.3 (2.257)	20.240 (13.600)

* Bar designation numbers approximate the nominal diameter of the bar in millimeters.

B Steel Fabric

Steel fabric will be measured by the mass incorporated into the structure, based on the quantity shown in the Plans. The quantity measured will include only splices that are shown in the Plans, and will not include bar chairs, spacers, or tie wires.

C Spiral Reinforcement

Spiral Reinforcement will be measured by the mass incorporated into the structure, based on the mass shown in a table in the Mn/DOT Bridge Construction Manual. The quantity measured will include only those splices that are shown in the Plans. Metal spacer strips, bar supports and tie wires will not be measured for payment.

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2472.5 BASIS OF PAYMENT

In general, metal reinforcement will be paid for under the item numbers specified in the detailed Specifications for the type of structure in which it is used. In cases of structures of types for which there is no detailed Specification, payment will be made on the basis of the following schedule, which bid price and payment will be compensation in full for furnishing, fabricating, delivering, and placing the metal reinforcement as specified.

Item No.	Item	Unit
2472.501	Reinforcement Bars	kilogram (pound)
2472.511	Steel Fabric.....	kilogram (pound)
2472.521	Spiral Reinforcement.....	kilogram (pound)

2476

Painting Metal Structures

2476.1 DESCRIPTION

Painting Metal Structures shall consist of surface preparation, furnishing and applying the paint, protection of and drying the paint coatings, protection of pedestrian and vehicular traffic and all property against any damage whatsoever resulting from these operations, and all work incidental to these operations.

2476.2 MATERIALS

Paint and its ingredients shall conform to these Specifications for the type and kind specified.

Paint shall be pre-mixed, ready for use, and shall be delivered to the place of use in the original containers, not to exceed 20 L (**5 gallons**) in capacity. Each container shall have the Department approval stamp on its label. In no case shall the contents be altered, except as permitted by the Engineer.

A Primer, Steel..... 3507

B Primer, Intermediate Coat 3507

C Bridge Paint, Ready-Mixed Aluminum, Finish Coat 3528

2476.3 CONSTRUCTION REQUIREMENTS

A General

Except as may otherwise be specified in the Contract for a particular project, ferrous metals shall be painted in accordance with these Specifications. Those appurtenances or surfaces that are to be embedded in or covered by fresh concrete, such as shear devices, anchorages, and the top surfaces of beams and girders, may remain unpainted. The term "contact surfaces", as used herein, means those surfaces that will be in contact with materials other than fresh concrete.

Preparation of bare surfaces and the application of the first coat of paint may, at the Contractor's option, be performed at the fabrication shop, or be performed at the job site with the members on temporary blocking or in the erected position.

At the time of assembly all contact surfaces, including those surfaces under bolt heads, nuts, and washers at bolted connections, shall have been prepared by removing all loose rust, loose mill scale, burrs, dirt, and other foreign material that would prevent solid seating of the parts. Contact surfaces of bolted splices in beams and girders shall not be painted, and shall be free of oil, lacquer, galvanizing, and any other substances that would tend to reduce friction between the surfaces. All other contact surfaces, except shop contact surfaces, shall have been painted with 3507 primer coat. Shop contact surfaces shall not be painted.

Surface preparations and painting shall not be started until all material and fabrication inspection has been made and approved by the inspector for the portion of the structure involved.

B Surface Preparation

B1 Bare Surfaces

Except as specified hereinbefore for contact surfaces, structural steel members for bridge superstructures shall be prepared for painting by blast cleaning all surfaces that would be exposed for blast cleaning with conventional equipment with the steel in the erected position, and by hand tool cleaning those isolated areas that would not be accessible in that position. Blast cleaning shall conform to Steel Structures Painting Council Surface Preparation Specifications, Commercial Blast Cleaning (SSPC-SP 6/NACE No. 3). All ferrous metal members that are not included in the superstructure, but that are to be painted, shall be thoroughly cleaned by approved methods.

Blast cleaning will be inspected by a representative of the Department as this operation is performed, and approval will be considered as final provided subsequent operations are properly performed, including painting, handling, transporting, storing, and erecting the steel. The Engineer responsible for inspection of the surface preparations and prime coat painting shall be notified sufficiently in advance of starting these operations so that proper arrangements can be made for this service. This may require up to 5 days advance notice when the work is to be performed at a site remotely located from the inspection source.

B2 Galvanized Surfaces

Galvanized surfaces that are to be painted shall first be thoroughly cleaned, then primed with primer meeting the requirements on file with the Materials Engineer or other primer formulated specifically for galvanized surfaces as directed by the Engineer.

2476.3

C Weather Conditions for Painting

Paint shall not be applied when the ambient air temperature is below 5°C (41°F), nor when the air is misty or the metal surfaces are damp or frosted, nor when the Engineer determines that weather conditions are otherwise unsatisfactory for the work. Red-iron oxide paint may be applied to field rivet heads and bolt heads and nuts during colder weather (below 5°C (41°F)), when the surfaces are dry, to protect them against corrosion, in which case a careful check shall be made for adherence of that paint before applying the second coat.

D Application

D1 General

Paint shall be applied in a neat, workmanlike manner, by brushing, spraying or rolling. Regardless of the method of application, the resultant paint film shall be smooth and uniform, without skips or areas of excessive paint. When spraying or rolling results in unsatisfactory surfaces, the Engineer shall have the authority to require brushing. Paint shall be thoroughly mixed before removal from the containers, and shall be kept in suspension during application. No paint applications shall be started without approval of the Engineer. Non-contact surfaces that will be inaccessible for painting after erection shall be painted with the required number of coats before erection.

Prior to painting over a previously applied coat, the previous coat shall have dried through. This will usually require at least 7 days for red iron oxide paints and at least 3 days for aluminum paints, in good drying weather. Longer drying periods will be required between coats when unfavorable weather conditions prevail. A "dry through" condition check can be made by pressing thumb against the paint film, exerting maximum pressure and simultaneously turning the thumb through an angle of 90 degrees in the plane of the film. Then examine for loosening, detachment, wrinkling, or other evidence of distortion of the film, any of which would indicate insufficient drying.

Prior to starting application of a subsequent coat the previous coat shall be inspected for damage, and any areas that are found to be scuffed, abraded or otherwise unsatisfactory shall be scraped smooth and repainted. Whenever previously applied paint coats become defective for any reason the Engineer may require conditioning or replacement of these coats.

To the extent determined by the Engineer, paint shall not be applied when wind or traffic causes dust, dirt, or sand to be carried in the air onto the metal surfaces.

D2 Brushing

When brushes are used, the paint shall be so manipulated under the brush as to produce a smooth, uniform coating over the entire surface,

including all corners and crevices. The final brush strokes shall generally be horizontal, and shall be parallel.

D3 Spraying

Power spraying equipment shall apply the paint in a fine, even spray. In cool weather the paint containers may be placed in warm water or on steam radiators to reduce the viscosity. Paint applied with spray equipment shall be brushed out immediately, when necessary, in order to obtain uniform cover and to eliminate wrinkling, blistering, sags, runs, and air holes.

The use of spray equipment to apply paint shall comply with State and local regulations applying thereto, with particular emphasis on those which concern the health and safety of the workers and the public.

Equipment for spray painting shall be of an approved type, and shall have provisions for agitating the paint and for water traps in the air lines.

Spray painting will not be permitted in areas where rebounding or blowing paint particles would be detrimental to adjacent environment or property, unless adequate protective shields are provided, or unless it is demonstrated that the work can and will be performed without undue scattering of wet paint particles. The Engineer shall have authority to suspend spray painting whenever it becomes apparent or evident that the application is not being properly controlled.

D4 Rolling

Rollers may be used for the field painting of those areas that can be properly painted by this method.

D5 Sheepskin Daubers

Surfaces that are otherwise inaccessible may be painted by the use of sheepskin or other approved daubers.

E Paint Coats

E1 General

Unless otherwise specified in the Contract, or in Specifications for a particular item of work, metal surfaces that are to be painted shall be painted with the four coats described hereinafter, so as to meet the specified requirements for dry paint film thickness. Paint film thickness shall be measured with a properly calibrated thickness-gauge operating on the attractive-power of a permanent magnet, or an approved equal.

Prior to applying the first coat of paint, the surfaces shall have been prepared as required hereinbefore under Surface Preparation. Metal painted with impure or unauthorized paint shall be entirely cleaned and repainted as directed by the Engineer.

E2 Primer (Steel)

After preparing the surfaces as hereinbefore specified, the first primer coat of paint shall be applied before there is any evidence of rusting on the surfaces so prepared. Application of the first coat shall

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not be started until the surface preparation has been approved by the inspector. On those surfaces prepared by blast cleaning, the primer coat shall only be applied in the presence of the inspector.

Before being painted, structural members that are not in the erected position shall be placed on suitable skids or blocking, and shall be separated from other pieces so as to provide ample space for painting and inspection and so as to preclude paint dripping from one member onto another. Painted members shall not be handled until the paint film has adequately dried. Paint shall not be applied on members that have been loaded for shipment.

Erection markings shall be preserved or transferred so as to be legible at the time the members are erected. Areas to be field welded shall be left unpainted along the weld zone for a width of 50 mm (**2 inches**) on each side of the weld.

The dry thickness of the first coat shall be not less than 38 μm (**1.5 mils**) for any reading, and shall average not less than 51 μm (**2 mils**) for any five or more readings distributed over any area equal to 0.1 m² (**1 square foot**) or larger.

E3 Second Coat (Intermediate Primer Coat)

Prior to application of the second coat of primer, all cracks and cavities between members shall be filled with approved caulk.

The second coat shall be tinted with approximately 11 g (**1.5 ounces**) of lamp black (or comparable carbon paste) per liter (**gallon**) of paint.

In the event of deterioration or breakdown of the first primer coat before the second coat is applied, such as may result from lengthy exposure to the elements, or from adverse environment, the affected areas will be declared unacceptable and become subject to 1512. This procedure will also govern for subsequent paint coats.

Before starting the intermediate primer coat application, field rivets and bolts, field weld areas, and surfaces on which the first coat has been damaged, shall have been properly cleaned by approved methods and painted with primer coat. Field welds shall first have been neutralized by scrubbing and washing with warm water, or with a 5 percent solution by volume of phosphoric acid followed by water rinsing and drying.

The intermediate coat shall be applied to all metal surfaces that will be exposed after all concrete is in place, except stainless steel and non-ferrous metals, surfaces of ferrous metals that have been galvanized or metalized, and those surfaces that are to be covered with waterproofing.

The total dry thickness of the first and second primer coats of paint shall be not less than 76 μm (**3 mils**) for any reading, and shall average not less than 89 μm (**3.5 mils**) for any five or more readings distributed over any area equal to 0.1 m² (**1 square foot**) or larger.

E4 Third and Fourth Coats (Under Coat and Finish Coat)

The third coat shall be bridge paint, ready-mixed aluminum, under coat, conforming to 3527.

The fourth coat shall be bridge paint, ready-mixed aluminum, finish coat, conforming to 3528.

The third coat shall not be applied until all other work has been completed that may tend to mar, stain, streak, or in any way be detrimental to the appearance or quality of this coat. This will generally mean that the concrete for the deck slab shall be in place and the supporting falsework removed, in the case of steel beam or girder spans with concrete decks, prior to application of the third coat.

The Engineer may, when necessary to facilitate the application of aluminum paint by spraying, permit the addition of not more than one half 1 L (**1 pint**) of mineral spirits to 20 L (**5 gallons**) of aluminum paint.

E5 Total Paint Thickness

The total dry thickness of the four coats of paint specified herein shall be not less than 100 μm (**4 mils**) for any reading, and shall average not less than 127 μm (**5 mils**) for any five or more readings distributed over any area equal to 0.1 m^2 (**1 square foot**) or larger.

In the event a deficiency in the total paint thickness exists over any part or all of a structure, but not to the extent that additional paint applications may be desirable, an equitable reduction in payment for the appropriate item of work will be made. A determination of the reduction percentage shall include consideration of the reduced life of the surface preparation as well as that of the paint.

F Cleanup

Painting Metal Structures will not be considered as having been completed until the paint coats are in satisfactory condition, nor until all foreign matter has been cleaned from the painted members. Paint that has spilled, dripped, or blown onto parts of the structure, or onto other areas where it creates an undesirable appearance, shall be removed by methods and to the extent satisfactory to the Engineer.

2476.4 METHOD OF MEASUREMENT

Painting Metal Structures will be measured separately as a complete unit of work (lump sum) or by area of acceptable paint coverage on non-contact surfaces, as computed from the dimensions given on the original construction Plans for the structure.

2476.5 BASIS OF PAYMENT

Painting Metal Structures will be paid for as a separate item only when the Proposal contains a specific item therefor; otherwise it shall be considered as being incidental expense, for which no direct compensation will be made.

2476.5

Item No.	Item	Unit
2476.501	Painting Metal Structure	lump sum
2476.502	Painting Metal Structures	square meter (foot)

2478

Shop or Field Applied Epoxy Zinc-Rich Paint System

2478.1 DESCRIPTION

A General

This work consists of surface preparations; furnishing and applying the paint; protection of and drying the paint; protection of pedestrians, vehicular traffic, and property against damage; and all other work incidental to these operations. This Specification applies to new construction and to repainting of existing structures.

B Definitions

Whenever the following terms are used in this Specification, the terms shall have the following meaning:

- (1) Shop (in shop painting): The site where structural metals are fabricated.
- (2) Contact surfaces: Those ferrous metal surfaces in the completed structure that touch other surfaces.
- (3) Non-contact surfaces: Metal surfaces that are unprotected from weathering by reason of their not being in direct contact with other surfaces.
- (4) Paint thickness: The dry-film paint thickness.

2478.2 MATERIALS

A Epoxy Zinc-Rich Paint System 3520

B Water-Based Inorganic Zinc-Rich Primer 3518

C General

The Contractor shall:

- (1) Deliver the required paint in the original containers, not to exceed 20 L (**5 gallons**) in capacity.
- (2) Not alter the contents except as permitted by the Engineer.
- (3) Have available a qualified manufacturer's technical representative to assist during paint application.
- (4) Provide the inspector and the Project Engineer with the paint manufacturer's written instructions for mixing, handling, and applying the paint.

2478.3 CONSTRUCTION REQUIREMENTS

The Contractor shall paint ferrous metals according to these requirements, unless otherwise specified in the Contract.

When painting a structure erected under a previous contract, disassembly of portions of the structure or removal of appurtenances to expose contact surfaces or otherwise inaccessible metal surfaces is not required unless specifically stated in the Plans or Special Provisions.

Unless otherwise specified, preparation of bare metal surfaces and the application of the prime coats to surfaces other than contact surfaces may be performed at one of the following:

- (a) The fabrication shop,
- (b) The job site with members supported on temporary blocking, or
- (c) The job site in the erected position.

The Contractor shall take adequate precautions to protect adjacent environment and property.

At the time of assembly, the Contractor shall ensure that all contact surfaces including those surfaces under bolt heads, nuts, and washers at bolted connections have been prepared by removing all loose rust, loose mill scale, burrs, dirt, and other foreign material that would prevent solid seating of the parts.

The Contractor shall paint all contact surfaces at the fabrication shop with primer except contact surfaces completely sealed by welding; bolt heads, nuts, and washers; and those ferrous metal appurtenances or surfaces that are to be embedded in or be covered by fresh concrete (such as shear devices, anchorages, and the top surfaces of beams and girders). Job site painting of contact surfaces may be substituted for shop painting if requested by the Contractor and approved by the Engineer.

The Contractor shall furnish a system for inspection of structural steel that will provide the inspector safe access to all parts of the steel. If such a system requires hardware to be temporarily fastened to the steel for the support of the system, the hardware design shall avoid or minimize marring the paint. The Contractor shall repair any mars that do occur.

A Contractor Qualifications and Documentation

The Contractor shall provide evidence that painters and quality control personnel have passed a training program given by the paint manufacturer's technical representative or other training in the paint system to be applied.

A1 Requirements for Shop Painting

Where painting is performed in the shop, the Contractor shall:

- (a) Conduct quality control inspection of the painting including measurements of temperature, dew point, surface profile, and paint thickness.

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- (b) Provide written documentation of the measurements taken to the Engineer on request. If the Engineer determines that the documentation is inadequate, the Engineer will not accept the paint system until the Contractor conducts testing, at no expense to the Department, that shows that surface preparation and painting meets specified requirements.

B Surface Preparation

B1 General

The Engineer will inspect surface preparation as this operation is performed. The Contractor shall notify the Engineer responsible for inspection of the surface preparations and prime coat painting sufficiently in advance of starting these operations so that proper arrangements can be made for this service. This may require up to 5 days advance notice when the work is to be performed at a site remotely located from the project site.

The Contractor shall:

- (a) Prepare surfaces to be prime coated by blast cleaning.
- (b) Remove oil and grease on metal surfaces, including fasteners, with solvent cleaner according to SSPC-SP 1 before blasting.
- (c) Use abrasive for blasting that has a conductivity less than 1000 micro-mho per cm^2 (6450 micro-mho per in^2) when tested according to ASTM D 4940.
- (d) Blast clean surface to conform to the Steel Structures Painting Council (SSPC) Surface Preparations Specifications SSPC-SP 10 Near-White Blast Cleaning.
- (e) Meet the required profile range of the blast cleaning of from 25 to 64 μm (**1 to 2.5 mils**) Profiles on blasted surfaces not meeting tolerance requirements are cause for rejection.
- (f) Ensure that, after blast cleaning, structural steel members are free of all surface defects, such as small seams, blisters, weld spatter, fins, laps, and tears. The Contractor shall remove surface defects by grinding and repair gouges before the prime coat is applied.

B2 Galvanized Surfaces

For galvanized surfaces that are to be painted, the Contractor shall thoroughly clean the surface and then apply a primer formulated specifically for galvanized surfaces. The primer shall be approved by the Materials Engineer.

C Application of Paint

C1 General

The Contractor shall not apply paint to metal surfaces when weather conditions are unsatisfactory for the work or when the ambient conditions include an air temperature below 4°C (**40°F**), metal surfaces

less than 3°C (37°F) above the dew point, air that is misty, or metal surfaces that are damp or frosted. Paint shall not be applied when other work operations, wind, or traffic causes dust, dirt, or sand to be carried in the air onto the metal surfaces.

When shop painting is required and it is not feasible to provide the complete paint system in the shop such as for field-welded areas, field splice plates, and fasteners, the Contractor shall apply the required paint coats to complete the paint system at the Project site.

Intermediate and finish coats shall not be applied in the shop to field splice plates or contact surfaces.

Paint shall not be applied to members that have been loaded for shipment except for touch-up painting approved by the Engineer.

Painting shall not be started until the Engineer has completed inspection and approval of all material and fabrication for the portion of the structure involved.

Application of paint shall follow the manufacturer's recommendations. Paint application shall not be started without approval of the surface preparation and paint by the Engineer. Metal painted before approval of surface preparation or with impure or unauthorized paint shall be entirely cleaned and repainted as directed by the Engineer.

The Contractor shall thoroughly mix the paint before removal from containers and keep it in suspension during application.

The Contractor shall apply paint in a neat, workmanlike manner only by spraying, except as allowed below for brushes and daubers. Roller application will not be allowed. Regardless of the method of application, the resultant paint film shall be smooth and uniform, without skips or areas of excessive paint.

Before application of paint, the Contractor shall ensure that the previous coat is completely cured, and any areas that are found to be wrinkled, detached, distorted, scuffed, abraded, or otherwise unsatisfactory are scraped smooth and repainted. Any dust or chalk-like deposits shall be thoroughly removed. Whenever previously applied paint coats become defective for any reason, the Engineer may require conditioning or replacement of these coats.

If the maximum time interval specified by the manufacturer between application of paint coats is exceeded, all affected areas shall be completely blast-cleaned to a Near-White Blast Cleaning (SSPC-SP 10/NACE No. 2) finish and recoated, at no expense to the Department.

C2 Brushes and Daubers

The Contractor may apply paint by means of brushing where areas to be painted are unsuitable for spray painting, such as surfaces requiring stripe coats, small surface areas where overspray would be excessive, and small areas requiring paint repair.

2478.3

When brushes are used, the Contractor shall manipulate the paint under the brush to provide a smooth, uniform coating over the entire surface, including all corners and crevices. The Contractor shall make final brush strokes generally horizontal and parallel to each other.

The Contractor may paint surfaces that are otherwise inaccessible by the use of sheepskin or other daubers that are acceptable to the Engineer.

During application of paint by brushing or daubers, the Contractor shall use a paint pot equipped with an agitator as described for spraying.

C3 Spraying

Power spraying equipment shall apply the paint in a fine, even spray. In cool weather, the Contractor may place the paint containers in warm water or on steam radiators to reduce the viscosity. Paint applied with spray equipment shall be brushed out immediately, when necessary, in order to obtain uniform coverage and to eliminate wrinkling, blistering, sags, runs, and air holes. Care shall be exercised to prevent dry spray. In no case shall the distance from the spray gun to the point of surface application be more than 0.6 m (**2 feet**).

The paint pot shall be equipped with an industry approved agitator that reaches to within 50 mm (**2 inches**) of the bottom of the pot and is in motion at all times during paint application. Such motion shall be sufficient to keep the paint well mixed. The air lines shall be equipped with water traps or an moisture removal system meeting industry standards.

Thinning of paint shall not be allowed except as detailed in the manufacturer's written instructions and then only with written permission of the Engineer. The Contractor shall use an industry approved power agitated stirrer to produce a smooth, uniform paint.

Whenever spray painting operations are interrupted for more than 1 hour, zinc-rich primer remaining in the fluid hose shall be expelled from the hose and the hose flushed with the thinner specified and approved in the manufacturer's written instructions except when continuous paint-circulating type equipment is used. The spray equipment shall be thoroughly cleaned at the end of each day with the approved paint thinner.

Spray painting will not be permitted in areas where rebounding or blowing paint particles would be detrimental to persons, adjacent environment, or property, unless adequate protective shields are provided, or unless it is demonstrated that the work can be performed without undue scattering of wet paint particles. The Engineer may suspend spray painting operations whenever it becomes evident that the application is not being properly controlled.

D Paint Coats**D1 General**

Primed surfaces shall be top coated within 6 months.

Mechanical grinding to reduce paint thickness shall not be permitted.

If the Engineer allows more than one thickness of paint to produce the thickness specified for the prime or intermediate paint coats, the paint shall be tinted so the color contrasts with both previous and future paints.

D2 Paint Thickness

Unless otherwise specified, metal surfaces that are to be painted shall be painted with the required number of coats as specified hereinafter and meet the thickness requirements of Table 2478-1.

**TABLE 2478-1
REQUIRED PAINT THICKNESS**

Coat	Minimum Thickness µm (mils)	Maximum Thickness µm (mils)	Minimum of Average of 5 or More Measurements µm (mils)
Primer	89 (3.5)	--	102 (4.0)
Primer (A)	114 (4.5)	--	127 (5.0)
Primer - Contact surface	32 (1.25)	64 (2.5)	38 (1.5)
Intermediate	76 (3.0)	--	89 (3.5)
Finish	51 (2.0)	--	64 (2.5)
Total	216 (8.5)	--	254 (10.0)
Total (A)	248 (9.8)	--	279 (11.0)

(A) Bottom flanges of all beams and outboard surfaces of fascia beams.

For steel through girders, the top flanges and the inboard surfaces of fascia beams shall meet the same thickness requirements for prime, intermediate, and finish coats and total paint thickness as required for bottom flanges and outboard surfaces of fascia beams according to Table 2478-1.

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When the paint thickness for prime coat, intermediate coat, or total of all coats, or one or more of these items, over any part or all of the structure, is less than required, the Engineer may either:

- (a) Require removal of the paint system and recoating, or
- (b) Accept the deficient system with a reduction in payment.

D3 Measurement of Paint Thickness

Paint thickness shall be measured with a properly calibrated industry-approved thickness gauge. The average thickness specified for each paint coat shall consist of 5 or more spot measurements. A spot measurement shall consist of 5 thickness gauge readings distributed over an area .09 m² (**one square foot**) or larger.

If the coating thickness of any paint coat cannot be satisfactorily determined after the intermediate or finish coat is applied, a destructive test using a device such as a "Tooke gauge" may be used to measure the dry film thickness. Repair of the destructively tested area shall be at no expense to the Department.

D4 Stripe Coats

Each coat specified shall be preceded by a stripe coat on all edges, corners, seams, crevices, interior angles, junctions of joining members, rivet or bolt heads, nuts and threads, weld lines, and similar surface irregularities. This stripe coat shall be of sufficient thickness to completely hide the surface being covered and shall be followed as soon as practicable by the application of the full prime, intermediate, or finish coat to its specified thickness.

D5 Prime Coats

After thorough mixing, the primer shall be strained through a 250-600 µm (**10 - 24 mil**) mesh screen or a double layer of cheesecloth. There shall be no undispersed lumps of zinc pigment remaining in the paint after mixing.

After acceptance of the surface preparation by the Engineer, the prime coat of paint shall be applied before there is any evidence of rusting.

Before being painted, structural members that are not in the erected position shall be placed on suitable skids or blocking, and shall be separated from other pieces so as to provide ample space for painting and inspection and so as to preclude paint dripping from one member to another. Painted members shall not be handled until the paint is dry enough so that the member can be moved without damaging the paint except to facilitate in-shop painting.

Erection markings shall be preserved or transferred so as to be legible at the time the members are erected. Areas to be field welded shall be left unpainted along the weld zone for a width of 50 mm (**2 inches**) on each side of the weld.

D6 Intermediate coat

D6a Preparations for Application

The prime coat shall be completely cured before application of the intermediate coat. Application of the intermediate coat shall not begin until:

- (1) Expiration of the minimum curing time for the primer as recommended by the manufacturer.
- (2) Approval of the prime coat by the Engineer.

All crevices and cavities between members shall be filled with primer or be caulked with non-sag polysulphide or polyurethane caulking compound conforming to the provisions of Federal Specification TT-S-230, Type II, or an approved equal. Before applying paint to the caulking compound, the caulk shall be allowed to cure in accordance with the manufacturer's recommendations.

A wash coat may be applied on the primer to enhance bonding or prevent bubbling of the succeeding paint coats. The wash coat shall conform to the recommendations of the manufacturer of the paint system.

D6b Paint Application

The intermediate paint coat shall be applied to all prime coated surfaces that are exposed in the completed structure.

D7 Finish Coats

Before use, the paint manufacturer shall submit a dry "draw down" sample of each batch of poly-urethane paint to the Materials Laboratory for color approval.

The final coat of paint on surfaces that are readily exposed to view shall be uniform in color, and shall be free of visible lap marks and other blemishes.

E Fasteners

E1 The Contractor shall prime coat fasteners before installation only when the fasteners are used to assemble steel members that have been painted.

E2 Requirements for coating

Fasteners and washers that are completely installed before application of the prime coat shall receive the same paint coatings as the structural steel. Fasteners and washers that are field installed after the application of the prime coat to the structural steel shall be mechanically galvanized according to ASTM B 695 or receive a coating of 3518 Primer.

The primer thickness on all surfaces shall be a minimum of 19 μm (**0.75 mils**). The galvanizing shall meet ASTM B 695 Class 50 requirements.

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Fasteners shall be free of all organic or other material that would interfere with proper adhesion of the coating.

Coating thickness shall not interfere with the proper fit of nuts and bolts.

E3 Lubrication of Fasteners

Before installation of fasteners, all nuts shall be lubricated with a water soluble lubricant, containing a dye that contrasts with the color of the coating. The lubricant must be completely removable, without blasting, so that the next applied paint coat will adhere properly to its substrate.

E4 Paint Thickness Requirements

After installation of fasteners and removal of lubricant and residuals from exposed parts of fasteners, additional primer shall be applied to meet the required primer thickness. Fasteners shall receive the required thicknesses of intermediate and finish coats Table 2478-1.

F Markings for Identification

Erection markings shall be placed as specified in 2471.3J and shall be preserved or transferred so as to be legible at the time the members are erected. Markings shall be removable or shall be placed at locations that are not visible in the completed structure. The material used for the markings shall be chemically compatible with the epoxy zinc-rich paint system, so that the paint system will not become damaged by the marking paint.

The Contractor shall stencil the year of painting and the Specification numbers of the prime and finish coats in numerals approximately 75 mm (**3 inches**) high on the interior surface of fascia beams at the name plate and diagonally opposite corners of the bridge.

G Handling and Shipping of Painted Steel

Extreme care shall be exercised in handling the painted steel in the shop and during shipping, erection, and construction of the bridge. Painted steel shall not be moved or handled until the coating is hard cured, but in no case sooner than recommended by the manufacturer. The steel shall be insulated from binding chains by softeners. Hooks and slings used to hoist the steel shall be padded. Diaphragms and similar pieces shall be spaced in such a way that, during shipment, no rubbing will occur that will damage the coatings. All handling and shipping procedures shall be submitted to the Engineer at the prefabrication meeting. The Contractor shall obtain the Engineer's approval of the procedures before shipping the steel.

H Field Assembly

The steel shall be stored on wooden pallets at the Project site, or by other means approved by the Engineer. The steel shall not rest on the ground and components shall not fall or rest on each other.

If shear studs are attached in the field, paint shall be removed to bare metal at the weld site. Repair of the prime coating on the tops of the top flanges will not be necessary, and removal of the coating shall be considered as an incidental expense for which no direct compensation will be made.

I Blank

J Paint Repair

All repair procedures shall be approved by the Engineer. All requirements specified previously, such as mixing and thinning the paint, weather conditions, paint application, paint thickness, and paint-curing conditions, shall apply to field repair of previously painted surfaces.

When erection of painted steel members has been completed, including all connections and the straightening of bent metal, the steel shall be prepared for paint repairs. Before field repairs are done, all work shall be completed that may tend to mar, stain, streak, or in any way be detrimental to adhesion of the intermediate coat to the prime coat or be detrimental to the appearance or quality of the intermediate coat or finish coat. This will generally mean, in the case of steel beam or girder spans, that the concrete for the bridge slab shall be in place and the supporting falsework removed.

Field weld areas and surfaces where the prime coat has been damaged shall be properly cleaned by methods acceptable to the Engineer and repainted with epoxy zinc-rich primer.

Damaged paint surfaces that will be inaccessible for coating after erection shall be repaired before erection.

All dirt, grease, form oil, or other foreign matter shall be removed by appropriate means from areas to be repaired. Rusted or uncoated areas shall be blast cleaned to a Near-White Blast Cleaning (SSPC-SP 10/NACE No. 2). All abrasive and paint residue shall be removed from adjacent painted surfaces. Where repair of intermediate coat or finish coat is required, the area to be repaired shall be thoroughly wire brushed, vacuumed, and recoated with the same coating system as used previously.

The Contractor shall use spray equipment recommended by the paint manufacturer for all coatings applied to repair areas located on outside surfaces of the fascia beams.

K Appearance, Protection, and Cleanup

Upon completion of painting, painted surfaces shall provide a smooth, uniform appearance with repairs blending neatly with adjacent surfaces. Nonuniform appearance on surfaces exposed to public view shall be mist-coated to the extent necessary to provide a uniform appearance. For surfaces not exposed to public view, some minor variations in appearance may be accepted by the Engineer.

2478.3

Painted members shall be protected from damage and their appearance preserved from staining, dust, and foreign matter due to erection and other construction operations by the Contractor.

The epoxy zinc-rich paint system will not be considered as having been completed until the paint coats are in satisfactory condition and all foreign matter has been cleaned from the painted members. Paint that has spilled, dripped, or blown onto parts of the structure, or onto other areas where it creates an undesirable appearance, shall be removed by methods and to the extent satisfactory to the Engineer. In addition, any blast-cleaning material and debris deposited on portions of the structure or adjoining areas shall be removed before traffic lanes or walkways are opened to traffic.

2478.4 METHOD OF MEASUREMENT

Area calculations are made using approximate methods and no allowance has been made for actual surface areas of rivet and bolt heads, curved surfaces of welds, radii, corners, etc. No adjustments in quantities will be made based on actual surface areas or on more accurate methods of calculation.

A Shop Painting

When shop painting is required by the Contract, measurement will be based on the area of acceptable paint coverage on non-contact areas, as computed from the dimensions given on the original construction Plans for the structure. Contact areas will not be measured for payment.

B Field Painting and Repair of Shop Painted Bridge

Field painting and repair painting of the structural steel on a shop painted bridge will be measured separately as a complete unit of work (lump sum) when this item is included in the Contract.

C Field Painting of New Structural Steel and of Existing Bridge

Field painting of structural steel will be measured based on the area of acceptable paint coverage, as computed from the dimensions given on the original construction Plans for the structure.

2478.5 BASIS OF PAYMENT

A Shop Painting

Payment for shop painted structural metals at the Contract price per m² (**square foot**) shall be compensation in full for all costs of furnishing and applying a shop-applied paint system in accordance with Specification requirements, including all necessary repairs to the paint coating that occur before unloading at the Project storage site.

B Field Painting and Repair of Shop Painted Bridge

Payment at the Contract price per lump sum shall be compensation in full for all costs of surface preparation and furnishing and applying

2481.1

field-applied paint coats to shop painted members, as described in this specification. Compensation will include, but not be limited to, the cost of providing all necessary repairs of damage to the paint coats that occur during and after unloading at the Project storage site.

C Painting of New Structural Steel

Payment for painting metal components of new structures at the Contract price per m² (**square foot**) shall be compensation in full for all costs of surface preparation and furnishing and applying the paint system in accordance with Specification requirements, including all necessary repairs to the paint coating.

D Painting of Existing Bridge

Payment for painting of existing structures at the Contract price per m² (**square foot**) shall be compensation in full for all costs of surface preparation and furnishing and applying the field applied paint system to existing structural steel in accordance with Specification requirements.

E Blank

F Price Reductions

In the event that there is a deficiency in the paint thickness of the prime coat, intermediate coat, or total of all coats, or one or more of these items, over any part or all of the structure, and the Engineers accepts the deficient system, the Department will make a reduction in the payment. The Engineer will determine the reduction in payment based upon the ratio of the measured thickness to the minimum required thickness for 5 or more measurements and the extent of the deficient area. The reduction will be accumulative for each deficiency.

G Payment

The Department will make payment for work performed under this Specification in accordance with the following schedule:

Item No.	Item	Unit
2478.502	Epoxy Zinc-Rich Paint System (Shop)	square meter (foot)
2478.503	Epoxy Zinc-Rich Paint System (Field).....	lump sum
2478.504	Epoxy Zinc-Rich Paint System (New)	square meter (foot)
2478.506	Epoxy Zinc-Rich Paint System (Old)...	square meter (foot)

2481

Waterproofing

2481.1 DESCRIPTION

This work shall consist of waterproofing joints with bituminous materials and bituminous-saturated fabric.

2481.2

2481.2 MATERIALS

- A Asphalt Primer for Waterproofing Concrete..... 3165**
- B Saturated Fabric for Waterproofing..... 3201**
- C Asphalt for Mopping Coat 3166**

2481.3 CONSTRUCTION REQUIREMENTS

A General

Before any surface is waterproofed, all form ties shall be removed, all cavities shall be filled with mortar, and all fins or rough spots finished reasonably smooth. Immediately prior to applying the primer, the surface of the concrete shall be cleared of all dust or other loose material. The surface of the concrete shall be dry at the time the primer is applied.

Waterproofing shall not be applied in wet weather or when the temperature is below 2°C (**36°F**) unless authorized by the Engineer.

All waterproofing shall be protected against damage during succeeding construction operations. Any damage to waterproofing shall be repaired to the satisfaction of the Engineer, at no expense to the Department.

B Three-Ply Joint Waterproofing

Joints in concrete structures so indicated in the Plans shall be waterproofed with three-ply joint waterproofing as follows.

Asphalt used for waterproofing shall be heated and placed at a temperature of not less than 149°C (**300°F**) and not more than 177°C (**350°F**), with frequent stirring to prevent local overheating.

Primers shall be applied cold.

The waterproofing shall be centered over the joint for its entire length. After the surface has been prepared, it shall be given a uniform and continuous coat of primer for a width of at least 50 mm (**2 inches**) wider than the widest piece of fabric. After the primer coat has thoroughly dried, the surface shall be mopped with a uniform coat of asphalt into which a layer of bituminized fabric, 300 mm (**12 inches**) wide, from which the selvedge has been removed, shall be rolled immediately. This process shall be repeated and a second layer, 450 mm (**18 inches**) wide, followed by a third layer, 600 mm (**24 inches**) wide, shall be placed. The last layer of fabric shall be covered with a mopping of asphalt applied at a rate of not less than 4 L per meter (**1 gallon per yard**) of joint.

When it is necessary to splice fabric, the end splices shall have a minimum lap of 300 mm (**12 inches**). The lap shall be coated with asphalt material immediately before the splice is made. Splices in the various layers of fabric shall not be made at the same location. All splices in fabric covering vertical joints shall be made "shingle fashion," with the end of the outer layer of lap at the lower elevation.

2481.5

Joint waterproofing shall precede the application of any surface waterproofing, membrane waterproofing, or protection courses required by the Plans or Special Provisions.

C Optional Waterproofing System

In lieu of providing the three-ply joint waterproofing, the following system may be substituted.

A 300 mm (**12 inch**) wide strip of approved membrane, consisting of rubberized asphalt integrally bonded to polyethylene sheeting, shall be centered on the joint on a surface that has been primed in accordance with the manufacturer's recommendations. The polyethylene sheeting shall have a thickness of 102 µm (**4 mils**), and the rubberized asphalt shall have a nominal thickness of 1.5 mm (**0.6 inch**), for a total nominal thickness of 1.6 mm (**0.6 inch**). The face of the rubberized asphalt opposite that which is bonded to the sheeting shall have a removable covering that shall remain on the membrane until it is ready for placement.

Splices in the joint waterproofing membrane may be made only when permitted by the Engineer. The membrane shall overlap not less than 150 mm (**6 inches**) at the splice, and the upper strip shall overlay the lower strip on vertical face joints.

2481.4 METHOD OF MEASUREMENT

A Joint Waterproofing

The Department will measure joint waterproofing by the length of the joints waterproofed.

2481.5 BASIS OF PAYMENT

The Department will pay for joint waterproofing only when the Contract contains a specific pay item for waterproofing. Otherwise, joint waterproofing will be considered as an incidental expense to the Contract with no compensation to the Contractor.

Payment, when specified in the Contract, will be as follows:

Item No.	Item	Unit
2481.501	Joint Waterproofing.....	meter (linear foot)

2501

2501
Pipe Culverts

2501.1 DESCRIPTION

This work shall consist of the construction of 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

Culvert pipe shall be one of the following kinds as specified or permitted as an option. Unless higher strength pipe is specified, pipe conforming to the lowest strength class covered in the referenced Specification will be acceptable. Special fabrication or jointing details shall be as required by the Plans.

A1	Corrugated Aluminum (CA).....	3225
A2	Corrugated Steel (CS).....	3226
A3	Corrugated Polyethylene (CP).....	3247
A4	Bituminous Coated-Corrugated Steel (BC-CS).....	3227
A5	Aramid Bonded-Corrugated Steel (AB-CS).....	3228
A6	Reinforced Concrete (RC).....	3236
A7	Polymeric Coated-Corrugated Steel (PC-CS).....	3229
A8	Corrugated Aluminized Steel (CAS)	3222

Coating Type shall be as specified in the Plans or Special Provisions.

B Structural Plate

B1	Corrugated Aluminum (CA).....	3233
B2	Corrugated Steel (CS).....	3231

C Aprons

Aprons shall be the type designated in the Contract. Galvanized steel aprons may be furnished for attachment to corrugated steel, corrugated polyethylene, bituminous coated-corrugated steel, aramid bonded-corrugated steel, and polymeric coated-corrugated steel pipe. Galvanized steel aprons may be furnished for attachment to corrugated aluminum and corrugated aluminized steel pipe provided that geotextile Type II or other insulation material approved by the Engineer is applied between the contact surfaces of the different materials.

C1	Reinforced Concrete (RC).....	3236
C2	Galvanized Steel (GS).....	3226

2501.3

C3	Aluminum Alloy (AA)	3225
C4	Bituminous Coated-Galvanized	
	Steel (BC-GS).....	3227
C5	Aluminized Steel	3222
D	Flap Gates	3399
E	Antiseepage Diaphragms.....	3351
F	Pipe Joint Sealer Materials	
F1	Preformed Rubber, Type A.....	3726
F2	Preformed Plastic, Type B.....	3726
F3	Bituminous Mastic.....	3728
G	Granular Materials.....	3149
H	Geotextile, Type II	3733
I	Blank	
J	Reinforced Concrete Dissipator Ring	3236

2501.3 CONSTRUCTION REQUIREMENTS

The following construction requirements shall apply to the installation of all types of pipe culvert, whether new or old materials are used.

A General

The provisions of 2451 relating to prefabricated structures shall apply to the excavation, foundation construction, and backfilling of the culvert, together with the additional requirements or modifications contained herein.

B Foundations

Entrance culverts may be installed to the required grade without special foundation shaping, except that the foundation shall be shaped as required in 2451.3C2 when the culvert is installed in a trench or when special bedding is specifically designated in the Plans.

C Laying Pipe

C1 General

Pipes that connect with inlet structures shall terminate flush with the inside of the structure wall.

Jacking of culverts through the existing earth structure into position may be required by the Plans or permitted by the Engineer. The flow line elevation at the starting point for jacking shall be within 30 mm (**0.1 foot**) of the staked grade; the flow line shall not be reversed at any point; and the line and grade at any point within the pipe shall not vary by more than 150 mm (**0.5 foot**) from the line and grade designated. Metal pipe installed by this method shall have bolted or riveted field

2501.3

C2 Metal Culvert

Corrugated metal pipes having circumferential joints shall be laid with the outside laps pointing upgrade and with the longitudinal joints on the sides.

Metal pipe sections shall be joined by the use of metal connecting bands, centered over the joint, and with the pipe sections as close together as possible. The band shall be tightened sufficiently to ensure a tight joint.

Structural plate culverts shall be assembled according to the instructions of the manufacturer, using approved fasteners. Where bolts are used, the bolts shall be tightened, after assembly, to a torque of 135 to 400 N•m (**100 to 300 foot pounds**). The Contractor shall furnish a calibrated torque wrench to prove, to the Engineer's satisfaction, the adequacy of the bolt tightening.

Bituminous coated pipe shall be handled with special care to preserve the coating. All exposed metal shall be recoated with a grade of asphalt similar to that originally applied. Fuel oil or similar solvent may be used to facilitate the installation of coupling bands.

The paved portion of bituminous coated and paved corrugated metal pipe shall be centered on the flow line.

Where beveled ends are required on metal pipe, the bevels shall be cut at right angles to a vertical plane through the longitudinal axis of the pipe.

C3 Concrete Culvert

Concrete pipe shall be laid with the groove end of each section up-grade and the sections shall be tightly joined. Each joint shall be effectively protected against infiltration of backfill soil by filling the joint space with an approved sealer material or by providing a full circumferential wrap of geotextile material extending 300 mm (**12 inches**) or more on each side of the joint and being secured in place. A combination of sealer and geotextile materials will be permitted.

Where so required by the Contract, the joints in concrete pipe shall be effectively sealed to provide a flexible water-tight joint, using an approved elastic joint sealer material (preformed rubber, preformed plastic, bituminous mastic). Where the pipe specified is specifically designed to accommodate preformed gasket type seals, the joints shall be sealed with the gasket type designed especially for that type of joint as shown in the Plans and the joints shall meet the performance requirements of AASHTO M 198.

Mastic joint sealer materials shall be applied in accordance with the recommendations of the manufacturer. All joints shall be wiped clean on the inside after sealing. Lifting holes shall be plugged with a precast concrete plug, sealed, and covered with mastic or mortar.

2501.3

Concrete culvert sections shall be tied together with approved fasteners, unless otherwise specified in the Plans or Special Provisions.

C4 Blank

C5 Extending In-Place Culverts

To the extent feasible, in-place culverts shall be cleared of any obstructions to water flow, before placing the extension pipe. Removal of sediment will only be required to the extent that improved flow is likely to be maintained. This work shall be incidental to the pipe extension, with no direct compensation being made therefor.

Where the pipe ends differ because of changed design, the connection to the in-place culvert shall be made as indicated in the Plans or to the satisfaction of the Engineer.

When cast-in-place concrete box culverts are to be extended with plant-fabricated pipe, details of the connection shall be as shown in the Plans.

When a box-type concrete cattle pass is to be extended using precast concrete sections, a transition section as shown in the detailed Plans shall be used. The ends of the in-place structure shall be exposed and concrete removed to the extent indicated in the Plans. The cast-in-place portion of the transition shall be constructed according to the applicable material and construction requirements of 2411.

D Culvert Appurtenances

Appurtenant items such as aprons, safety aprons, and grates, diaphragms, dissipator rings, flap gates, and safety grates (this includes special grates for concrete pipe and large size pipe, trash racks and other devices of this nature requiring a special design) shall be furnished and installed as required by the Plans or Special Provisions.

E Induced Trench Installation

When required by the Plans, the backfill over the culvert shall be constructed as follows:

The embankment shall be constructed according to 2105 for a width on each side of the installed culvert at least equal to 3 pipe widths and to an elevation over the top of the culvert equal to the pipe height plus 300 mm (**1 foot**). Where specified density is called for, the density in each layer shall be not less than 100 percent of maximum density.

A trench shall then be excavated to a level 300 mm (**1 foot**) above the top of the culvert, for the width and length of the pipe, and with vertical sides. The trench shall be loosely filled with highly compressible soil, after which the remainder of the embankment shall be constructed in accordance with 2105.

2501.3

F Culvert Cleaning

Before final acceptance of the Project, all culverts installed under the Contract shall be inspected and cleared of any sedimentation or other debris existing inside the pipe.

2501.4 METHOD OF MEASUREMENT

A Culvert Excavation

When the proposal contains separate items for Culvert excavation under the payment provisions of this Specification, the excavations for culverts will be classified and measured in accordance with the applicable provisions of 2451.

B Culvert Pipe

Culvert pipe will be measured by length, as determined by summation of the nominal laying lengths of the individual pipe sections incorporated in each structure. Measurements will be separated as to size, type, kind, and strength class, to the extent indicated in the item name.

Elbow, tee, and wye sections will be measured for payment as pipe, with the measurements being made along the centerline of the culvert barrel. No length allowance will be made for branch legs, except as included in the measurements for a connecting structure. Transition sections will be measured for payment as pipe of the larger (or more costly) size, except for such special sections as may be designated for measurement as a unit.

On metal pipe installations requiring special fabrication such as skewed or sloped ends, length measurements will be to the extreme ends such as to include waste material, unless other limits are shown in the Plans.

C Culvert Appurtenances

Appurtenant items such as aprons, safety aprons, and grates, diaphragms, dissipator rings, flap gates, and other specially designed and identified units designated for payment on a per each basis, will be measured separately by the number of units of each type and size incorporated in the culvert structures. A safety apron and grate is to be considered as a unit.

No direct compensation will be made for cast-in-place concrete work required in connection with the construction of pipe culverts.

D Granular Materials

Granular materials for special backfill or bedding will be measured in accordance with 2451.4B

2501.5 BASIS OF PAYMENT

Payment for culvert pipe of each size, type, kind, and strength class, at the appropriate Contract prices per unit of measure, will be

2501.5

compensation in full for all costs of furnishing and installing the pipe complete in place as specified, except as otherwise provided herein.

Aprons, safety aprons and grates, flap gates, dissipator rings, diaphragms, and other specially designed and identified appurtenant items, as required by the Plans, will be paid for separately by type, size, and number of units incorporated in the structures, which payment will be compensation in full for all costs of furnishing and installing those items complete in place.

Granular materials for special backfill or bedding will be paid for separately in accordance with the payment provisions of 2451.5.

Culvert Excavation will be paid for separately, to the extent that the Proposal contains specific items and unit prices therefor, in which case payment will be subject to 2451.5. Otherwise, all excavating costs shall be included in bid prices for culvert pipe and appurtenant items.

For any culvert elbows, tee or wye sections and necessary additional connectors that are ordered by the Engineer but that are not indicated in the Plans, additional compensation will be made in the amount of the actual invoice cost of the materials involved.

Payment for installing culvert materials provided by the Department will be made under the applicable installation items indicated in the Proposal, and, except for Extra Work or work designated under other items, will be considered as full compensation for all the work and additional materials required for the installation complete in place.

Where installation by the jacking method is required or permitted in the absence of a separate bid item, payment will be made on the same basis as if the culvert were installed by the trenching method.

Payment will be made on the basis of the following schedule:

Item No.	Item	Unit
2501.501	Culvert Excavation, Class (1)	cubic meter (cubic yard)
2501.511	___mm (inch) (2) Pipe Culvert (3).....	meter (linear foot)
2501.515	___mm (inch) (2) Pipe Apron	each
2501.517	Anti-seepage Diaphragm for (4) Pipe	each
2501.519	Flap Gate for (4) Pipe	each
2501.521	___mm (inch) Span (2) Pipe-Arch Culvert (3).....	meter (linear foot)
2501.525	___mm (inch) Span (2) Pipe-Arch Apron	each
2501.527	Anti-seepage Diaphragm for (4) Pipe-Arch	each
2501.531	___mm (inch) (2) Elliptical Pipe Culvert (5)	meter (linear foot)
2501.535	___mm (inch) (2) Elliptical Apron.....	each

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2501.541	___ mm (inch) High (2) Cattle Pass Culvert (3).....	meter (linear foot)
2501.543	___ mm (inch) High (2) Cattle Pass Transition Section (3)	each
2501.545	___ mm (inch) High (2) Cattle Pass Apron..... Culvert (3)	each
2501.551	___ mm (inch) (2) Structural Plate Pipe..... Culvert (3)	meter (linear foot)
2501.555	___ mm (inch) Span (2) Structural Plate Pipe-Arch..... Culvert (3)	meter (linear foot)
2501.561	___ mm (inch) (2) Pipe Culvert, Design (6) (3).....	meter (linear foot)
2501.565	___ mm (inch) Span (2) Pipe-Arch Culvert, Design (6) (3)	meter (linear foot)
2501.567	___ mm (inch) (2) Safety Apron & Grate (6).....	each
2501.569	___ mm (inch) (2) (7)	each
2501.571	Install (7)	meter (linear foot)
2501.573	Install (7)	each
2501.575	___ mm (inch) RC Dissipator Ring.....	each

- NOTE: (1) Specify Class U, E, or R only---See 2451.3B2
(2) Specify Kind---See 2501.2
(3) Specify Strength Class, if other than minimum requirement.
(4) Specify Size and Kind.
(5) Specify HE or VE, and Strength Class, if other than minimum requirement.
(6) Give Standard Plate Number for special pipe or joint designs.
(7) Specify item name.

2502
Subsurface Drains

2502.1 DESCRIPTION

This work shall consist of the construction of subsurface drains, using plant-fabricated pipe and appurtenant materials, installed to:
(a) collect and discharge water infiltrating into the pavement system (pavement edge drain).

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(b) collect and discharge water accumulated in the bottom of a granular-backfilled subcut (subcut drain).

(c) cut off or intercept ground water flowing toward the roadway (cut-off drain).

Subsurface drains include all materials used to collect ground water and conduct it to a discharge point either at a structure or on a side slope. The typical system will include a drain pipe, radial connecting pipe, discharge pipe, and drain outlet.

2502.2 MATERIALS

Drain pipe shall be one of the following kinds as specified or permitted as an option. Fittings connecting multiple length of drain pipe shall be of the same material as the pipe. Nonperforated pipe shall be furnished except where the perforated type is specified. Unless higher strength pipe is specified, pipe conforming to the lowest strength class covered in the referenced specification will be acceptable. All discharge pipe, radial connecting pipe, and associated fittings shall be nonperforated TP pipe. Special fabrication or jointing details shall be as required by the Plans or as approved by the Engineer.

A	Drain and Discharge Pipe	
A1	Thermoplastic (TP).....	3245
A2	Corrugated Polyethylene Drainage Tubing (PE)	3278
B	Precast Concrete Headwall (Drain Outlet).....	Standard Plate 3131
C	Granular Materials.....	3149
D	Geotextile, Type I.....	3733
E	Wood Fiber Blanket, Rapid Degradable Type	3885
F	Seed.....	3876
G	Marking Tape	3354

2502.3 CONSTRUCTION REQUIREMENTS

The following shall apply unless otherwise provided in the Plans or Special Provisions:

A Excavation

The trench shall be excavated to the designated lines and grades, as shown in the Plans and as necessary to permit placement of the drains in accordance with the provisions hereof. Minimum trench width at the bottom of the excavation shall be the nominal pipe width plus two times the pipe diameter (for example, a 100 mm (**4 inch**) diameter pipe would be placed in a 300 mm (**12 inch**) wide trench). Corrugated polyethylene drainage tubing (PE) may be used only when placed in a narrow, controlled-width trench as typically constructed by a chain- or wheel-type trenching machine designed and used for this application. Other types of rigid pipe shall be used for all other uses where compaction is

2502.3

not controlled in a narrow trench. Installation of PE tubing by plowing is not permitted.

Rock encountered within the excavation shall be removed to a minimum width as specified above, and to a minimum depth of one pipe diameter below the pipe. Except where granular material is required, the backfill up to the bottom of the pipe may be made with suitable material removed from elsewhere in the excavation, which shall be compacted uniformly to provide a proper foundation.

B Laying Drains

All perforated pipe drains shall be bedded on fine filter aggregate meeting 3149.2J, placed to a minimum thickness of 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 such elevation as will permit the specified foundation preparations. Granular bedding will not be required on nonperforated pipe installations unless specifically required by the Plans. Stones in excess of 25 mm (**1 inch**) will not be permitted in the trench. The foundation for all drains, whether bedded on granular material or not, shall be carefully shaped to fit at least the lower 30 percent of the outside circumference of the pipe. Drains shall be laid carefully to line and grade, with uniform bearing throughout and with the perforations down unless otherwise directed.

All perforated pipe shall be wrapped with geotextile that is factory seamed or produced as a continuous knit weave. The fabric seam shall be placed at the top of the pipe (opposite the perforations). Where seams are necessary at fittings or connectors, the adjoining geotextiles shall be mechanically fastened, or overlapped a minimum of 150 mm (**6 inches**).

Pipe sections shall be joined securely with the appropriate coupling bands or fittings. Solvent type joints shall be cemented unless otherwise specified. Upgrade ends of all subdrain pipe shall be closed with suitable caps. All junctions and turns shall be made with wyes or bends and be suitable for cleaning and inspection.

Where a drain connects with a structure or catch basin, the Contractor shall make a suitable and secure connection through the wall of the structure. Unless otherwise specified, drainage outlets to the surface shall terminate at a standard precast concrete headwall.

C Backfill

Backfilling of drains shall proceed without delay as the installations are made. On all perforated pipe installations, fine filter aggregate shall be placed adjacent to and to a minimum height of 150 mm (**6 inches**) above the top of the pipe, and to the extent indicated in the Plans. Above that elevation, and on all nonperforated pipe installations, the backfill may be made with suitable material removed from the

2502.3

excavations. In all applications, stones greater than 25 mm (**1 inch**) shall not be used adjacent to, and for 150 mm (**6 inches**) above the pipe.

Fine filter aggregate need not be compacted, unless otherwise indicated in the Plans, but all other backfill material shall be compacted to a density equivalent to that of the adjacent soils, or to specified density where applicable.

D Drain Outlets

D1 Precast Concrete Headwall

Headwall outlets shall be kept 300 mm (**12 inches**) above ditch grades whenever possible, with the absolute minimum being 150 mm (**6 inches**). The uppermost point of the headwall shall be placed flush with the in-slope at a minimum downward grade of 2 percent to provide easy water exit. The earthen side slopes adjacent to the headwall shall then be shaped to conform to the sides and toe of the headwall. All soils around and under the concrete headwall outlet shall be compacted to the satisfaction of the Engineer to minimize future movement.

D2 Discharge Pipe

The discharge pipe to the drain outlet shall be constructed concurrently with the drains and be laid at roughly right angles to the roadway centerline. The discharge pipe shall be fully inserted/coupled to the headwall. Connections shall be made with 3A Grout, rubber gasket on the pipe, rubber or plastic gasket cast into the headwall, or by solvent or gasket joint into a TP coupling securely cast into the headwall. The coupling method shall secure the pipe well enough so that small movements of the headwall will not cause separation. The method of coupling shall be approved by the Engineer. The radial connection between the drain pipe and the discharge pipe shall have a minimum radius of 300 mm (**12 inches**) and will provide easy access for probes, cleaners, and video cameras. All connections and solvent joints shall be secure to the extent that they will not decouple during backfilling and will prevent soil intrusion. Connection and coupling methods shall be approved by the Engineer.

The discharge trench shall be constructed similar to the drains, but shall be backfilled with compacted mineral soil to the satisfaction of the Engineer. Discharge pipe grades shall be no less than the drain pipe and a minimum of 2 percent. Crushed or deformed discharge pipe or connection shall be replaced by the Contractor at no cost to the Department. All discharge pipes shall have concrete headwalls attached before termination of the construction season.

D3 Turf Establishment

The Contractor shall use seed and wood fiber blankets at the drain outlets except when outlets are placed at a location that will normally be sodded under terms of the Contract.

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A wood fiber blanket (Rapid Degradable Type), meeting 3885, shall be placed to a width of 0.6 m (**2 feet**) on either side of headwall centerline (or to meet existing turf) and extend 1 m (**3 feet**) above and 0.5 m (**1.5 feet**) below headwall. Anchor staples shall be placed at 0.5 m (**1.5 feet**) maximum intervals. When a headwall is placed at a location that will normally be sodded under terms of the Contract, the seed and mulch shall be deleted in favor of sod. Installations shall be watered and maintained in accordance with 2575.3L. Seed for use with the wood fiber blanket shall be according to 3876, Mixture 50A, placed at the rate of 1 kg per square meter (**2 pounds per square yard**) before fastening the blanket.

D4 Marking Outlet Locations

The Contractor shall permanently mark the location of all outlets with a 150 by 450 mm (**6 by 18 inch**) strip of white marking tape according to 3354. The Contractor shall 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 is still hot. When two runs of drain pipe come together at a low point and discharge via a "Y" to a single outlet, the Contractor shall place two markings side-by-side with a 150 mm (**6 inch**) spacing. If there is no bituminous shoulder, the Contractor shall place the tape on the bituminous pavement or spray a white paint strip on concrete pavements. If paint or tape marking is not appropriate, the Engineer may approve alternate methods. The furnishing of, and placement of the tape or paint, is incidental work.

D5 Inspection and Cleanout

It shall be the responsibility of the Contractor to ensure that once installed, the discharge pipe and headwalls remain clean and operative so that water is not trapped in the pipe, and also to make a final inspection, with the Engineer, of all discharge pipes and headwalls to ensure that they have the proper grade, are clean, properly landscaped, erosion control has been properly installed and maintained, and are generally in satisfactory operating condition.

The inspection shall be conducted with a probe mounted on the end of a flexible fiberglass rod that has the dimensions of 100 mm (**4 inches**) long and a diameter of one nominal pipe size smaller than the drain pipe that is being inspected. The inspection will be conducted through the discharge pipe, radius connection, and at least 1 m (**3 feet**) into the main drainage line to verify that it is open and operative. Discharge pipe and connections that are judged to be inoperative, shall be cleaned or repaired to the satisfaction of the Engineer. Inspections and any required remedial work shall be at no cost to the Department.

2502.4 METHOD OF MEASUREMENT**A Subsurface Drains**

Drains will be measured by installed length along the centerline of the pipe. Terminal points of measurement will be the pipe end at free outlets; the point of junction with in-place pipe; or the center of structures, catch basins, or multiple junction points as they apply.

Where subsurface drains are furnished as a part of the Contract, the lengths of each size and type of pipe will be measured separately.

B Granular Materials

Granular materials for special backfill or bedding will be measured in accordance with 2451.4B.

Measurement on the basis of compacted volume will be limited to the minimum dimensions shown in the Plans.

C Precast Concrete Headwalls

Measurement will be by the number of precast concrete headwalls furnished.

2502.5 BASIS OF PAYMENT

Payment of subsurface drains and outlets of each size, type, kind and strength class, at the appropriate Contract prices per unit of measure will be compensation in full for all costs of furnishing and installing the item as specified, except as otherwise provided herein.

For any subdrain elbow or wye sections and necessary additional connectors that are ordered by the Engineer but that are not indicated in the Plan, additional compensation will be made in the amount of the actual invoice cost of the materials involved.

Unless otherwise provided, granular materials for special bedding or backfill will be paid for separately in accordance with 2451.5.

Payment for the drain outlet (precast concrete headwall and discharge pipe) is full compensation for furnishing and placing the unit, wood fiber blanket and seed, marking, inspecting, and all other associated work. Where sodding is required, the Engineer will include the sod with other sod quantities on the Project.

No direct compensation will be made for geotextiles or other joint wrapping or sealing materials.

Any trench excavation required below an elevation more than 300 mm below the bottom of the pipe or tile as shown in the Plans will be paid for as Extra Work.

Unless its existence is shown in the Plans, the removal of ledge rock or rocks larger than 0.4 m³ (**0.5 yard³**) volume from the excavation will be paid for as Extra Work.

Payment for subsurface drains will be on the basis of the following schedule:

2502.5

Item No.	Item	Unit
2502.501	___mm (inch) Precast Concrete Headwall	each
2502.541	___mm (inch) Perforated (1) Pipe Drain (2)	meter (linear foot)
2502.571	___mm (inch) Install (3)	meter (linear foot)
2502.573	___mm (inch) Install (3)	each

- NOTE: (1) Specify Kind---See 2502.2B
(2) Specify Strength Class, if other than minimum requirement.
(3) Specify item name.

2503
Pipe Sewers

2503.1 DESCRIPTION

This work shall consist of the construction of pipe sewers, using plant-fabricated pipe and other appurtenant materials, installed for conveyance of sewage, industrial wastes, or storm water.

Manhole and catch basin construction shall be in accordance with 2506. Where aprons are required, they shall be furnished and installed under the provisions of 2501.

2503.2 MATERIALS

A Pipe

Sewer pipe shall be one of the following kinds as specified or permitted as an option. Unless higher strength pipe is specified, pipe conforming to the lowest strength class covered in the referenced Specification will be acceptable. Special fabrication or jointing details shall be as required by the Plans.

A1	Nonreinforced Concrete (NC)	3253
A2	Reinforced Concrete (RC)	3236
A3	Corrugated Aluminum (CA).....	3225
A4	Corrugated Steel (CS)	3226
A5	Corrugated Aluminized Steel (CAS)	3222
A6	Bituminous Coated-Corrugated	
	Steel (BC-CS).....	3227
A7	Aramid Bonded-Corrugated Steel.....	
	(AB-CS).....	3228
A8	Blank	
A9	Corrugated Polyethylene (CP).....	3247

2503.3

A10 Plastic Truss (PT) 3241
 A11 Vitrified Clay (VC)..... 3251
 A12 Polymeric Coated-Corrugated
 Steel (PC-CS) 3229
 Coating Type shall be as specified in the Contract.
 A13 Thermoplastic 3245
B Flap Gates 3399
C Pipe Joint Sealer Materials
 C1 Hot-Poured Sealing Compound 3724
 C2 Preformed Rubber, Type A..... 3726
 C3 Preformed Plastic, Type B 3726
 C4 Bituminous Mastic 3728
D Granular Materials..... 3149

2503.3 CONSTRUCTION REQUIREMENTS

A General

All sewer installations shall be made according to the following requirements.

The requirements of 2451, as they related to the excavation, foundation construction, and backfilling of prefabricated structures, shall apply together with the additional requirements or modifications contained herein.

B Excavation

Where the cover over the top of the pipe will be 4.5 m (15 feet) or more, that portion of the required excavation that is below an elevation 300 mm (1 foot) above the top of the pipe shall have side slopes as nearly vertical as practicable and, at a point 300 mm (1 foot) above the top of the pipe, the width of the trench shall be no wider than the widths given in the following tabulation:

<u>Pipe Diameter</u>	<u>Maximum Trench Width</u> <u>(300 mm (1 foot) above pipe)</u>
Less than 1050 mm (42 inches) Outside Diameter plus 600 mm (24 inches)
1050 mm to 1350 mm (42 to 54 inches) 1.5 times Outside Diameter
Over 1350 mm (54 inches) Outside Diameter plus 900 mm (36 inches)

If the trench is excavated to a greater width than that authorized according to the above tabulation, the Engineer may direct the Contractor to provide a higher class of bedding, a higher strength pipe,

2503.3

or both, than that required by the Contract; without additional compensation therefor; as the Engineer deems necessary to satisfy the design requirements.

C Laying Pipe

The pipe shall be laid to the required line and grade, each section having a firm and uniform bearing throughout its entire length.

Corrugated metal pipes having circumferential joints shall be laid with the outside laps pointing upgrade and with the longitudinal joints on the sides.

Metal pipe sections shall be joined by use of approved metal connecting bands, centered over the joint, and with the pipe sections as close together as possible. The band shall be tightened sufficiently to ensure a tight joint.

Bituminous coated pipe shall be handled with special care to preserve the coating. All exposed metal shall be recoated with a grade of asphalt similar to that originally applied. Fuel oil or similar solvent may be used to facilitate the installation of coupling bands. The paved portion of bituminous coated and paved pipe shall be centered on the flow line.

Clay and concrete pipe shall be laid with the bell or grooved ends upgrade.

All joints in concrete pipe shall be effectively sealed to provide a flexible water tight joint, using an approved elastic joint sealer material (rubber gasket, preformed plastic, bituminous mastic). Where the pipe specified is specifically designed to accommodate preformed gasket type seals, the joints shall be sealed with the gasket type designed especially for that type of joint as shown in the Plans and the joints shall meet the performance requirements of AASHTO M 198.

All joints in bell-and-spigot type clay pipe, which are not provided with factory fabricated compression seals, shall be effectively sealed with an approved mastic joint sealer, or by being caulked with asphalt impregnated oakum and filling the remainder of the annular space within the bell with hot-poured joint sealing compound. A pouring collar or other device shall be used to hold the hot sealer until set. When the air temperature is below 0°C (32°F), the pipe shall be heated before pouring the sealer.

Mastic joint sealer materials shall be applied in accordance with the recommendations of the manufacturer. All joints shall be wiped clean on the inside after sealing. Lifting holes shall be plugged with a precast concrete plug, sealed, and covered with mastic or mortar.

Pipe junctions and turns shall be made using standard or specially fabricated fittings.

2503.4

When a sewer connects with an existing manhole or catch basin, the Contractor shall make a suitable connection through the wall of the manhole or catch basin.

All branch openings or service connections provided for future use shall be plugged with vitrified clay or concrete stoppers sealed in place.

Where specifically required by the Contract, concrete pipe sections shall be tied together with approved fasteners.

D Backfill

The sewer installations shall be backfilled as required by the Plans and in accordance with 2451.

Excavated materials not required for backfill shall be disposed of as directed by Engineer.

E Installation by Jacking

The applicable requirements of 2501.3C1 shall apply to installation of pipe by jacking.

F Cleanout

The sewers shall be free of any debris before final acceptance.

2503.4 METHOD OF MEASUREMENT

A Excavation

Trench excavation shall be incidental to the sewer installation. Measurement of any Extra Work excavation will be as described in 2451.4 for prefabricated structures.

B Sewer Pipe

Each pipe, as classified by Proposal item, will be measured separately by length along the line of the sewer. Terminal points of measurement will be the pipe end at free outlets; the point of junction with in-place pipe; or the center of manholes, catch basins or multiple junction points as they apply.

Pipe transition sections will be measured as the larger size pipe.

Sections of metal pipe at the outlets of clay or concrete sewers will be considered as metal sewers.

Sewer materials that are furnished by the Department for installation under the Contract will be measured as length of installed sewer, separated as to type but without regard to size.

C Sewer Appurtenances

Flap gates and other specially identified appurtenant items designated for payment on a per Each basis will be measured separately by the number of units of each type and size incorporated in the sewer structures.

2503.4

D Granular Materials

Granular materials for special backfill and bedding will be measured in accordance with 2451.4B.

Measurement on the basis of compacted volume will be limited in width to the maximum trench widths allowed under 2503.3, Excavation.

2503.5 BASIS OF PAYMENT

Payment for sewer pipe of each size, type, kind, and strength class, at the appropriate Contract prices per unit of measure, will be compensation in full for all costs of furnishing and installing the pipe complete in place as specified, except as otherwise provided herein.

For elbow, tee or wye sections and the necessary additional connectors that are ordered by the Engineer but that are not indicated in the Plans, additional compensation will be made in the amount of the actual invoice cost of the materials involved.

Payment for installing sewer materials provided by the Department will be made under the applicable installation item indicated in the Proposal and, except for Extra Work or work designated under other items, will be considered as full compensation for all the work and additional materials used in installing the sewer complete in place.

Granular materials for special bedding or backfill will be paid for separately in accordance with 2451.5.

Where installation by jacking is permitted, in the absence of a specific pay item therefor, payment will be made on the same basis as if the sewer were installed by the trenching method.

Payment for flap gates at the Contract price per unit will be compensation in full for furnishing and installing the gates complete in place as specified.

Any aprons required in connection with the sewer construction will be paid for separately in accordance with 2501.5.

Any required excavation more than 300 mm (**1 foot**) below the bottom of the pipe, as shown in the Plans, will be paid for as Extra Work.

Unless its existence is shown in the Plans, the removal of ledge rock or rocks larger than 0.4 m³ (**1/2 cubic yard**) in volume from the excavation will be paid for as Extra Work.

Payment for sewers will be made on the basis of the following schedule:

Item No.	Item	Unit
2503.511	___mm (inch) (1) Pipe Sewer (2).....	meter (linear foot)
2503.519	Flap Gate for (3) Pipe	each
2503.521	___mm (inch) Span (1) Pipe-Arch Sewer (2)..... meter (linear foot)

2506.2

2503.531	___ mm (inch) (1) Elliptical Pipe Sewer (4)	meter (linear foot)
2503.541	___ mm (inch) (1) Pipe Sewer, Design (5) (2)	meter (linear foot)
2503.571	Install (6)	meter (linear foot)
2503.573	Install (6)	each

- NOTE: (1) Specify Kind---See 2503.2A.
(2) Specify Strength Class, if other than minimum requirement.
(3) Specify Size and Kind.
(4) Specify HE or VE, and Strength Class, if other than minimum requirement.
(5) Special Pipe or Joint Designs---Give Standard Plate Number.
(6) Special item name.

2506

Manholes and Catch Basins

2506.1 DESCRIPTION

This work shall consist of constructing or reconstructing brick or concrete block masonry, cast-in-place concrete, precast sectional concrete, or pipe structures, built for the purpose of providing access to underground drainage or other systems for the ingress of surface water into underground drainage systems.

For the purposes of this Specification, precast concrete median drains will be considered to be casting assemblies.

2506.2 MATERIALS

A Concrete 2461

3B42 concrete shall be used for cast-in-place structures of Designs A, C, E, F, or G; and for drop inlet surface block.

3Y43 concrete shall be used in all other cast-in-place structures.

B Mortar

Mortar shall conform to ASTM C 270. The cement shall be either Type S masonry cement or 2 to 4 parts of Portland cement to 1 part of Type S hydrated lime. Mortar sand shall have a volume equal to 2.25 to 3 times the total of the volume of cement and lime. Sufficient water shall be added for proper consistency.

2506.2

The cement and lime shall be air-entrained unless approved otherwise by the Concrete Engineer. The entrained air content of the mortar shall be within the range of 7-10 percent.

B1	Portland Cement	3101
B2	Hydrated Lime (Type S).....	3106
B3	Masonry Cement (Type S)	3107
B4	Mortar Sand	3128
C	Clay Brick	3612
D	Concrete Brick	3616
E	Concrete Masonry Units	3621
F	Sectional Concrete Manhole/Catch Basin Units.....	3622
G	Clay Pipe, Standard Strength	3251
H	Nonreinforced Concrete Pipe	3253
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

A1 Combination Construction

The Engineer may permit a combination of cast-in-place and prefabricated concrete construction for those structures where a type of construction is not specified and where structural strength and continuity is maintained.

A2 Intercepting Existing Facilities

Where the new structure will intercept an existing underground facility, the existing facility shall be incorporated into the structure to the extent required, including any necessary removal, replacement, or special connections, without detriment to the planned function of the facility.

A3 Abandoned Pipes

Any abandoned pipes that enter a structure that will not be abandoned shall be detached from the structure and the wall opening shall be permanently plugged with concrete or masonry. The upgrade

end of the abandoned pipes shall also be plugged with concrete or masonry.

A4 Excavation, Bedding, and Backfill

Excavation, bedding, and backfill construction requirements shall be as indicated in 2451.

A5 Inspection Before Construction

Mortar shall not be placed in any unit or section of work, until the Engineer has inspected and approved the required foundation preparations, materials, and provisions for cold weather protection.

A6 Temperature Restrictions

A6a Mortar shall not be placed on a frozen foundation or against any surface with a temperature below freezing.

A6b Concrete or mortar production shall not commence or continue when the air temperature at the construction site in the shade or away from artificial heat is below 2°C (**36°F**) :

- (1) Unless authorized by the Engineer when the air temperature is rising and has reached 1°C (**34°F**).
- (2) Unless provisions satisfactory to the Engineer have been made in advance for cold weather protection.

A6c Masonry units or aggregate whose temperature is 0°C (**32°F**), or less, shall not be used except under direct supervision of the Engineer.

A6d All concrete or mortar mixes shall have a temperature of not less than 10°C (**50°F**) nor more than 32°C (**90°F**). The mix shall be maintained within this temperature range until it is deposited in the work.

A6e The Engineer may approve heating of masonry units, mix materials, or mortar by an approved heating system operated in an acceptable manner. Spot heating of such materials by means of steam jets or direct application of combustion heating devices as the work progresses will not be permitted.

B Cast-In-Place Concrete 2411

C Masonry

The following requirements shall apply when part or all of the structure is constructed using clay brick or concrete masonry units. The term, "unit", as applied herein, shall refer to either the brick or concrete block unless otherwise qualified.

Concrete masonry units shall not be moistened prior to placement in the work, but all other types of masonry units shall be moistened before being laid.

Units shall be laid in a full mortar bed, in horizontal courses, using the "shove joint" method. All joints shall be filled with mortar. Joints

2506.3

on the inside of the structure shall be no more than 13 mm (**1/2 inch**) wide and shall be struck. The outside of the structure shall be plastered with mortar to a smooth surface.

Steps, pipes, or other required fixtures shall be installed as the work progresses. The units shall be fitted carefully around any pipe that penetrate the structure, using only part of a unit as necessary to form a neat juncture at the pipe. All attachments to the structure shall be bonded using mortar to fill all voids.

Where the manhole/catch basin is constructed of brick, the following additional requirements shall apply:

- (1) In circular type structures, the bricks shall be laid 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 outside bricks may be laid circumferentially, using full header construction in at least each sixth course.
- (2) In rectangular type manholes, the bricks shall be laid in regular courses of stretchers, using full header construction in at least each sixth course. No bats or spalls shall be used except for shaping around openings or for finishing out a course, in which case full bricks shall be placed in the corners and the bats in the interior of the course. The least dimension of the exposed faces of bats shall be not less than 50 percent of the width of a brick.

Where the Contractor elects to use the alternate method of constructing the tapered portion of a manhole with concrete block, as shown in the Plans, specially shaped concrete units shall be used to transition between the vertical and the sloped walls.

D Sectional Concrete

The bottom pre-cast section shall be set in a full mortar bed and the joints between sections and around pipes shall be filled with mortar or an approved plastic cementing compound.

E Pipe

Metal or concrete pipe manholes shall be constructed in accordance with the details shown in the Plans.

F Castings

The frame or ring castings shall be set to the designated elevation on a full mortar bed except when metal pipe construction is used.

Where the Plans indicate that the casting shall not be bonded to the manhole/catch basin, the mortar bed shall be finished to the required grade and allowed to set, after which an approved lubricant shall be applied thereto and the casting installed.

G Adjusting Frame or Ring Castings

Vertical adjustment of access castings shall be made to the planned elevation on the existing structure, based on the criteria that full support

2506.4

for the casting is obtained above the cone section and that the structure construction above the cone does not exceed 600 mm (**2 feet**). Where these criteria cannot be maintained in the adjustment work, the structure shall be reconstructed.

For upward adjustment of castings, any of the structure materials or applicable construction methods indicated herein which are compatible with the in-place construction may be used. Auxiliary ring castings and adjusting rings, as indicated in the Plans, may be used as they apply.

H Reconstructing In-Place Structures

When the Plans call for a portion of the manhole/catch basin to be reconstructed, or when the frame or ring casting is to be raised or lowered beyond the limits defined in 2506.3G above, the structure shall be reconstructed to the extent shown in the Plans or directed by the Engineer.

Reconstruction shall be consistent, so far as possible with the type of construction used for the in-place structure. The work shall conform to the requirements specified above for new construction except that the salvaged material may be used if of acceptable quality. New work shall be thoroughly bonded to the old.

I Blank

J Construction in Conjunction with Pavement Construction

When manholes/catch basins are constructed, reconstructed or adjusted, in connection with the construction of a concrete pavement or base, the telescoping type of ring shall be used unless otherwise specified in the Plans.

When the telescoping type of ring is required, the frame or ring casting shall be set to the proper elevation before the pavement is placed.

K Backfilling

When the structure is made of cast-in-place concrete or of bricks or blocks laid in mortar, the backfilling shall not be made until at least 3 days have elapsed after the completion of the manhole or catch basin.

Excavated materials not required for backfill shall be disposed of as directed by the Engineer, within a haul distance of 1 km (**1/2 mile**).

2506.4 METHOD OF MEASUREMENT

Manholes and catch basins will be measured as drainage structures.

A Constructing Drainage Structures

When measurement by length is specified, for vertical structures constructed on a concrete base, the length measurement will be the difference in elevation between the bottom of the casting and the invert elevation of the outlet pipe, plus an allowance of 0.20 m (**0.70 foot**) for the depth of the concrete base, regardless of its actual thickness.

2506.4

When measurement by length is specified, for pipe structures where the design provides for the use of a "tee" section in the sewer or culvert line, the length measurement will be the difference in elevation between the bottom of the casting and the flow line elevation of the sewer or culvert pipe in the case of vertical construction, or as shown in the Plans in the case of other special designs not constructed vertically. The "run" of the "tee" section will also be measured and paid for as culvert or sewer pipe, as the case may be.

When measurement by the structure is specified, drainage structures of each design will be measured separately as individual units complete in place, including any castings furnished and installed.

B Reconstruction

Measurement will be made, to the nearest 30 mm (**1/10 foot**), of the height from the bottom of the reconstructed portion to the bottom of the newly set casting, with no regard as to type.

C Castings

Measurements for casting assembly will be by the number of casting assemblies furnished and installed.

Measurements for install casting will be by the number of castings installed by the Contractor.

No measurement will be made of castings for structures that are measured as a unit. All castings required for an individual structure will be considered as one assembly.

D Adjusting Castings

Measurement will be by the number of casting assemblies adjusted, all castings in any one structure being considered as one assembly.

2506.5 BASIS OF PAYMENT

Manholes and catch basins will be paid for as drainage structures.

Payment for constructing or reconstructing drainage structures at the appropriate Contract prices will be compensation in full for all costs of the work (including all necessary excavation) except those costs for which the Proposal contains specific items, subject to the following additional provisions:

- (a) Any excavation that is in ledge rock and the removal of boulders or detached rocks each having a volume of more than 0.4 m³ (**1/2 cubic yard**) will, unless the existence of such rock is shown in the Plans, be paid for as Extra Work.
- (b) Payment for reconstructing drainage structures includes removal of the existing casting but does not include placement of a casting on the reconstructed structure.
- (c) Payment will be made for the removal and replacement of concrete base or concrete pavement when, except for the structure

2506.5

construction, the surface would not otherwise have been disturbed. Payment will be at the appropriate unit prices on the basis of the area, to the nearest 0.1 m² (**1/10 square yard**), within a rectangle having sides that lie 0.5 m (**1-1/2 feet**) outside of the structure limits. No direct compensation will be made for removing and replacing any pavement outside of these limits or for replacing any other type of surfacing.

- (d) Payment for drainage structure construction by the structure as individual units complete in place will be compensation for furnishing and installing any castings required.
- (e) No direct payment will be made for removal and replacement of concrete surfacing in connection with the item of adjust frame and ring castings.
- (f) Granular materials for special bedding or backfill will be paid for in accordance with 2451.5.

Payment for drainage structures will be made on the basis of the following schedule:

Item No.	Item	Unit
2506.501	Construct Drainage Structure,.....	
	Design _____	meter (linear foot)
2506.502	Construct Drainage Structure, Design _____	each
2506.503	Reconstruct Drainage Structure.....	meter (linear foot)
2506.516	Casting Assembly	each
2506.521	Install Casting	each
2506.522	Adjust Frame and Ring Casting	each

2511

**2511
Riprap**

2511.1 DESCRIPTION

This work shall consist of furnishing and placing stone riprap, with or without grouting as specified, at the locations shown in the Plans or ordered by the Engineer, as a protective covering on earth slopes, piers, abutments, walls, or other structures, where the soil is susceptible to erosion.

Riprap will be classified by type as random riprap, handplaced riprap, or quarry-run riprap, depending on the method of placement and the stone size specified. Riprap shall be grouted when specified in the Contract or ordered by the Engineer. The riprap shall be placed on a filter layer consisting of granular material or geotextile unless otherwise specified.

2511.2 MATERIALS

A	Riprap Materials	3601
B	Filter Materials	
B1	Granular Filter	3601
B2	Geotextile Filter	3733
C	3A-Grout	2461

2511.3 CONSTRUCTION REQUIREMENTS

A General

The foundation for the riprap, with or without filter material, shall be excavated and shaped to the cross-sections indicated in the Plans, unless otherwise directed by the Engineer. All loose foundation material shall be thoroughly compacted before placement of the riprap or filter material.

When riprap is required, the Contractor shall place a thickness of 300 mm (**1 foot**) of riprap on a filter material unless otherwise indicated in the Contract or ordered by the Engineer.

B Filter Material

The Contractor shall place filter material under the riprap unless otherwise specified in the Contract. Filter material shall cover the entire area on which the riprap is to be placed. The Contractor may choose the type of filter material, except as restricted for geotextile filters, unless the type is specified in the Contract.

B1 Granular Filter

1. When granular filter is used, the thickness shall be 150 mm (**6 inches**) unless other dimensions are specified.

Granular filter materials shall be spread to uniform thickness over the prepared foundation. Granular material placed under water shall

2511.3

be deposited directly on the foundation by means of a bucket or similar container. Discharging the granular material above the water surface will not be permitted.

B2 Geotextile Filter

Wherever geotextile filter material is placed, the Contractor shall ensure that:

- (a) The foundation surface is relatively smooth and free of stones, sticks, and other debris or irregularities that might puncture the fabric.
- (b) Placing material or conducting construction operations do not tear, puncture, or shift the fabric.

Where multiple fabric widths or lengths are required, they shall be placed with the longest dimension parallel to the direction of water flow. If not seamed, splices and joints shall be overlapped a minimum of 0.5 m (**18 inches**), except that under water the overlap shall be 1 m (**36 inches**). The joint laps shall be shingled (both in the flow direction and from top of slope to bottom) so as to direct water flow over the joint without undermining. In lieu of joint overlapping, multiple fabric pieces may be sewn to meet appropriate sections of 3733. Upgrade edges of the fabric area shall be buried sufficiently to direct water flow over the fabric without undermining. If not seamed, washered steel pins, edge stakes, stones, etc. shall be placed at locations and in quantities as approved by the Engineer, to prevent movement of the geotextile filter during placement of the riprap.

Dumping of stone at the top of the slope and rolling of stone down the slope will not be permitted. When stones are placed directly on the geotextile filter without a granular cushion, equipment will not be permitted to operate on top of the stones once they are placed. Construction equipment shall not operate directly on top of the geotextile.

Geotextile filter material shall not be used under handplaced or grouted riprap unless so specified.

Geotextile filter may be used only on 1 vertical to 3 horizontal or flatter slopes, unless slopes up to 1 vertical to 2 horizontal are stepped (terraced) before fabric placement.

C Riprap Stone

Stones shall not be dropped on the fabric from a height greater than 0.3 m (**1 foot**) unless the fabric is covered with a 150 mm (**6 inch**) thick granular cushion course, in which case the riprap stone may be dropped from a height not greater than 1 m (**3 feet**).

Riprap shall generally be placed by starting at the lowest elevations and working upwards.

2511.3

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 3 m² (**4 square yards**) of riprap to inspect for fabric damage, subject to 1511.

C1 Random Riprap

Random riprap shall be positioned in a manner that will provide uniform distribution of the various sizes of stone and produce a dense, well-keyed layer of stones with the least practical quantity of void space. The surface shall be leveled as necessary, to produce a reasonably uniform appearance and the required thickness.

C2 Hand-Placed Riprap

The stones for hand-placed riprap shall be firmly embedded in the foundation material, with the axis of the stone that most nearly approximates the specified thickness of riprap laid perpendicular to the foundation slope. Stones shall be laid with minimum practicable quantity of space between them and positioned to stagger the joints up the slope. Each stone shall be so placed that its mass is carried by the foundation material as well as adjacent stones.

The ends and edges of each riprap area shall be well defined using selected stones set to line and grade.

After the larger stones have been laid, the spaces between the stones shall be filled with firmly seated, smaller stones to produce a uniform surface.

C3 Quarry-run Riprap

Quarry-run riprap shall be placed as specified for random riprap.

D Grouting

For grouted riprap, the Contractor shall eliminate some of the smaller stones so that the spaces between stones, throughout the entire thickness of the riprap, is filled with grout.

Immediately before placing the grout for grouted riprap, the stones shall be thoroughly wetted with water. Grout shall not be poured over stones that have become surface dry. The surface of the grouted riprap shall be finished by sweeping with a stiff broom.

E Thickness Requirements

The riprap on each separate area shall have, upon completion, a minimum thickness of not less than 80 percent of the specified thickness and an average thickness of not less than 95 percent of the specified thickness, as measured at right angles to the face.

2511.5

2511.4 METHOD OF MEASUREMENT

A Riprap

Riprap of each type and class measured by volume will be computed on the basis of actual surface dimensions as staked and the specified thickness.

Riprap of each type and class measured by mass will be based upon scale tickets of materials delivered and placed within the staked areas.

B Filter Materials

Filter materials measured by mass will be based upon scale tickets of material delivered and placed within the staked areas.

Filter materials measured by volume will be computed on the basis of actual surface dimensions as staked and the specified thickness.

Geotextile filter material measured by area will be computed on the basis of actual surface dimensions as staked, with no allowance for overlaps or seams.

2511.5 BASIS OF PAYMENT

The Contractor will accept payment for riprap of each type and class at the Contract price per unit of measure as compensation in full for all costs of furnishing the required materials; excavating and preparing the foundations; and placing the riprap stone, grouting, and filter materials as specified. The Contractor will receive separate compensation for filter materials only when the Contract contains the appropriate pay items.

Payment will be as follows:

Item No.	Item	Unit
2511.501	Random Riprap, Class ____	cubic meter (cubic yard)
2511.502	Random Riprap, Class ____	metric ton (ton)
2511.503	Quarry-run Riprap	cubic meter (cubic yard)
2511.504	Quarry-run Riprap	metric ton (ton)
2511.505	Hand-placed Riprap.....	cubic meter (cubic yard)
2511.507	Grouted Riprap	cubic meter (cubic yard)
2511.511	Granular Filter	cubic meter (cubic yard)
2511.513	Granular Filter	metric ton (ton)
2511.515	Geotextile Filter, Type ____	square meter (square yard)

2512

2512

Gabions and Revet Mattresses

2512.1 DESCRIPTION

Furnish and construct gabions and revet mattresses (placing stone in wire baskets) at the locations shown in the Plans or ordered by the Engineer.

2512.2 MATERIALS

A	Riprap Materials	3601
B	Filter Materials	
B1	Granular Filter	3601
B2	Geotextile Filter	3733
C	Gabions.....	3602
D	Revet Mattresses.....	3602

2512.3 CONSTRUCTION REQUIREMENTS

A General 2511.3

The Contractor shall:

- (1) Excavate, shape, and compact the foundation to the elevation and alignment indicated in the Contract.
- (2) Furnish and place filter material, unless otherwise stated in the Contract.
- (3) Furnish and place gabions and revet mattresses.

B Filter Material

The Contractor shall place filter material over the entire area on which the gabions and revet mattresses are to be placed.

B1	Granular Filter	2511.3
B2	Geotextile Filter	2511.3

The Contractor may place geotextile filter material under gabions and revet mattresses on slopes without stepping when specified in the Contract or approved by the Engineer.

C Baskets and Fasteners

C1 Documentation

The Contractor shall provide:

- (a) Certification that the baskets and fasteners meet the requirements.
- (b) Manufacturer's drawings of the baskets and fasteners.
- (c) Manufacturer's assembly recommendation and instructions for the baskets and fasteners.

C2 Construction

The Contractor shall install the baskets to the dimensions, profile, and alignment shown in the Contract or ordered by the Engineer.

2512.3

The Contractor shall:

- (a) Assemble the baskets according to the manufacturer's recommendations unless the following requirements, 3602, or the Plan state otherwise.
- (b) Place and fasten the diaphragms in the baskets to the side and bottom mesh so that cell dimensions are not more than 1 m (**3 feet**).
- (c) Fasten adjoining empty baskets together at their perimeters.
- (d) 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 in the dimensions shown in the Plans. This will require some stones to be hand-placed.
- (e) Generally fill cells in 300 mm (**12 inch**) lifts. Fill cells of up to 300 mm (**12 inches**) in one lift. Fill cells of up to 450 mm (**18 inches**) in two equal lifts. Do not fill cells more than 300 mm (**12 inches**) higher than stone layers in adjacent cells or baskets.
- (f) For twisted wire gabions place horizontal connecting wires on top of the stone layer in both directions where there is not a supporting basket, to prevent the sides from bulging. For welded wire gabions install preformed stiffeners across the corners of the gabions before filling. Two rows of stiffeners (4 per cell) are required for the front face and the side faces. A single row of stiffeners (2 per cell) are required on the back face. No stiffeners are required in interior cells. Preformed stiffeners shall have a nominal length of 450 mm (**18 inches**). The stiffeners should be hooked at crossing wires. Lacing wire may be used as a stiffener.
- (g) Fold the top of baskets shut and fasten to the ends, sides, diaphragms, and adjacent baskets, after the basket is filled.
- (h) Stack empty baskets on filled baskets and fasten to the filled baskets at front, exposed sides, and back before filling.
- (i) Blank
- (j) Stagger the vertical joints between the baskets of adjacent rows and layers unless otherwise shown in the Contract.
- (k) Blank
- (l) Backfill behind a gabion structure simultaneously with the cell filling operation.

C3 Fasteners

The Contractor may use either lacing wire, an approved alternative fastener, or a combination, to fasten the baskets.

C3a Lacing Wire

The Contractor shall place lacing wire at each joint alternating single and double loops every 75 to 150 mm (**3 to 6 inches**).

2512.3

C3b Alternative Fastener

The Contractor shall place alternative fasteners at each joint at every mesh opening. If spiral binders are used they shall be adequately secured at the ends to prevent unwinding.

D Acceptance

The Engineer may consider the work as unacceptable if visible baskets have a variation of more than 150 mm (**6 inches**) from the profile or alignment shown in the Plans or as directed by the Engineer.

2512.4 METHOD OF MEASUREMENT

A Gabion and Revet Mattress

The Engineer will measure the 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 Department will make payment for gabions and revet mattresses at the Contract price per unit of measure as full compensation for all costs of furnishing the required materials, excavating and preparing the foundations, furnishing and installing filter materials, and constructing and filling the gabions and revet mattresses as specified.

The Department will make separate compensation for filter materials only when the Contract contains the appropriate pay items as listed in 2511.

The Department will pay as follows:

Item No. Item	Unit
2512.517 Gabion	cubic meter (cubic yard)
2512.519 Revet Mattress	cubic meter (cubic yard)

2514

Slope Paving

2514.1 DESCRIPTION

This work shall consist of paving embankment slopes and waterways with Portland cement concrete or crushed aggregate, as specified, to provide erosion protection.

2514.2 MATERIALS

A Concrete 2461

Unless otherwise specified, the concrete shall meet the requirements for Mix Designation 3A34, except that the slump requirement may be adjusted as approved by the Engineer to achieve the desired results. The delivered batch size shall not exceed 2.5 m³ (**3 cubic yards**).

2514.3

- B Reinforcement Bars..... 3301**
- C Preformed Joint Filler..... 3702**
- D Bituminous Material..... 3151**

Reinforcement shall be either Grade 300 or Grade 420 (**Grade 40 or Grade 60**) deformed billet Steel, of ASTM A 615/A 615M.

Bituminous material for stabilizing aggregate slope paving shall be Liquid Asphalt, Grade MC-250, MC-800, RC-70, RC-250, RC-800, or Emulsified Asphalt, Grade CSS-1, CSS-1H, RS-1, or CRS-2.

E Aggregate

The material for aggregate slope paving shall conform to 3137 for gradation class CA-1, CA-2, or CA-3, except that the fourth paragraph of 3137.2E (multiple fraction requirement) shall not apply and washing of the aggregate will not be required.

2514.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

The foundation upon which the paving material is to be placed shall be prepared as necessary to achieve the specified paving dimensions and surface elevations as indicated in the Plans or directed by the Engineer. Foundation preparations shall include the excavating of high spots and the filling and compacting of low spots until the foundation conforms to the required elevation and slope and is of uniform density.

In the event the rough grading was performed by others under another contract and the Engineer determines that there is either a shortage or excess of material to construct to the planned foundation elevations, the Engineer may make such minor adjustments in grade to balance out the available material or may order the placement of additional material from other sources or the removal and outside disposal of excess material, as may be required to achieve acceptable foundation elevations. The furnishing and placing of additional material and the removal and outside disposal of excess material by order of the Engineer will be compensated for as Extra Work to the extent that loading and hauling of the material is necessary. Excess material disposed of on areas adjoining the slope paving as directed by the Engineer, without loading and hauling, will not be compensated for separately as Extra Work but will be considered as being incidental to the slope paving item.

B Aggregate Slope Paving

The aggregate shall be deposited, spread, consolidated, and shaped by mechanical or hand methods that will provide uniform depth and density and produce uniform surface appearance. Liquid asphalt shall be applied when ambient air temperature is not less than 5°C (**40°F**), at an approximate rate of 8 L per m² (**1.8 gallons per square yard**). Emulsified asphalt shall be applied when ambient air temperature is not

2514.3

less than 10°C (50°F), at an approximate rate of 11 L per m² (2.5 gallons per square yard). Bituminous materials shall penetrate to a depth of not less than one-half the required thickness of the aggregate slope paving. Adjacent structure surfaces shall be protected against bituminous splatter.

C Concrete Slope Paving

Construction shall be in accordance with the applicable provisions of 2401. The concrete shall be placed, consolidated, struck-off, and hand floated as will secure dense pavement relatively free of voids and cavities and produce uniform surface appearance. Side forms shall be so set and supported and the concrete so finished as to result in surfaces that do not deviate from a true plane and the prescribed grade by more than plus or minus 13 mm (1/2 inch). Metal reinforcement and preformed filler material shall be placed as required by the Plans and shall be suitably supported to maintain correct position during concrete placement.

Toe walls and side walls shall be formed and cast prior to placing concrete for contiguous slope paving. The subgrade shall be moist at the time of concrete placement, and care shall be taken to prevent subgrade displacement and contamination of the concrete. The slope paving shall either be placed in equally spaced alternate strips running in the direction of maximum slope, or in full width sections when mechanical equipment adequate for such placement and finishing is provided.

Immediately after placement the concrete shall be consolidated and struck off. When the concrete has set sufficiently to maintain shape, the surface shall be struck off again, after which the surface shall be given a final finish by hand floating with a cork or wood float and then broomed to produce a uniform texture and appearance.

After the final floating, all edges not formed with v-strip inserts shall be finished with a suitable edging tool and all panel lines shall be cut with suitable grooving tools or they may be sawed as directed by the Engineer. All edging and grooving flange trails shall be obliterated by floating to secure uniform surface appearance.

After completion of the concrete finishing operations, all exposed surfaces shall be given curing protection in accordance with 2401.3G until a strength gain of at least 30 percent has been attained.

2514.4 METHOD OF MEASUREMENT

Slope paving of each type will be measured separately 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

Payment for slope paving of each type specified at the Contract price per unit of measure of surface area will be compensation in full for all costs of constructing the work complete in place as specified.

2520.3

Payment for slope paving will be made on the basis of the following schedule:

Item No.	Item	Unit
2514.501	Concrete Slope Paving	square meter (square yard)
2514.503	Aggregate Slope Paving	square meter (square yard)

2520

Lean Mix Backfill

2520.1 DESCRIPTION

This work shall consist of placing a lean cementitious backfill into utility and culvert trenches, or other such excavations, where the use of conventional compacting equipment is deemed inappropriate or impractical. It is neither a low strength concrete nor a soil cement, but is a controlled-density backfill material.

2520.2 MATERIALS

A	Cement	3101
B	Fly Ash	3115
C	Fine Aggregate	3126
D	Coarse Aggregate	3137

The provisions of 3137.2C and 3137.2D shall not apply.

E	Water	3906
F	Admixtures	3113

2520.3 MIX REQUIREMENTS

A Mix Design and Control

Lean mix backfill design shall be governed by the absolute volume relationships; and basic mix proportions set forth herein for the control of cement, fly ash, water, and aggregate content; and the degree of workability necessary for proper placement.

A1 Tentative Material Proportioning

The proportions shall be such as to obtain the flowability, workability, and consistency required for the Project. Once the Contractor provides the Engineer with the source of materials, the Engineer will, within 10 days, furnish a mix design for the use on this Project. This design will be based on the following proportions per unit batch (volume approximately 1 m³ (**cubic yard**)).

Cement	75 kg (125 lbs)
Fly Ash.....	150 kg (250 lbs)
Water.....	225 kg (375 lbs)

2520.3

The remaining volume will consist of:

Fine Aggregate50%
Coarse Aggregate50%

Gradation Range 6 as shown in 2461.3B3

A2 Mix Requirements

Slump 250 mm ± 25 mm (**10" ± 1"**)

Unconfined Compressive Strength:

Minimum desirable: 500 kPa (**75 psi**) at 28 days

Maximum desirable: 2750 kPa (**400 psi**) at 28 days

A3 Job Mix Proportions

The tentative job mix will be designed based on the above proportions for use at the start of construction and until the required water content and strengths can be determined. Experience from previous work using the same material sources may be used to modify the tentative proportions.

As soon as practicable after the tentative mix has been used on the Project, the Engineer will establish the job mix in accordance with the mix requirements.

A4 Mix Adjustments

The Department reserves the right to make adjustments in the mix any time as may be found necessary to maintain the specified consistency and strengths.

B Production Controls

The production shall meet the requirements of 2461.4 A1, A2, A3, and A5 except where the word concrete is used it shall be understood to mean lean mix. The manual referred to shall be the Mn/DOT Concrete Manual.

C Batching and Mixing Requirements

C1 Proportioning Methods

Lean mix batch materials shall be proportioned by mass (weight) except where volumetric proportioning is authorized in writing by the Engineer.

C2 Other Batching and Mixing Requirements

These requirements shall meet 2461.4 B2, B3, B4, B5, and 2461.4C except that the word concrete shall be understood to mean lean mix.

D Ready-Mixed Lean Mix Backfill

The provisions of 2461.4, Ready-Mix Concrete, shall apply except that the word concrete shall be understood to mean lean mix.

E Construction Requirements

The mix has a very high slump, flowability and workability, that eliminates the need for labor-intensive vibration and compaction. The mix consistency is similar to that of a slurry and as such will seek its own level; therefore, it is the responsibility of the Contractor to plug openings below the level of the desired backfill that would permit escape of the mix. The lean mix shall be placed so that it flows around and beneath such footings, foundations, walls, pipes, or other structures it was designed to support. When properly placed, the material is self-compacting, self-densifying, and has sufficient plasticity that compaction or mechanical vibration is not required. Air pockets that water would normally fill must be vented or otherwise eliminated so as to preclude voids remaining in the completed backfill.

E1 Curing and Protection

The air in contact with lean mix backfill surfaces should be maintained at temperatures above freezing for a minimum of 72 hours.

There is a substantial water gain (bleeding) on the surface that is normal. Once this water has evaporated no other means of curing is deemed necessary.

2520.4 METHOD OF MEASUREMENT

Only when payment is prescribed under the following provision will the quantity of lean mix backfill produced and furnished be measured as a separate pay item. Then, the volume of the lean mix backfill will be measured as the computed, theoretical volume based on the mass of the individual batch ingredients. The quantities so determined will be reduced for payment by all accountable waste.

2520.5 BASIS OF PAYMENT

In general payment for lean mix backfill will be considered as incidental to other work as would common backfill.

Should the Department determine a need exists for such a pay item, it will be shown in the Plans. Payment will be made at the Contract price per unit of measure. This will be compensation in full for all costs of producing and furnishing the lean mix backfill and for all costs of forming, plugging, placing, venting, protecting as required except for such costs that are specifically compensated for under other Contract items.

Item No. Item	Unit
2520.501 Lean Mix Backfill	cubic meter (cubic yard)

2521

2521
Walks

2521.1 DESCRIPTION

This work shall consist of bituminous or concrete walkway construction in accordance with these Specifications and close conformity with the lines and grades indicated in the Plans or established by the Engineer.

2521.2 MATERIALS

A	Concrete, Mix No. 3A32.....	2461
	Concrete, Mix No. 3A36.....	2461
B	Preformed Joint Filler.....	3702
C	Blank	
D	Concrete Treating Oil.....	3917
E	Bituminous Mixture, Type as Specified.....	2331
F	Curing Materials	
F1	Curing Paper.....	3752
F2	Plastic Sheeting.....	3756
F3	Membrane Curing Compound.....	3754
F4	Extreme Service Membrane Cure.....	3755
G	Granular Materials.....	3149

2521.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

The foundation shall be excavated, shaped, and compacted to a firm, uniform bearing surface, conforming to the planned section and established grade. Unsuitable subgrade soils shall be removed and replaced as directed. Granular material, as specified and where required by the Plans, shall be furnished, placed, and compacted thoroughly to the required depth.

B Forms

Forms shall be of wood or metal, coated on the contact face with form treating material, and in a condition that will allow proper finishing and subsequent form removal. The form height shall be at least that of the planned walk thickness.

C Concrete

C1 Placing and Finishing Concrete

The foundation and forms shall be thoroughly wetted immediately prior to the placing of the concrete.

The concrete shall be placed, consolidated to fill all voids, struck off to the required grade, and floated smooth. After the water sheen has

2521.3

disappeared, the joints shall be edged and the surface lightly brushed to a uniform texture.

The surface shall not vary more than 5 mm (**3/16 inch**) from a 3 m (**10 foot**) straight edge, and the formed concrete shall be within 13 mm (**1/2 inch**) of the required location.

Forms shall remain in place for a minimum 12 hours after placing the concrete therein unless earlier removal is authorized by the Engineer.

C1a Exposed Aggregate Finish

Concrete Mix No. 3A36, modified for exposed aggregate construction shall conform to the requirements of Mn/DOT 3137 CA-50 and be multi-colored rounded stone.

Provide an exposed aggregate finish using surface retardation to produce a medium to deep exposure, so that the aggregate becomes the dominant surface feature. Embedment or top seeding of aggregate is not permitted.

Apply retardant coating as soon after the concrete surface has been screeded, edged, and jointed. Retardant shall be applied in accordance with the manufacturer's instructions to produce a 6 mm (\pm 2mm) etch of mortar removal after final set.

Surface mortar shall be removed by washing with water under pressure. Avoid excessive pressure which loosens individual aggregate particles.

Following approval of the exposed aggregate finish obtained, a 10 percent muriatic acid wash shall be applied to the exposed aggregate surfaces. Surfaces shall be flushed thoroughly with water following a 5 to 10 minute interaction period between the acid solution and the surface.

Curing of the concrete shall be continued by covering with white polyethylene sheeting. Any staining or streaking of the exposed aggregate surface resulting from the moist curing shall be removed before applying the sealer.

The exposed aggregate finish shall be sealed with two coats of a clear acrylic based compound with 18 percent minimum solids conforming to ASTM C309.

C2 Joint Construction

The walk shall be divided into panels of uniform size, outlined with contraction or expansion joints as required by the Plans. The panels shall be square where practicable and generally have not more than 3 m² (**36 square feet**) of area.

Joints shall be vertical and straight, and be parallel with or at right angles to the walk centerline where possible. The joints shall align with like joints in adjoining work unless the work is isolated by 13 mm (**1/2 inch**) preformed joint filler.

2521.3

All joints and edges of the walk shall be rounded with a 6 mm (**1/4 inch**) radius edging tool.

Contraction joints shall extend to at least 30 percent of the walk thickness and shall be approximately 3 mm (**1/8 inch**) wide.

Expansion joints shall be 13 mm (**1/2 inch**) wide and shall be equal in depth to the full thickness of the walk.

Joint construction at locations where a fixed object or structure extends through the walk shall be modified to the extent deemed necessary by the Engineer. Preformed joint filler material, 13 mm (**1/2 inch**) thick, shall be placed adjacent to all fixed objects so as to separate the object from the abutting concrete edges.

C3 Concrete Curing and Protection

After the finishing operations have been completed and as soon as the set of the concrete permits, the concrete shall be cured for a minimum period of 72 hours. The curing shall be in accordance with one of the methods prescribed herein. Where side forms are used, the edges shall receive the curing media within 30 minutes after removal of the forms. During cold weather, the Contractor shall protect the concrete from frost damage prior to and throughout the duration of the cure.

After September 15th, in that part of the State which is north of the 46 degree Parallel, and after October 1 in that part of the State which is south of the 46 degree Parallel, or before April 15, only the blanket curing or extreme service membrane methods of curing will be permitted.

With the blanket method, after being cured the prescribed minimum period of 72 hours, the concrete shall be treated with two applications totaling approximately 4 m² per liter (**1 gallons per 150 square feet**) of concrete treating oil applied over all concrete surfaces that will remain exposed in the completed work. The concrete shall be clean and dry when the treating oil is applied.

C3a Blanket Curing Method

The concrete shall be covered with waterproof paper or plastic sheeting as soon as possible (without marring the concrete) after completion of the finishing operations. The curing blankets shall be in such condition and be utilized in such manner as to envelop the exposed concrete and prevent loss of water vapor.

C3b Membrane and Extreme Service Membrane Curing Method

All Surfaces exposed to air at the time of cure shall be coated with membrane curing compound within 1 hour after finishing the concrete surfaces. The compound shall be applied by an approved airless spraying machine at the approximate rate of 4 m² per liter (**1 gallon per 150 square feet**) of surface curing area.

2521.5

As conditions for approval, the spraying machine shall have as essential elements; a recirculating bypass system that provides for continuous agitation of the reservoir material; separate hose and nozzle filters; and a multiple or adjustable nozzle system that will provide for variable spray patterns.

Before application, the curing compound as received in the shipping container shall be agitated until a homogeneous mixture is obtained. Application shall be such that a uniform coating is obtained. Any areas that, by visual inspection, appear to have received too light a coating shall be resprayed immediately. Also, should the membrane film become damaged at any time within the required curing period, the damaged areas shall be repaired immediately by respraying. Wherever the initial or corrective spraying is such as to result in unsatisfactory curing, the Engineer may require use of the blanket curing method at no additional cost to the Department.

D Bituminous

The bituminous mixture shall be placed on the compacted foundation material in one or more courses as indicated in the Plans, so as to give the required thickness. Compaction shall be accomplished to a uniform density in a manner and quantity deemed satisfactory by the Engineer.

E Backfilling

Following removal of the forms, the area adjacent to the walk shall be finished in a neat and workmanlike manner using material obtained from the excavation. Surplus excavated materials shall be disposed of by the Contractor in a manner satisfactory to the Engineer.

2521.4 METHOD OF MEASUREMENT

Each uniform thickness item will be measured separately by top surface area.

2521.5 BASIS OF PAYMENT

Payment for the concrete or bituminous construction provided for herein, at the Contract prices per unit of measure, will be compensation in full for all costs of furnishing the materials and constructing the work complete in place as specified, except that any granular materials furnished and placed by order of the Engineer in the absence of specific Plan requirements will be paid for separately under 2451.5.

Concrete and Bituminous walk construction will be paid for on the basis of the following schedule:

Item No.	Item	Unit
2521.501	___mm (")Concrete Walk	square meter (square foot)
2521.503	___mm (")Concrete Terrace ...	square meter (square foot)
2521.511	___mm (")Bituminous Walk...	square meter (square foot)

2521.5

2521.513 ___mm (")Bituminous Terrace square meter (square foot)

2531

Concrete Curbing

2531.1 DESCRIPTION

This work shall consist 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

Mix designations shall be as given below for the method of placement:

A1 Manual Placement Mix No. 3A32

A2 Slip-form Placement Mix No. 3A22

B Reinforcement Bars 3301

C Steel Fabric 3303

D Preformed Joint Filler 3702

E Blank

F Concrete Treating Oil 3917

G Curing Materials

G1 Curing Paper 3752

G2 Plastic Sheeting 3756

G3 Membrane Curing Compound 3754

G4 Extreme Service Membrane Cure 3755

H Granular Materials 3149

2531.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

The foundation shall be excavated, shaped, and compacted to a firm, uniform bearing surface, conforming to the planned section and established grade. Unsuitable subgrade soils shall be removed and replaced as directed. Granular material, as specified and where required by the Plans, shall be furnished, placed and compacted thoroughly to the required depth.

B Forms

Forms shall be of metal, wood, or other suitable material, and shall be capable of sustaining the concrete in its proper position until set. Face forms for curbing shall conform to the required shape and design. Side forms shall have a depth at least equal to the edge thickness of the concrete being formed. The forms shall be fully supported on the foundation and be adequately restrained at the proper line and grade.

Approved flexible or curved forms of proper radius shall be used on curves having a radius of 45 m (**150 feet**) or less.

The contact surfaces of all forms shall be coated with form treating material conforming to 3902, prior to placing the concrete.

C Joint Construction

Transverse expansion joints, filled with 13 mm (**1/2 inch**) preformed joint filler material, shall be placed at the ends of all curved sections; and at the ends of the curved portions of entrance and street returns. Longitudinal expansion joints shall be placed as shown in the Plans. Expansion joints with filler material shall also be placed at locations where the concrete surrounds or adjoins any existing fixed objects such as fire hydrants, building foundations, and other rigid structures.

Contraction joints shall be provided at 3 m (**10 foot**) intervals in curb or curb and gutter construction and at 6 m (**20 foot**) intervals in solid median construction, except as otherwise provided in the Plans. The contraction joints shall generally be formed to the full depth of the concrete, using 3 mm (**1/8 inch**) thick removable inserts conforming to the cross sectional shape of the concrete. Where practicable, such as in driveway pavement or where a curb machine is used, the contraction joints may be formed or sawed as approved by the Engineer to a depth of at least 50 mm (**2 inch**) from all exposed surfaces.

Joints shall be constructed perpendicular to the subgrade and shall align with similar joints in adjoining work when practicable. Transverse joints shall be placed at right angles to the longitudinal axis of the work unless otherwise indicated in the Contract.

Longitudinal construction joints between a concrete median or gutter section and a concrete pavement shall have a surface groove, either formed or sawed, that is approximately 10 mm (**3/8 inch**) wide and at least 13 mm (**1/2 inch**) in depth.

D Metal Reinforcement

Metal reinforcement shall be provided and placed as required by the Plans and in conformance with the applicable provisions of 2472.

E Placing and Finishing Concrete

Immediately before placing the concrete, the inside faces of the forms shall be wetted and the foundation moistened with water.

The concrete shall be placed in a manner that will prevent segregation; consolidated by hand tamping or internal vibrating to fill all voids; struck off to the required grade; and floated smooth. Curb face forms and contraction joint inserts shall be removed as soon as the concrete has set sufficiently to retain its molded shape.

The top surface and face of curbs shall be hand-floated with a suitable trowel as soon after the face forms have been removed as the condition of the concrete will permit.

2531.3

After the water sheen has disappeared, joints and edges shall be rounded to the radii shown in the Plans or as directed by the Engineer, and all concrete surfaces exposed to view shall be lightly brushed to a uniform texture.

Side forms shall remain in place for at least 12 hours after the concrete has been cast. All cavities shall be filled with mortar, upon removal of the side forms.

F Slipform Machine Placement

Instead of using fixed side forms, concrete may be placed and formed to the required shape by using an approved type of extrusion machine that will produce a finished product meeting the standards for dimension, quality, workmanship, and appearance as would be achieved with fixed-form construction provided for herein. Hand finishing will be required only to the extent necessary to obtain the specified surface finish and texture.

G Concrete Curing and Protection

After the finishing operations have been completed and as soon as the set of the concrete permits, the concrete shall be cured for a minimum period of 72 hours. The curing shall be in accordance with one of the methods prescribed herein. Where side forms are used, the edges shall receive the curing media within 30 minutes after removal of the forms. During cold weather, the Contractor shall protect the concrete from frost damage prior to and throughout the duration of the cure.

After September 15th, in that part of the State that is north of the 46 degree Parallel, and after October 1 in that part of the State that is south of the 46 degree Parallel, or before April 15, only the blanket curing or extreme service membrane methods of curing will be permitted.

With the blanket method, after being cured the prescribed minimum period of 72 hours, the concrete shall be treated with two applications totaling approximately 4 m² per liter (**1 gallon per 150 square feet**) of concrete treating oil applied over all concrete surfaces that will remain exposed in the completed work. The concrete shall be clean and dry when the treating oil is applied.

G1 Blanket Curing Method

The concrete shall be covered with waterproof paper or plastic sheeting as soon as possible (without marring the concrete) after completion of the finishing operations. The curing blankets shall be in such condition and be utilized in such manner as to envelop the exposed concrete and prevent loss of water vapor.

G2 Membrane and Extreme Service Membrane Curing Method

All surfaces exposed to air at the time of cure shall be coated with membrane curing compound within 1 hour after finishing the concrete

surfaces. The compound shall be applied by an approved airless spraying machine at the approximate rate of surface curing area.

As conditions for approval, the spraying machine shall have as essential elements, a recirculating bypass system that provides for continuous agitation of the reservoir material; separate hose and nozzle filters; and a multiple or adjustable nozzle system that will provide for variable spray patterns.

Before application, the curing compound as received in the shipping container shall be agitated until a homogeneous mixture is obtained. Application shall be such that a uniform coating is obtained. Any areas that, by visual inspection, appear to have received too light a coating shall be resprayed immediately. Also, should the membrane film become damaged at any time within the required curing period, the damaged areas shall be repaired immediately by respraying. Wherever the initial or corrective spraying is such as to result in unsatisfactory curing, the Engineer may require use of the blanket curing method at no additional cost to the Department.

H Blank

I Blank

J Backfill Construction

As soon as possible without subjecting the concrete work to damaging stresses, the required backfill or embankment construction shall be completed to the elevations indicated in the Plans, using selected materials from the excavations where no other material is provided by the Contract. Placement and compaction of the material shall be in accordance with the applicable provisions of 2451.

All surplus excavated materials shall be disposed of by the Contractor in a manner satisfactory to the Engineer.

K Workmanship and Finish

The complete concrete work shall give the appearance of uniformity in surface contour and texture, and shall be accurately constructed to line and grade.

Edge and surface alignment on curved construction shall conform closely to the planned curvature, and the flow line surface of gutters shall be finished as necessary to eliminate low spots and avoid entrapment of water.

Concrete edges and surfaces designed to straight lines or grades will be checked with a 3 m (**10 foot**) straightedge, and any deviations therefrom in excess of 8 mm (**5/16 inch**) will be considered to be unacceptable work.

Unacceptable work shall be removed and be replaced with acceptable work as ordered by the Engineer. In the absence of an order to remove and replace, the Contractor shall have the option of so doing

2531.3

or may elect to leave the unacceptable work in place and accept the following price reductions:

- (1) For 10 to 14 mm (**3/8 to 9/16 inch**) deviation, payment at 75 percent of Contract price.
- (2) For deviation over 14 mm (**9/16 inch**), payment at 50 percent of Contract price.

2531.4 METHOD OF MEASUREMENT

The construction provided for herein will be measured, as indicated in the Proposal, by the length, area, or volume. No deductions will be made for any castings or minor fixtures encompassed in the work.

A Length

Length measurements on curbs and curb and gutter will be made along the face of the curb at the gutter line. In the case of transitions from one size or design to another, the entire transition will be measured for payment under the item bid at the higher unit price of the two involved.

Length measurements on solid medians and other construction having uniform width and symmetrical cross section will be made along the center of the longitudinal axis. Unless a variance from the basic design results in increased cross sectional area, short sections of modified design (such as tapers and depressions) will be included for payment with the basic design if there is no separate item provided therefor.

At entrances and alleys, any curbing constructed beyond the curb returns or driveway pavement will be measured for payment as shown in the Plans.

B Area

When measurement is by area, computations will be based on the length as staked and the extreme width between outside faces as shown in the Plans or otherwise authorized, without regard to variations in concrete thickness caused by integral construction such as curbs, drainage openings, etc. However, driveway pavement of each specified thickness, and other items of different design will be measured separately as provided for in the Contract.

C Volume

When measurement is by volume, computations will be based on the length as staked and the cross sectional dimensions shown in the Plans or otherwise authorized.

All concrete structures not otherwise designated for payment by type or design will be included for payment under the item of structural concrete.

2531.5 BASIS OF PAYMENT

Payment for the concrete construction provided for herein, at the Contract prices per unit of measure, will be compensation in full for all costs of furnishing the materials and constructing the work complete in place as specified, except that any granular materials furnished and placed by order of the Engineer in the absence of specific Plan requirements will be paid for separately under 2451.5.

Payment for concrete curbing, median, and driveway construction will be made on the basis of the following schedule:

Item No.	Item	Unit
2531.501	Concrete Curb and Gutter, Design.....	meter (linear foot)
2531.502	Concrete Curb, Design	meter (linear foot)
2531.503	Concrete Median	square meter (square yard)
2531.505	Concrete Median	meter (linear foot)
2531.507	___mm (inch) Concrete Driveway Pavement	square meter (square yard)
2531.511	Concrete (Type of Structure).....	cubic meter (cubic yard)
2531.521	Structural Concrete	cubic meter (cubic yard)

2533

Concrete Median Barriers

2533.1 DESCRIPTION

This work shall consist of constructing or reconstructing cast-in-place or precast median barriers built for the purpose of providing traffic lane separation.

2533.2 MATERIALS

- A Concrete 2461**
- A1 3Y32 concrete shall be used for all fixed form cast-in-place concrete median barriers.
- A2 3Y12 concrete shall be used for all slipform concrete median barriers.
- A3 3Y32 concrete shall be used for all precast concrete median barriers.
- B Reinforcement Bars..... 3301**
- C Precast Concrete Median Barrier 3630**

2533.3 CONSTRUCTION REQUIREMENTS

A General

The Engineer may permit a combination of cast-in-place and precast concrete construction for those structures where a type of construction

2533.3

is not specified and where structural strength and/or continuity are maintained.

Where a new median barrier will join to an existing barrier the connection shall be interlocked by a tongue and groove joint with tied reinforcement bars or other positive connection, acceptable to the Engineer, to prevent movement.

The foundation shall be excavated, shaped, and compacted to a firm, uniform bearing surface, conforming to the planned section and established grade. Unsuitable subgrade soils shall be removed and replaced as directed by the Engineer. Granular material, when specified in the Plans or required by the Engineer, shall be furnished, placed, and compacted thoroughly to the required depth.

B Cast-In-Place Fixed Form Construction

Forms shall be of metal, wood or other suitable material, and shall be capable of sustaining the concrete in its proper position until set. All forms shall conform to the required shape and design. The forms shall be fully supported on the foundation and be adequately restrained at the proper line and grade.

Immediately before placing the concrete, the inside faces of the forms shall be wetted and the foundation moistened with water.

The concrete shall be placed in a manner that will prevent segregation; consolidated by internal vibration to fill all voids; struck off to the required grade; and floated smooth. Forms for the roadway face of the median barrier may be removed as soon as the concrete can retain its molded shape. Non-roadway face forms shall remain in place for at least 12 hours after the concrete has been cast.

After roadway face forms have been removed all edges shall be rounded to the radii shown in the Plans or as directed by the Engineer.

C Cast-In-Place Slipform Construction

Concrete may be placed and formed to the required shape by using an approved type of extrusion machine that will produce a finished product meeting the standards for dimension, quality, workmanship and appearance as would be achieved with fixed form construction provided for herein. Hand finishing will be required only to the extent necessary to obtain the specified surface finish and texture.

D Surface Finishes

D1 Cast-In-Place

Cast-In-Place concrete median barriers shall receive an Ordinary Surface Finish as specified in 2401.3. The ordinary surface finish shall start immediately after the removal of the forms and shall be carried on continuously to completion. As the ordinary surface finish progress, it shall be followed by immediately rubbing the surface with a cork

float or fine carborundum stone (depending on the set of the concrete) to produce a paste on the surface and to expose and fill all depressions and all surface cavities. The paste shall be floated to a smooth surface free of coarse texture, swirls, and ridges and before it is set, shall be brushed lightly with a fine bristled brush until all cement films present are removed and the surface has a uniform, fine grained sanded texture.

Concrete placement, form removal, and finishing operation shall be planned and carried out so that the surface finishing of the formed surface can be completed within 48 hours after concrete placement of that section has been completed.

D2 Precast

Precast concrete median barriers shall receive the special surface finish as specified in 2401.3. The object of this operation is to obtain a surface that is reasonably smooth and uniform in texture and appearance and blends in with any cast-in-place concrete median barrier.

The Contractor shall not apply the special surface finish on the precast concrete median barrier until the barrier is placed in its final location and the Engineer has approved the surface condition of the barrier.

E Concrete Curing and Protection

Newly placed concrete shall be properly cured by providing protection against rapid loss of moisture, freezing temperatures, high temperatures, abrupt temperature changes, vibrations, shock waves, and prematurely applied loads. This protection shall be provided when directed by the Engineer, and for a period of time that is not less than that specified in 2401.3, Concrete Curing and Protection.

F Workmanship and Finish

Irregularities in any 3 m (**10 feet**) length of the finished concrete median barrier shall not exceed 6 mm (**1/4 inch**) (horizontal and vertical). Surfaces and edges not meeting this tolerance shall be considered to be Unacceptable Work. Unacceptable Work shall be removed and replaced with acceptable work when so ordered by the Engineer. Extensive areas with deviations greater than 13 mm (**1/2 inch**) shall be removed and replaced. In the absence of an order to remove and replace, the Unacceptable Work may be left in place with the following price adjustments:

- (1) For 8 to 13 mm (**5/16 to 1/2 inch**) deviations, payment at 75 percent of the Contract price.
- (2) For minor areas with deviations over 13 mm (**1/2 inch**), payment at 50 percent of Contract price.

2533.4

2533.4 METHOD OF MEASUREMENT

The concrete median barrier will be measured on the top of the barrier along the centerline of Type A barriers and 75 mm (**3 inches**) back of the front face of Type AA barriers. In the case of transitions, special and modified barriers, the length will be measured on the top of the barrier and 75 mm (**3 inches**) back of the front face. Each concrete median barrier will be measured separately.

2533.5 BASIS OF PAYMENT

Payment for the concrete median barriers provided for herein, at the Contract prices per unit of measure, will be compensation in full for all costs of furnishing the materials, placement of the work to the lines and grade of the Plan and surface finish as specified.

Payment for the concrete median barrier will be made on the basis of the following schedule:

Item No. Item	Unit
4 Concrete Median Barrier, Design 8334 Type A	
..... meter (linear foot)	
2533.502 Concrete Median Barrier, Design 8334 Type AA	
..... meter (linear foot)	
2533.503 Concrete Median Barrier, Design 8334 Type AL	
..... meter (linear foot)	
2533.504 Concrete Median Barrier, Design 8323	
..... meter (linear foot)	
2533.505 Concrete Median Barrier, Design 8334 Type___	
..... meter (linear foot)	
2533.506 Concrete Median Barrier & Glass Screen, Design 8336	
Type ___meter (linear foot)	

2535

Bituminous Curb

2535.1 DESCRIPTION

This work shall consist of constructing bituminous curbing composed of a mixture of aggregate and bituminous material.

2535.2 MATERIALS

The bituminous mixture for the curb shall be produced in accordance with the requirements for wearing course mixtures as provided in 2331, subject to the following provisions:

- (a) The mixture shall be of the same type as that used in the wearing course upon which the curb is to be constructed, unless the use of another type is specified or approved by the Engineer.

2533.5

(b) The bitumen content of the mixture may be increased if necessary, at the discretion of the Engineer. The Engineer may require the substitution of a lower penetration asphalt cement for the specified grade.

2535.3 CONSTRUCTION REQUIREMENTS

Bituminous curb shall be placed under the same restrictions as those that apply to the wearing course construction 2331. If so directed by the Engineer, a tack coat shall be applied to the area on which the curb is to be constructed, as provided for in 2357.

The bituminous mixture shall be placed by an approved automatic curb machine that shapes and compacts the mixture to the specified cross section. The use of manual methods of placement will only be permitted where machine placement is not feasible, and then in a manner approved by the Engineer.

The alignment of the finished curb shall be true to line and grade, within reasonable tolerances. The finished curb shall be uniform in appearance and texture.

2535.4 METHOD OF MEASUREMENT

Bituminous curb will be measured by length along the face of curb at the gutter line.

2535.5 BASIS OF PAYMENT

Payment for bituminous curb at the Contract price per unit of measure will be compensation in full for all costs of its construction, including the costs of producing and furnishing the bituminous mixture.

Payment for bituminous curb will be made on the basis of the following schedule:

Item No.	Item	Unit
2535.501	Bituminous Curb	meter (linear foot)

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2545

Electric Lighting Systems

2545.1 DESCRIPTION

A General

This work includes constructing complete and operational electric lighting systems, electric power systems, sign lighting systems, or the required portion thereof, as specified in the Contract.

B Definitions

Abbreviations and definitions of words and phrases pertaining to electric lighting systems or related type work shall be as defined in 1101, 1103, these Specifications, or in the Special Provisions.

2545.2 MATERIALS

A General

A1 Regulations and Code

The Contractor shall furnish electrical equipment in accordance with 2565.2, and in conformance to IES, ANSI, ICEA, AASHTO, and ASTM; whichever is applicable.

All electrical conductors for electric lighting systems shall be copper or aluminum as specified in the Contract and all wire sizes shall be based on the American Wire Gage (AWG).

A2 Materials and Electrical Equipment..... 2565.2

A3 Material Samples for Testing..... 2565.2

A4 Tests 2565.2

A5 Warranties, Guarantees, and Instruction Sheets

Warranties, Guarantees, and Instruction Sheets shall be in accordance with 2565.2 except that the first paragraph of (b) is modified as follows:

(b) The Contractor shall warrant and guarantee satisfactory in-service operation of all materials and electrical equipment for a period of 6 months. The 6-month in-service warranty period shall begin with the "turn-on" of the electric lighting system. "Turn-on" shall be defined as the time when the complete and operational electric lighting system meets all installation, operational and testing requirements of the Contract.

B Hardware

All ferrous metal hardware, except stainless steel, shall be galvanized according to 3392.

B1 Fasteners 3391

B2 Anchor Rods 3385

B2a Lighting Service Cabinet Anchorages

2545.2

High strength bolts, nuts and washers for lighting service cabinet installation shall be in accordance with 3391; shall be galvanized in accordance with 3392; and shall be sized in accordance with 3850.

B2b Lighting Unit Anchorages

Anchor rods, nuts and washers for lighting unit installation on concrete foundations shall be in accordance with 3385; Type A – Carbon Steel Anchor Rods; shall be galvanized the top 300 mm (**1 foot**) of the anchor rod and nuts; and shall be sized as specified in the Contract.

Threaded studs and nuts for lighting unit installation on steel screw-in foundations shall be in accordance with 3391; shall be galvanized in accordance with 3392; and shall be sized as specified in the Contract.

B2c Rust Inhibitor

Threaded portions of all anchor rods above concrete foundations shall be coated with a rust inhibitor before installation of lighting service cabinets, lighting units, or other type cabinets on the anchor rods.

B3 Cap Screws, Set Screws, and Tap Bolts

Cap screws, set screws, and tap bolts shall be made of commercial brass or bronze. Washers shall be made of galvanized steel or commercial brass.

C Conduit and Accessories

C1 Rigid Steel Conduit (RSC) 3801

C2 Intermediate Metal Conduit (IMC)..... 3802

Wherever installation of Rigid Steel Conduit (RSC) is specified, the Contractor may elect to use Intermediate Metal Conduit (IMC) as an alternate, except for conduit runs under roadbed surface areas carrying vehicular traffic. IMC shall not be permitted for sizes less than 78 mm (**3 inch**) nominal diameter.

C3 Non-metallic Conduit (NMC)..... 3803

C4 Conduit Fixtures

Fixtures for metal conduit, where required, shall be made of cast or malleable iron, galvanized according to 3394, and shall have threaded connections. All access covers shall be made of the same material as the fixture and shall provide a watertight fit.

Fixtures for NMC shall be non-metallic intended for use with the type of conduit used.

C5 Expansion Fittings 3839

D Electrical Cables and Conductors

Conductors for main circuits shall be No. 8 or larger, and those for single lamp branch circuit shall be No. 10 or larger.

D1 Armored Underground Cable, Polyethylene 3815

D2 Electrical Conductors 3815

D3 Overhead Light Cable..... 3815

E Light Standards 3811

Light standards shall be of the style and type specified in the Contract.

F Light Fixtures

Light fixtures shall be of the style and type specified below or in the Contract.

F1 Roadway Lighting Luminaires 3810

F2 Sign Lighting Fixtures..... 3810

F3 Underpass Lighting Fixtures..... 3810

F4 Lamps 3810

Lamps for the luminaires or fixtures shall be the wattage and type specified in the Contract, and shall be universal or base-down to horizontal burning type. Lamps shall be General Electric, Phillips, Sylvania, or an approved equal.

G Concrete 2461

G1 General

Concrete for light standard foundations shall be Mix. No. 3Y43.

Concrete for equipment pad foundations shall be Mix. No. 3A32.

Concrete meeting the requirements for Type 3, Grade A shall be furnished where use of a specific mix designation is not specified in the Contract.

Concrete pavement or base removed because of trenching or construction operations shall be constructed or replaced with Mix. No. 3Y43 high early strength concrete.

G2 Reinforcement Bars 3301

H Service Equipment..... 3837

I Blank

J Lighting Service Cabinet..... 3850

K Electrical Junction Boxes 3838

L Wood Poles..... 3840

M Pullboxes

Pullboxes shall be of the type specified in the Contract.

N Photoelectric Control 3812

O Blank

P Miscellaneous Materials

Materials and electrical equipment for which no requirements are included in the Contract shall be in accordance with the best standard

2545.2

practices and workmanship. All materials and electrical equipment shall be approved by the Engineer before installation.

Q Switch 3837

2545.3 CONSTRUCTION REQUIREMENTS

A General

The locations of component parts, as indicated in the Contract, are approximate only. The exact locations will be established at the job site by the Engineer.

The Contractor shall perform no work on the job site until all underground utilities are located in accordance with 1507. Electrical cable damaged due to the Contractor's negligence shall be repaired within 24 hours at no expense to the Department. Damaged electrical cable shall be required to be replaced between pull boxes or light poles rather than be spliced underground.

Highways, streets, and roads shall be kept open to traffic during construction, subject to 1404. Any openings or uncompleted work that may, after working hours or during construction, cause a hazard to vehicle or pedestrian traffic shall be suitably protected to the satisfaction of the Engineer.

A1 Compliance with Electrical Codes and Standards 2565.3

A2 Permits and Inspections 2565.3

A3 Utility Property And Service 2565.3

B Existing Electrical Systems 2565.3

C Excavation and Backfill 2565.3

D Conduit and Fitting Installation 2565.3

E Pullbox Installation 2565.3

F Concrete Foundation Installation

F1 General

Light foundations (light bases and equipment pads) shall be constructed in accordance with 2565.3, as specified in the Contract, and the following:

F2 Light Bases

Light bases shall contain one 50 mm (**2 inch**) NMC 90 degree elbow for each direct buried cable that enters the base, and one spare 50 mm (**2 inch**) NMC 90 degree elbow, capped at each end, for expansion of the lighting system. These conduit elbows are in addition to extra conduit elbows called for in the Contract.

When light bases are located in a cut section the Contractor shall shape the backslope around the base with a maximum 25 mm (**1 inch**) base projection on the exposed side.

2545.3

When light bases are located in a fill section the Contractor shall mound the foundation excavation to maintain a 25 mm (**1 inch**) maximum base projection on the exposed side.

Where the required ground rod electrode is separated from the light base, a 50 mm (**2 inch**) NMC elbow having bushings at each end shall be installed to carry the grounding wire. The electrode shall be located 305 mm (**1 foot**) or more below the surface of the foundation.

F3 Equipment Pad

Where the required ground rods are separated from the equipment pad, NMC elbows of the size indicated in the Contract, having threads and bushings at each end shall be installed to carry the grounding wire. The electrode shall be located 305 mm (**1 foot**) or more from the equipment pad and 153 mm (**6 inches**) or more below the surface of the foundation.

G Wiring and Conductor Installation

G1 General

The installation of wiring and conductors shall be in accordance with the applicable provisions of 2565.3, and the following:

Service conductors shall be run in a separate conduit system from all other conductors.

Separate lighting branch circuits may be placed in a single conduit but shall be electrically independent. All conductors of a lighting branch circuit shall be run in a single conduit.

G2 Underground Wiring

Armored cable shall be installed by trenching or plowing methods and shall be installed at a depth of not less than 610 mm (**2 foot**). Where solid rock or other obstructions are encountered, installation of the cable shall be permitted at a depth of not less than 460 mm (**18 inches**) provided a 50 mm (**2 inch**) thick concrete slab is placed in the trench over the cable. Installation of the cable shall be permitted at a depth of not less than 153 mm (**6 inches**) provided the cable is run through rigid steel conduit and a 50 mm (**2 inch**) thick concrete slab is placed above the cable and conduit.

Armored cable shall be installed at the same distance behind the bituminous shoulder or back or curb as the light bases. An additional 600 mm (**2 foot**) of slack armored cable shall be installed near the light base before the cable enters the base conduit.

Armored cable shall extend at least 600 mm (**2 foot**) above the light base foundation with a minimum of 100 mm (**4 inches**) of the outer jacket extending above the conduit.

Wiring in conduit shall be installed with sufficient slack to allow for contraction.

2545.3

An independent grounding wire shall be run through all non-metallic conduit systems and electrically connected to all metal fixtures and equipment along the run.

For all expansion sleeves in metallic conduit, a No. 8 grounding jumper shall be installed internally between conduit sections.

All pulling of wires through conduit or raceways shall be done by hand and without damage to the wires or their covering. The conduit shall be clean and dry at the time the wiring is installed. The cable or conductors shall be dry and clean, except powdered graphite or soapstone that may be used to ease the pulling.

G3 Above Ground Wiring

Within roadway lighting standards, unless otherwise specified, the wires connecting the luminaire to the underground cable or base mounted ballast shall be 12-2 UF cable with ground and a 6 A cartridge type fuse. The fuse shall be mounted in an inline molded fuse connector/holder with casing that shall be located at the level of the handhole. Fuses in breakaway poles shall be of the breakaway type. Sufficient excess conductor length shall be provided to allow withdrawal of the connected fuse holder. The neutral and grounding wires shall not be fused.

Neutral-supported aluminum cable, conforming to the ICEA/NEMA Specification for "Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy" may be used to provide temporary power distribution through aerial lines. The overhead cable shall be attached to the poles in a manner acceptable to the Engineer. Overhead light cable shall not be supported by the luminaires.

G4 Splices 2565.3

No underground splices, except in pullboxes, will be permitted that are not called for in the Contract or authorized in writing by the Engineer.

G5 Terminal Blocks 2565.3

H Lighting Standard Installation

Light standards with balanced fixtures or luminaires shall be set plumb. Standards with unbalanced fixtures or bracket arms, or standards that act as supports for overhead wires or guy lines, shall be set with a rake sufficient to counterbalance lateral deflection.

Standards shall be adjusted to the proper position by shims or double nuts before being anchored in position.

Damage to the lighting standard, mast arm, brackets, or other appurtenances to the light standard shall be repaired and restored to the satisfaction of the Engineer.

I Blank

J Sign Lighting Installation

J1 General

Construction of sign lighting shall be as specified in the Contract and the applicable sections of this Specification.

Power distribution to the sign structure shall, unless otherwise required, be by trench laid cable.

J2 Switch

Install the safety switch in a vertical upright position.

J3 Wiring from the Switch to Fixtures

Install No. 12 conductors in 21 mm (**3/4 inches**) RSC between the switch and the fixtures. All splicing shall be accomplished with a wire nut and waterproof coating. All conduit connections shall be rain tight.

Install a No. 12 green conductor in 21 mm (**3/4 inches**) RSC between safety switch and fixtures, to provide ground. The No. 12 conductor shall be connected to the grounding lug attached to the switch enclosure (enclosure isolated from the neutral terminal) and the grounding screw attached to each fixture housing.

Wiring installed between the sign post and the switch shall be run in 21 mm (**3/4 inches**) RSC. Install No. 12 conductors between the switch and the sign base.

Splice the existing or new power conductors to the conductors from the switch with split bolt type connectors as detailed in the Contract. The splices shall be insulated to the level of insulation of the power conductors and shall be waterproofed. The splices shall be dressed in the center of the post and up from the base plate with sufficient excess conductor length provided to permit withdrawal of the splices through the handhole.

Upon completion of new or modified sign lighting system(s) for each feed point, a burn test shall be performed as specified in 2545.3K2.

Furnish and install a feed point identification plate for each new lighted overhead sign in accordance with the details shown in the Contract. The plate shall incorporate the feed point identification number appearing in parenthesis directly below or along side the sign number in the Contract.

Strap mount the plate to the overhead sign post in accordance with the details in the Contract. The plate shall be installed on the right post when looking in the direction of traffic flow. When signs face both directions of travel on a single structure, two plates will be required. The plate shall be installed at a height of approximately 1.8 m (**6 feet**) above the base plate elevation and facing traffic.

The plate shall be installed on bridge mounted signs as specified in the Contract.

2545.3

K Electrical System Testing and Acceptance

Before completion of the work, the Contractor shall test the entire system for unwanted grounds and conduct a 12-hour burn test for each feed point.

K1 Megohm meter test (Test for unwanted grounds)

A megohm meter test, at 500 VDC, indicating the insulation resistance of each circuit shall be made. The megohm tester shall be energized for 15 s on the circuits to check if any break down of the circuits occurs. The Contractor shall furnish the Engineer with a written report of the megohm meter readings for the permanent record. The report shall contain the following information:

- (a) PROJECT NUMBER AND LOCATION
- (b) FEEDPOINT NUMBER - As indicated in the Plans.
- (c) BRANCH CIRCUIT - Identify each lighting branch circuit being tested by indicating the number of the first light connected to that circuit, as indicated in the Plans.
- (d) PHASE CONDUCTOR INSULATION RESISTANCE - Measure the resistance between the phase conductors, and the resistance between each phase conductor and the equipment ground bar in the service cabinet with the fuses removed from the inline fuse connectors in the lighting poles. The resistance shall not be less than 100 M Ω .
- (e) NEUTRAL CONDUCTOR INSULATION RESISTANCE - Measure the resistance between each neutral conductor and the equipment ground bar in the service cabinet with the fuses removed from the inline fuse connectors in the lighting poles. The resistance shall not be less than 100 M Ω .
- (f) CIRCUIT INSULATION RESISTANCE - Measure the resistance between each phase conductor and the equipment ground bar in the service cabinet with all fuses in place in the lighting poles. The resistance shall not be less than 100 M Ω .

The Contractor shall make sure that the circuits conductors are connected to the circuit breaker of the opposite phases (some manufacturers alternate every other breaker with opposite phases, and other manufacturers split the top and bottom halves of the circuit breaker with opposite phases).

All tests shall be made at the service cabinet, in the presence of the Engineer, with all grounding connections in place. The phase and neutral conductors shall be disconnected at the service cabinet for the insulation resistance tests.

Where test results indicate faulty insulation or a faulty connection within the circuit, all necessary corrections shall be made and the circuit retested, all at no expense to the Department. No additional payment

will be made for replacing any part of or the entire circuit as required to make the circuits meet the test requirements.

K2 12-Hour Burn Test

Upon completion of a feed point and before no more than 90 percent of the feed point cost is paid, the service cabinet must be energized and the entire electrical system must operate successfully without interruption for 12 hours, during daylight hours only. The Contractor shall pay all power costs incurred and all such costs shall be incidental to the cost of the Project.

L Lighting Service Cabinet Installation

Pad mounted lighting service cabinets shall be installed in accordance with 2565.3.

M Painting

Painting of all nongalvanized ferrous metalwork, except for stainless steel, shall be in accordance with the applicable requirements of 2476.

Unless otherwise specified, the prime coats shall be two coats of iron oxide primer conforming to 3507.

Painting of all galvanized ferrous metalwork, shall be in accordance with 2478.

For steel lighting service cabinets, unless otherwise specified, the finish coats shall be two field coats of dark green enamel conforming to 3552.

The finish coats shall be applied by brush or spray application. The inside of light standard shafts need not be painted.

For aluminum service cabinets, unless otherwise specified, shall be anodized to match Duranodic finish #311.

If a manufacturer's shop coat paint is accepted or specified in the Contract, the Contractor shall make every effort during erection of a painted pole to protect the factory applied finish. The collar used for handling the pole shall be lined with a felt pad and the protective wrapping on the pole shall be left on at the lift point area to protect the finish of the pole. Any nicks, scratches, paint chips or other damage to the finish shall be repaired and restored to the satisfaction of the Engineer.

N Restoration and Cleanup 2565.3

O Blank

P Light Standard, Light Fixture, and Lighting Service Cabinet Numbering

The Contractor shall number the light standards or light units (underpass luminaires, tunnel luminaires, high mast luminaires, special luminaires, etc.) and lighting service cabinets with decals in accordance with the numbering shown in the Plans.

2545.3

Numbers shall consist of the feed point numbers and letters placed immediately above the pole number at a height of 1.8 m (**6 feet**) above the concrete base at an angle of 45 degrees facing oncoming traffic.

Each letter and number shall be black, 50 mm (**2 inches**) high on a 38 x 64 mm (**1 ½ x 2 ½ inches**) grey background.

Decals shall be self-sticking acrylic with optical lens elements, 127 µm (**5 mil**) low temperature permanent acrylic adhesive with a -23°C (**-10°F**) rating, and a service temperature rating of -48°C (**-55°F**) to +34°C (**94°F**).

A sample decal shall be submitted to the Engineer for approval before the decals are installed.

The pole shaft shall be "lightly sanded" to remove oxidation, and wiped with isopropyl alcohol before applying numbers and letters.

Wood pole lighting standards shall be numbered to the satisfaction of the Engineer.

Underpass lighting units shall be numbered with the last letter of the feed point and with the luminaire number.

Q Luminaire Installation

The Contractor shall install and level luminaires in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer.

Place a level on the area provided on the top of the luminaire, and level in a side to side and front to back direction. Adjust the luminaire as required to completely level the luminaire.

R Bonding and Grounding

All bonding, grounding, ground rod electrodes, grounding electrode conductors, and grounding connections shall be in accordance with the applicable provisions of 2565.3, the NEC and the following:

All metal poles, conduit, service cabinets, service equipment, and other non-current-carrying metal surfaces shall be made mechanically and electrically secure to form a continuous, bonded, grounded system and to provide a low impedance path from any exposed metal surface to the system ground at the service cabinet or service equipment.

A No. 6 grounding and bonding jumper shall bond the bronze tape armor or grounding conductor, the grounding lug of the lighting standard, the grounding lug of metal conduit bushings, and the foundation ground rod, except the tape armor shall be fastened to the grounding bolt in the sign base for sign lighting systems. The bonding and grounding jumper shall be a copper conductor no less than No. 6. The neutral conductor shall be grounded only at the feedpoint.

The grounding and bonding jumper shall be connected to the bronze tape armor with a bronze or copper lug type connector or bolt. Other

2545.4

attachments of the grounding and bonding jumper shall be by means of cast clamps or grounding bushings with a bronze lug to accommodate the jumper.

Where indicated in the Contract, a supplemental ground rod electrode shall be installed. Ground rods used for this purpose shall be copper coated, have a minimum diameter of 16 mm (**5/8 inch**) and be 3 m (**10 feet**) in length.

Ground rod electrodes shall be provided at every other light base and the light base located at both ends of a run, unless otherwise indicated in the Contract. Ground rod electrodes shall be installed 80 to 150 mm (**3 to 6 inches**) below the ground surface and within 25 mm (**1 inch**) of a light base.

All main switch cabinets, control cabinets, or service cabinets shall have a direct grounding connection to a ground rod. When installed on bridges or buildings, each cabinet or metal structure shall be bonded to the bridge or building grounding system. Grounding conductor runs shall be as short as possible.

S Service Equipment Installation 2565.3

T Existing Materials and Electrical Equipment

Existing materials and electrical equipment required by the Contract or as directed by the Engineer to be removed, salvaged, reinstalled, or stockpiled shall be in accordance with 2565.3.

U Wood Pole Installation 2565.3

2545.4 METHOD OF MEASUREMENT

A Complete Systems

When separate items are listed in the Contract for various types of complete electrical systems, each separate system will be measured in accordance with the following:

A1 Electric Lighting System

Each separate electric lighting system will be measured as a single unit, complete in place.

A2 Electric Power System

Each separate electric power system will be measured as a single unit, complete in place.

A3 Sign Lighting System - ___ Fixtures

Each separate sign lighting system - ___ fixtures, will be measured as an integral unit, complete in place.

A4 Sign Lighting System Bridge Mounted - ___ Fixtures

Each separate sign lighting system bridge mounted - ___ fixtures, will be measured as an integral unit, complete in place.

2545.4

A5 Conduit System

Each separate conduit system will be measured as an integral unit, complete in place.

B Electrical System Components

When separate Items are listed in the Contract for the various component parts of an electrical system, they will be measured in accordance with the following:

B1 Lighting Units

Lighting units of each type of mounting and fixture design will be measured separately by the number of units of each type, complete in place.

B2 Luminaires

Luminaires of each type and wattage will be measure separately by the number of luminaires complete in place.

B3 Light Bases

Concrete bases of each design for lighting units will be measured separately as integral units, complete in place.

B4 Conduit

Conduit of each kind and diameter will be measured separately by the length between end terminals along the centerline of the conduit as actually installed.

B5 Underground Wire

Underground wire of each kind and size will be measured separately by the length between end terminals along the centerline of the wire as actually installed.

B6 Armored Cable

Armored cable of each kind and size will be measured separately by the length between end terminals along the centerline of the cable as actually installed.

B7 Overhead Light Cable

Overhead light cable of each kind and size will be measured separately by the length between end terminals along the centerline of the wire as actually installed.

B8 Service Cabinets

Service cabinets of each type will be measured separately by the number of cabinets, complete in place.

B9 Equipment Pads

Equipment pads of each type will be measured separately by the number of equipment pads complete in place.

B10 Junction Boxes

Junction boxes will be measured by the number of junction boxes complete in place.

B11 Pull Boxes

Pull boxes of each design will be measured separately by the number of pull boxes complete in place.

B12 Underpass Lighting Fixtures

Underpass lighting fixtures of each design will be measured separately by the number of underpass lighting units complete in place.

2545.5 BASIS OF PAYMENT

Payment for lighting systems, power systems, sign lighting systems, modify sign lighting systems, and conduit systems at the appropriate Contract price per system will be compensation in full for all costs of furnishing and installing the complete system as specified.

Payment for lighting units of each type at the Contract price per unit will be compensation in full for furnishing and installing the lighting unit as specified, including lamps, luminaire, ballast, pole base, pole and bracket, inline fuse, wiring between pole base and fixtures, numbering of the light standard, and all other miscellaneous items required for a complete installation.

Payment for luminaires of each type and wattage at the Contract price per luminaire will be compensation in full for furnishing and installing the luminaire as specified, including the housing, reflector, glassware, lamp, ballast, mounting, mounting hardware, wiring, connections, numbering of the luminaire if not installed on a light standard, and all other miscellaneous items required for a complete installation.

Payment for light bases of each design at the Contract price per base will be compensation in full for furnishing and installing the light base as specified, including excavation, concrete, reinforcement, anchor rods, ground rod, ground lead, grounding connections, conduit elbows and bushings, and all other miscellaneous items required for a complete installation.

Payment for conduit of each kind and diameter at the Contract price per unit of measure will be compensation in full for furnishing and installing the conduit as specified, including the 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 the like, and all other miscellaneous items required for a complete installation of the conduit.

2545.5

Payment for underground wire of each kind and size at the Contract price per unit of measure will be compensation in full for furnishing and installing the wire as specified, including the wire, pulling, splicing, terminals, making required connections, testing, and all other miscellaneous items required for complete installation of the wire.

Payment for armored cable of each kind and size at the Contract price per unit of measure will be compensation in full for furnishing and installing the cable as specified, including the cable, trenching, armor grounding, connections, fittings, fastenings, hangers, backfilling and surface restoration, testing, and all other miscellaneous items required for a complete installation of the cable.

Payment for overhead light cable of each kind and size at the Contract price per unit of measure will be compensation in full for furnishing and installing the cable as specified, including the cable, grounding of the messenger wire, connections, fastenings, hangers, testing, and all other miscellaneous items required for a complete installation of the cable.

Payment for service cabinet of each type at the Contract price per cabinet will be compensation in full for furnishing and installing the lighting service cabinet as specified, including panelboard enclosure, circuit breakers, switches, relays, photoelectric control, 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 all miscellaneous items required for a complete installation.

Payment for equipment pads of each type at the Contract price per equipment pad will be compensation in full for furnishing and installing the equipment pads as specified, including excavation, concrete, reinforcement, anchoring hardware within the pad, conduits within the pad, ground rods, grounding connections, mounting brackets, mounting hardware, surface restoration, and all other miscellaneous items required for a complete equipment pad installation.

Payment for junction boxes at the Contract price per box will be compensation in full for furnishing and installing the boxes as specified, including the junction box, bushings, covers, gaskets, and all appurtenances required for a complete installation.

Payment for pull boxes of each design at the Contract price per pull box will be compensation in full for furnishing and installing the pull boxes as specified, including the pull box, cover, excavation, backfilling, sealing around the cover and conduit entrances, and all miscellaneous items required for a complete installation.

Payment for underpass lighting fixtures of each type and wattage at the Contract price per unit will be compensation in full for furnishing and installing the underpass lighting unit as specified, including the housing, reflector, glassware, lamp, ballast, mounting, mounting

2550.1

hardware, wiring, connections, numbering of the lighting fixtures, and all other miscellaneous items required for a complete installation.

Payment for electrical systems will be made on the basis of the following schedule:

Item No.	Item	Unit
2545.501	Electric Light System	lump sum
2545.503	Electric Power System	lump sum
2545.505	Sign Lighting System - ____ Fixtures	system
2545.506	Sign Lighting System Bridge Mounted - ____ Fixtures.....	system
2545.509	Conduit System	lump sum
2545.511	Lighting Unit, Type ____	each
2545.513	Luminaire	each
2545.514	Underpass Lighting Fixture, Type ____	each
2545.515	Light Base, Design ____	each
2545.521	____mm (") Rigid Steel Conduit.....	meter (linear foot)
2545.522	____mm (") Intermediate Metal Conduit	meter (linear foot)
2545.523	____mm (") Nonmetallic Conduit.....	meter (linear foot)
2545.531	Underground Wire, ____ Conductor No. ____	meter (linear foot)
2545.533	Armored Cable, ____ Conductor No. ____	meter (linear foot)
2545.537	Overhead Light Cable, ____ Conductor No. ____	meter (linear foot)
2545.541	Service Cabinet, ____ Type ____	each
2545.545	Equipment Pad	each
2545.551	Junction Box.....	each
2545.553	Pull Box.....	each

2550

Traffic Management System

2550.1 SCOPE

This work includes furnishing and installing: closed circuit television systems; closed circuit television assemblies; system integration; electrical cables; fiberoptic cables; fiberoptic systems; analog and digital optical multiplexers, demultiplexers, transmitters, and receivers; control cabinets; splice cabinets; fiberoptic splice vaults;

2550.1

handholes; junction boxes; foundations; ramp control signals; lane control signals; conduits; vehicle detectors; changeable message signs; and electric services for the traffic management system specified in the Contract.

Each bidder shall submit a written statement with the bid. The statement shall comply with 1201 and shall identify all subcontractors.

Glossary

AIC	Aggregate Interface Card
AT&T	American Telephone and Telegraph
B8ZS	Binary Eight Zero Suppression
BD-4	TWP Distribution Pedestal (Splice Cabinet)
BD-7	TWP Distribution Pedestal (Splice Cabinet)
C-C	Center to Center
CAD	Computer Aided Drafting
CD	Carrier Detect
CMS	Changeable Message Sign
CSU	Channel Service Unit
CTS	Clear To Send
DCE	Data Communications Equip
DCP	Data Channel Port
DIP	Dual In-line Package
DSX	Digital Signal Crossconnect
DTE	Data Terminal Equipment
EIA	Electronics Industry Association
ESF	Extended Superframe
FC-PC	Fiber Connector
FDF	Fiber Distribution Frame
FNBT	Facing NSEW Bound Traffic
FO	Fiberoptic
HD	Heavy Duty handhole
JB	Junction Box
LD	Light Duty handholes
LED	Light Emitting Diode
LRx	Long Range Receiver
LTx	Long Range Transmitter
MM	Multimode Cable
Modem	Modulate/Demodulate
MRx	Medium Range Receiver

2550.2

MTx	Medium Range Transmitter
NMS	Network Management System
OH	Overhead sign
OTDR	Optical Time Domain Reflectometer
PC	Printed Circuit
PCB	Printed Circuit Board
PDA	Power Distribution Assembly
p-p	peak to peak
Pixel	smallest element of TV image (picture)
PTZ	Pan Tilt and Zoom
QRSS	Quasi Random Signal Source
RTS	Request To Send
SM	Singlemode Cable
SOV	Single Occupant Vehicle
SRx	Short range Receiver
ST	Fiber Connector
STx	Short Range Transmitter
TIA	Telecommunication Industry Association
TWP	Twisted Wire Pair
WDT	Watch Dog Timer
ZDS	Zero Dispersion Slope
ZDW	Zero Dispersion Wavelength

2550.2 MATERIALS

A General

All materials, work methods, and equipment shall comply with the standards of the National Electrical Manufacturers Association; the Electronic Industries Association; the Underwriters Laboratory, Inc; the National Electrical Code; local codes and ordinances; these specifications; and with the requirements of the Contract.

Each component is designed for 10 years of industrial use. The Contractor warranties all materials and workmanship for 6 months after completion and acceptance of the Contract. The warranty period begins on the date all construction obligations of the Contractor are completed as documented by the final completion date on the change in construction status report.

During the warranty period the Contractor shall, at no cost to the Department, make repairs to all equipment and devices furnished and installed during the Project. The Engineer will notify the Contractor that

2550.2

a warranted item needs repair. The Contractor will acknowledge the notification within 24 hours and furnish the repair with 48 hours. The repair must satisfy the Engineer.

B	Foundations.....	3951
C	Conduit and Accessories	3952
C1	Conduit.....	3952
C2	Handhole.....	3952
C3	Junction Box	3838
C4	Locator Ball	3952
C5	Locator Ball Detector.....	3952
C6	Fiberoptic Splice Vault	3953
C7	Outdoor Fiber Splice Enclosure.....	3954
D	Electrical Cable and Conductors.....	3815
D1	Armored Cable.....	3815
D2	Signal Control Cable	3815
D3	Power Cable.....	3815
D4	Loop Detector Conductor.....	3815
D5	Loop Detector Lead-in Cable.....	3815
D6	Telephone Cable	3815
D7	Video Cable	3815
D8	Radio Frequency Transmission Cable.....	3815
D9	Camera Control Cable.....	3815
D10	Digital Signal Crossconnect	3974
D11	Optical Pigtails and Patch Cord.....	3815
D12	Data Interface Cable	3815
D13	Data Interface Crossover Cable.....	3815
D14	DS-1 Cable	3815
E	Fiberoptic Cables.....	3815
E1	Trunk Cables.....	3815
E2	MM Pig Tails	3815
E3	MM Patch Cord	3815
E4	Armored Pigtails	3815
F	Cabinets.....	3826
F1	334Z Series Cabinet	3826
F2	334 Mux cabinet	3826
F3	336 Series Cabinet	3826
F4	Shelter Cabinet.....	3826

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F5 480 mm (19 inch) EIA Cabinet..... 3826
F6 Splice Cabinet (BD-4 and BD-7) REA approved
F7 Loop Detector Module 3826
F8 Model 170E Controller 3980
F9 400 Series Modems 3981
F10 400 Modem Card Cage..... 3982
F11 Receiver/Driver 3983
F12 Video Transmitter/Receiver 3984
G TMS Electric Service..... 3964
H Ramp Control Signal and Advance Flasher 3965/Plan
H1 Signal Pedestal 3832/Plan
H2 Signal Face..... Plan
H3 Lane Control Signal 3836
H4 Advance Flasher 3965/Plan
I BLANK
J Closed Circuit Television Assembly
J1 Standard 3827/Plan
J2 Camera and Lens..... 3828
J3 Pan and Tilt Unit 3829
J4 Environmental Housing 3830
K Changeable Message Sign
K1 Changeable Message Sign (Design Drum)..... 3970/Plan
K2 Changeable Message Sign (Design LED) 3971/Plan
K3 Changeable Message Sign (Design FO)..... 3972/Plan
L Buried Cable Sign..... 3973
M Fiberoptic Components
M1 Fiber Distribution Frame 3974
M2 Multiplexer Common Equipment 3974
N System Integration..... 3976
O Blank
P Loop Detector
P1 Loop Detector 3966
P2 Loop Detector Splice 3967

2550.3 CONSTRUCTION REQUIREMENTS

The Contractor shall do the work, or ensure that the work is completed as follows.

2550.3

A Cable Installation

The Contractor shall place conduit and direct buried cables in the same trench only when the cable is installed 900 mm (**36 inches**) deep, 150 mm (**6 inches**) of fill is added, and the conduit is installed on the fill.

Install direct burial cable by trenching or by plowing, as far from the paved portion of the roadway as practical. Install direct burial cable under bituminous or concrete surfaces in conduit.

Permanently secure 6 mm (**1/4 inch**) character labels to each cable in each handhole and in each cabinet. The Department will provide the cable identifiers.

A1 Cable Installed In Conduit

The Contractor shall pull cable into conduit by hand or machine, and record the pulling tension indicated on a dynamometer when pulling cable by machine. Use a limiting device to prevent exceeding the pulling tension specified by the manufacturer.

The Contractor shall: apply a material compatible, industry accepted lubricant to the cables to reduce pulling tension; install each cable with enough slack to compensate for contraction; and permanently secure 6 mm (**1/4 inch**) character labels to the cable(s) in each handhole and cabinet with the identification provided by the Department. Damaged cable is not acceptable. Remove abandoned cable(s) from each conduit. The operating TMS must remain active while the cables are removed.

A2 Direct Buried Cables

Trench or plow direct buried cables at 900 mm (**36 inches**) deep, or place them in conduit. Locate the cable route as far from the paved portion of the roadway as practical.

Install a 80 mm (**3.15 inches**) wide, stretchable, orange, warning tape, between 460 mm (**18 inches**) above the cable and 300 mm (**12 inches**) below the surface. The tape bears the permanent legend "CAUTION: Mn/DOT CABLE BELOW".

Place buried cable warning signs, described in 3973, at less than 210 m (**690 feet**) intervals, offset 1.5 m (**5 feet**), along the cable route.

A3 Copper Cable Installation

The Contractor has full and immediate responsibility to repair every existing TMS cable damaged by Contractor activity. The repair includes everything needed for a complete repair. The quality of the repair must satisfy the project Engineer.

- (a) Replace damaged radio frequency (RF) transmission cable with new cable between the existing terminations. Splices in RF transmission cable or telephone cable are not allowed between existing terminations. Below ground splices are never allowed.

2550.3

- (b) Terminate RF transmission cables (COAX and telephone cables (____/PR No. 19 in above ground cabinets to amplifiers, or with connectors designed for use with that specific cable.
- (c) Install the cables inside CCTV standards to the cable supports.
- (d) Test power cables in accordance with 2545.
- (e) series cabinets and the TMS shelter cabinets. Crimp the lug over Terminate telephone cables on screw-on terminal blocks in the 334 each wire installed in cabinets so the insulation serves as a strain relief.
- (f) Splice telephone cables in BD-4 and BD-7 cabinets with a weather resistant, crimp connector designed to splice three No. 19 conductors.

A4 Fiber optic Cable Installation

The Contractor shall submit a plan detailing each fiberoptic cable installation, the installation method, and the calculated pulling tension. The cable is taken up at intermediate pulling points with a device made for that purpose. The cable pulls are continuous and steady between pull points.

The Contractor shall:

- (a) Accomplish direction changes of fiberoptic cable before entering a handhole or other conduit access point. Do not change the direction of fiberoptic cables in handholes.
- (b) Install fiberoptic cable in split conduit through the handholes. Extend the conduit 50 mm (**2 inches**) beyond the wall of each handhole and seal the conduit to the handhole with duct seal.
- (c) Splice optic fibers only in fiberoptic splice vaults, fiber splice panels and FDFs. Splices between cabinets and splice vaults are not allowed.
House the fiber splices at the central node and at remote nodes in splice trays on the FDF.
Splice trunk cable fibers to factory terminated pigtails with fusion splices that have less than 0.3 dB loss.
- (d) Continuously monitor the tensile load on the cable. The Engineer may direct the fiberoptic cable route to be pre-ripped to prevent harm to plowed-in cable.
- (e) Place 150 mm (**6 inches**) of aggregate that complies with 3149.2G, beneath cables placed in a trench before backfilling the trench. The backfilling shall comply with 2451.
- (f) Provide a smooth transition from one elevation to the other when installing fiberoptic cable in existing conduits, that are in existing handholes. This may require re-installing existing conduits and is incidental to the cable installation.

2550.3

- (g) Label the destination of each trunk cable onto the cable in each vault. The system integrator shall label the fiberoptic patchcords and pigtails at terminations with their source, destination, and cable function. The labels are permanent and have 6 mm (**1/4 inch**) characters.

B Cabinet Installation

The system integrator shall prove each cabinet functions as specified, before the system operational test, described in 3976, begins.

B1 Cabinet Labels

Label each control cabinet with permanent 40 mm (**1.6 inch**) high characters, using the cabinet name provided by the Department.

B2 Two Days Notice

The Contractor shall notify the TMC Operations Supervisor 2 days before removing an active cabinet from service.

B3 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 6 mm (**1/4 inch**) high x 50 mm (**2 inch**) wide, one piece neoprene gasket.

B4 Conduit

Install conduits at the center of the cabinet base and 80 mm (**3.15 inches**) above the foundation.

C Changeable Message Signs (CMS)

The changeable message sign structures and mounting hardware shall comply with 2564.

The electrical equipment located on the sign structure shall not protrude over the walkway, shall not interfere with moving the walkway safety rail or with opening the sign door.

The Contractor installs 120/240 VAC to the sign within 1 week after installation to enable operating the ventilation units.

D Lane Control Signals (LCS)

Make the clearance between the bottom of the lane control signal and the pavement at least 5.3 m (**17 feet**). The mounting hardware complies with 2564.

E Restore Shrubs and Bushes

The Contractor shall restore all shrubs and bushes damaged by Contractor activities, in accordance with 1712.

F Handholes (HH)

Make all openings in the side of handholes water tight with a material compatible compound.

2550.3

Cast the Light Duty metal cover frame and the heavy duty metal cover frame in concrete.

Fill Handholes abandoned in sodded areas, with tamped granular material that complies with 3149.2E. Salvage useable handhole covers from abandoned Handholes, to Department's Electrical Services Section.

Secure the HH ball to the eye bolt, or to the highest easily accessible cable in the HH, with a 6 mm (**1/4 inch**) wide wire wrap.

G Ramp Control Signal (RCS)

Cover each installed RCS and keep it covered until the beginning of the system operational test.

H Conduit

Conduit installation complies with 2565.3D and the following additions.

H1 Conduit on Bridges

Conceal conduit on bridges behind the fascia girder, in a location not readily visible to motorists. Install deflecting expansion joints, as per NEC requirements.

H2 Factory Bends

Factory bends in 76 mm (**3 inches**) and larger conduit are greater than 900 mm (**36 inch**) radius.

H3 Conduit Pushes are 900 mm (**36 inches**) below the pavement bottom.

H4 Foundation Locations

The Contract foundation locations are approximate. The Engineer will stake the actual locations, outside the clear zone, as far from the paved portion of the roadways as practical.

I Blank

J Bonding and Grounding2565.3J

Each foundation includes a ground rod.

J1 Insulated Cable

Insulated cable may be used instead of bare ground cable if 300 mm (**12 inches**) of the cable is wrapped with green electrical tape in the cabinet and in each handhole through which the cable passes.

J2 Shield Continuity

Maintain the electrical continuity of the cable shields while terminating and splicing cables. The shield bonding conforms to REA splicing Standard PC-2, Section 3.3. The bonding connectors comply with REA Specification PE-33 for Cable Shield Connectors. Bond and ground the cable sheaths to a 4.6 m (**15 feet**) long x 16 mm (**5/8 inch**) diameter ground rod.

2550.3

K Loop Detector Installation

Loop Detector Installation complies with the Contract detail and these requirements.

K1 Loop Detector Conductors

Loop Detector Conductors end in the near handhole. Splice the conductors to the lead-in cable with a soldered butt splice. Wrap the splice with one wrap of electrical tape before placing it into the splice encapsulator device.

K2 Detector Test

Test all detectors in the presence of a Department inspector and furnish all items required for the test. Use copies of the Loop Detector Test Report, detailed in the Contract, when recording the Loop Detector values.

L Fiberoptic System

The system integrator proves the fiberoptic system functions as specified before the operations test begins.

L1 Network Management System (NMS)

The system integrator tests the NMS components individually and as a system. Use DSO #0 for the NMS throughout the system.

The TMC central node is the source of synchronized timing for all nodes. The time slot assignments provide efficient use of aggregate bandwidth.

The camera control channels are in a digital multidrop configuration.

Communications from the TMC to each of the field nodes is via a single channel.

The Contractor shall:

- (a) Enter and store all tables and network maps in the NMS software. Use DS-1 crossover cables for aggregate connections. Configure the interfaces for B8ZS coding and ESF framing.
- (b) Never transport mainframes with the PC cards installed. Use antistatic enclosures when storing and transporting all PC cards. Wear an antistatic wrist strap, grounded to the chassis, when inserting or removing the mainframe PC cards.
- (c) Before installing TDMs, configure the TDM as if they were in the field and test them in a laboratory.
- (d) Cover all unused card slots with blank filler plates.
- (e) Connect the TDM power supply to the communication equipment power source. Train the data interface cables along the equipment rack support rails.
- (f) Install the Digital Signal Crossconnect (DSX) where shown in the Contract.

2550.3

Connect the LINE jacks (right side) to the DS-1 optical modems and the EQPT jacks (left side) to the DS-1 aggregate interfaces of the central node. "IN" is the signal into the equipment, and "OUT" is the signal out of the equipment.

Crossconnects via the rear wirewrap terminals are allowed.

L2 Video Transmitter and Receiver Pairs

Place the transmitter and receiver pairs where shown in the Contract. The system integrator coordinates the space requirements.

The cabinet communications receptacles power the video power supplies. The Contractor shall:

- (a) Test the fiberoptic path, of each video link, before installation.
 - (b) After connecting the video transmitter and receiver pairs, insert simultaneous video test patterns into each modulator and set the optical power at the receiver end of the fiber, to the sensitivity level. Route the demodulated video signal to a monitor. Assess the monitor output and record the Signal-to-Noise and Signal-to-Low Frequency Noise at each demodulator output.
 - (c) After establishing the video link measure the SNR of the VMx and VDx, the signal levels of each pair and of each channel.
 - (d) Ensure that these baseband video signal characteristics from the receivers and demodulators, meet the medium haul performance Specifications defined in EIA TIA-250-C.
 - (1) Output signal level.
 - (2) Amplitude vs frequency characteristic.
 - (3) Chrominance to luminance gain inequality.
 - (4) Chrominance to luminance delay inequality.
 - (5) Field time waveform distortion.
 - (6) Line time waveform distortion.
 - (7) Insertion gain variation.
 - (8) Differential gain.
 - (9) Differential phase.
 - (10) Signal-to-noise ratio.
 - (11) Signal-to-low frequency noise ratio.
- L3 Ensure that each outdoor fiber splice enclosure:
- (a) Is bonded to the cable armor by a cable clamp;
 - (b) Is bonded to the closest ground rod by a 1/C No. 6 ground wire and clamp;
 - (c) Has non-oxidizing coating on all connections.

2550.3

L4 Fiber Splice Panel

Mount the fiber splice panel where indicated in the Contract. Secure the fiberoptic cable(s) and pigtail(s) to the panel. Bond the shields to the splice panel ground lug.

L5 Fiberoptic Splice Vault

Place the fiberoptic splice vault on 300 mm (**12 inches**) of filter aggregate complying with 3149.2H. Seal and flash test the vault as per the manufacturer recommendations.

Coil 15 m (**50 feet**) of cable in each vault containing splices. This allows moving the splice enclosure to the splicing vehicle.

L6 Optical Link Attenuation Test

The test equipment includes a light source emitting light at the required wavelength and an optical power meter. Calibrate the light source and the power meter at the beginning of each day of testing and after every 20 measurements. Design the light source and power meter to couple to an optical fiber through an ST or FC-PC connector, or through a bare fiber adapter to fibers that have no connector.

To calculate the attenuation, subtract the difference in the received power from the light source before and after measurement through the link.

Record these values during the Optical Link Attenuation tests:

- (a) The length of the link.
- (b) The attenuation of each splice (0.3 dB maximum).
- (c) The mean attenuation of each splice in the link.
- (d) The attenuation of each MM link at 850 nm and 1300 nm.
- (e) The attenuation of each SM link at 1300 nm.

Label optical links with the identifier, the source, and the destination of each cable.

M CCTV Assembly Installation

Do not degrade the existing CCTV signals during CCTV Assembly installation.

Orient the environmental housing lightning protection 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.

The housing mounting bolts do not hit the pan and tilt unit cover in any tilt position.

N System Operational Test

Perform the system operational test on all material and equipment installed as part of this Contract while the system is operating.

Test the system for 30 days after the Engineer and the TMC system inspector agree all Contract requirements have been met. Start the test

2550.4

on a day agreeable to the Contractor, the Engineer and the system inspector.

N1 Test Days

The test is 30 Test Days long. Test Days are Monday through Friday of a normal work week. Saturdays, Sundays, and Department Holidays do not count as Test Days. Counting of Test Days continues as long as all furnished and installed material and equipment functions to the satisfaction of the Engineer.

N2 Component Failure First 20 Days

Should a Contractor supplied component fail during the first 20 days of the test, test day counting stops. When the Contractor has repaired the defective component, test day counting resumes with the count one day after the last complete test day. A partial day out of service is not a test day.

During the test, the Contractor shall repair all new TMS components within 24 hours of notification or the counting of test days shall stop. After the repair is complete, counting resumes with the test day count 1 day after the last test day completed. N3

Component Failure Last 10 Days

Should a Contractor supplied component fail after the first 20 days of the test, test day counting stops. The test day count is reset to day 21, and counting resumes after the component is repaired. A partial day out of service does not count as a test day.

The final 10 days are consecutive test days.

N4 Existing Component Failure

Should existing equipment fail during the test, test day counting stops. After the Department completes the repair, counting resumes with the test day count 1 day after the last test day completed.

N5 Final Acceptance

Final acceptance of the Contract happens after completion of the system operational test and after these conditions are fulfilled:

- (a) The Engineer has approved the physical, functional, and full performance acceptance tests.
- (b) The Department has received all required documentation.
- (c) All cabinets are cleaned and arranged in a professional manner.
- (d) General cleanup is finished.

2550.4 METHOD OF MEASUREMENT

The Engineer will only measure items for payment that are completed and accepted.

2550.4

A Complete Systems

Measure _____ system separately by the number of systems installed.

Measure systems integration as a single unit.

B Traffic Management System Components

The Engineer will measure the various system components by the units of measure listed in the Contract.

C Conduit

The conduit to the first handhole is part of the foundation.

2550.5 BASIS OF PAYMENT

The Department will:

- (a) Retain 10 percent of the amounts payable on each partial estimate, in accord with 1906.
- (b) Pay for material on hand.
- (c) Pay 50 percent of the retainage upon completion of the first 20 days of the system operational test.
- (d) Pay the remaining percentage retained upon completion of the last 10 days of the system operational test.

The Department will make payment according to the following:

Payment for _____ system, at the Contract price, is compensation in full for all costs incidental to furnishing and installing the system specified, complete in place.

Payment for system integration at the Contract price, is full compensation for all costs incidental to incorporating the work and material of the Contract, into the existing system. Payment is based on the percent of the Contract completed, as indicated on the project progress chart. When the chart indicates 10 percent of the Contract has been completed, 10 percent of the systems integration item bid price is paid.

Payment for _____ foundation, at the appropriate Contract price per unit of measure, includes all work materials and costs involved in furnishing and installing the foundation specified.

When the cabinet foundation is part of a larger pad, the cabinet foundation includes the concrete and conduit under and adjacent to the cabinet.

When the service foundation is part of a larger pad, the service foundation includes the concrete, conduit and conductors under and adjacent to the service equipment.

Payment for each of the pay items at the appropriate Contract price per unit, is compensation in full for all costs incidental to furnishing and installing that item.

2550.5

Payment for TMS is made on the basis of this 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
2550.519	Truck Pad	each
2550.521	_ mm Rigid Steel Conduit	meter (linear foot)
2550.523	_ mm Non metallic Conduit	meter (linear foot)
2550.524	_ mm Pushed Conduit	meter (linear foot)
2550.531	_ Cable _ Pr. No. _	meter (linear foot)
2550.532	_ Cable _ Conductor No. _	meter (linear foot)
2550.533	_ Cable _	meter (linear foot)
2550.534	Fiberoptic Trunk Cable _ MM _ SM	meter (linear foot)
2550.535	Armoured Fiberoptic Pigtail	each
2550.541	_ m (*) X _ m (*) Loop Detector, Design _	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	Changeable Message Sign, Design _	each
2550.571	_ Cabinet	each
2550.572	Service _____	each
2550.581	Loop Detector Module	each
2550.582	Controller	each
2550.584	_ Multiplexer	each
2550.585	_ Demultiplexer	each
2550.587	_ Range Video Transmitter	each
2550.588	_ Range Video Receiver	each

2554

2554

Traffic Barriers

2554.1 DESCRIPTION

This work shall consist of the construction of guardrail, barrier fencing, permanent barricades, and similar devices that protect or prohibit traffic at the locations indicated in the Plans or as directed by the Engineer. It shall also include the installation of guide posts and the resetting of existing barriers.

2554.2 MATERIALS

A Metal Posts

A1	Flanged Channel Sign Post.....	3401
A2	Structural Metal Posts.....	3406

B Blank

C	Wood Posts.....	3412
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D	Timber Plank, S4S	3426
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E	Wire Rope	3381
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F Steel Beams

F1	Steel Plate Beams	3382
F2	Rub Rail	3306

G	Hardware and Fittings	3381, 3382
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H Paints, as specified in the Contract

I Blank

J	Concrete	2461
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Concrete for anchor blocks and bearing blocks shall develop a compressive strength of not less than 19 Mpa (2750 psi) at 14 days. No air entrainment will be required.

K	Anchorage Rods	3385
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2554.3 CONSTRUCTION REQUIREMENTS

A Excavation and Foundations

Post holes may be dug by hand or mechanical methods. The depth of each excavation shall be that required to place the rail elements at the specified height above the ground surface and meet the requirements for post top and side alignment. Anchorage excavations shall be made in a manner that will provide bearing on firm, undisturbed earth at the proper depth.

The foundation of line, guide, and permanent barricade posts shall be the natural soil at the bottom of the excavation, tamped to provide firm bearing. End posts and posts at intermediate guardrail anchorages shall be founded on concrete bearing blocks of the dimensions shown in

the Plans, which shall be installed firmly on a properly prepared foundation.

B Installing Posts

Posts of the required size and type shall be installed at the intervals indicated in the Plans and to the staked lines. Post tops shall be within 10 mm of the required elevation and grade.

Type A guide posts shall be 140 mm (**5-1/2 inch**) nominal diameter (120 to 160 mm (**4-3/4 to 6-1/4**) by 1.8 m (**6 feet**) long, treated wood conforming to 3412, and installed with the top of the post 760 mm (**30 inches**) above the shoulder P.I. elevation, unless otherwise indicated.

Type B guide posts (culvert markers) shall be flanged channel steel posts with a mass of 3.0 kg per meter (**2 lbs/ft**) of length conforming to 3401 and shall be installed as shown in the Plans.

Mechanical driving of posts, where required or permitted, shall be accomplished by means that will give the necessary accuracy of placement without damage.

Required backfill materials shall be installed and consolidated thoroughly in a manner that will maintain the post plumb and in the correct position.

C Installing Barriers

Traffic barriers of the required design shall be installed as shown in the Plans.

Holes drilled in wood posts shall be the same diameter as the bolts or fittings to be accommodated. In metal posts, drilled holes for bolts or other fittings shall have a diameter no more than 1.6 mm (**1/16 inch**) greater than that of the bolt or fitting. Field cuts in treated wood shall be given two applications of copper naphthenate or another compatible preservative material meeting AWWPA Standard M4, with a minimum time lapse of 2 hours between applications. Field bored holes may be left untreated.

Bolt length shall not be any longer than necessary to allow full nut contact after tightening at the overall nominal depth of the assembled parts, plus reasonable allowance for oversize components. Wherever vehicle contact is possible, bolt end projections beyond the rail contact face shall be avoided, or the excess length shall be cut off within 15 mm of the nut head.

C1 Wire Rope Installations

Except where cable clips are permitted, free ends of wire rope shall be wire wrapped to prevent unraveling.

At intermediate anchorages, the cables shall be properly spaced to prevent contact between the separate cables.

2554.3

C2 Steel Plate Beam Barriers

When offset blocks are required, the blocks shall be of treated timber or other material on the approved list on file with the Materials Engineer. The Contractor shall treat field cuts on treated wood according to 2554.3C.

Rail and end sections shall overlap the adjacent section in the direction of traffic.

End treatments shall be constructed in accordance with the details as shown in the Plans and as staked in the field. Installation of the required guardrail end treatments shall be done concurrently with the installation of the guardrail.

C3 Chain Link Fence Barriers

Installation shall be in accordance with the Plans. Tension on the fence shall be that which will allow no visible sag of the fence between supports.

C4 Permanent Barricades

Permanent barricades shall be fabricated as shown in the Plans.

D Painting and Field Repairs

Steel that is not coated according to 3406 and is above the ground shall be given two coats of paint as shown in the Plans and in accordance with the applicable provisions of 2476. The Contractor shall make other field repairs according to the manufacturer's recommendations

E Disposal of Surplus Excavated Material

All surplus excavated material shall be disposed of by the Contractor, at no expense to the Department, and in a manner satisfactory to the Engineer.

2554.4 METHOD OF MEASUREMENT

A Traffic Barriers

Traffic barriers of each design designation will be measured by length, to the nearest 0.3 m (**1 foot**), between the centers of end posts in each continuous section, with no deduction for expansion assemblies.

B Permanent Barricades

Permanent Barricades will be measured by length, to the nearest 0.3 m (**1 foot**), from end to end of the planks of each unit.

C Guide Posts

Guide posts will be measured by the number of posts placed. Each type, as indicated in the Plans, will be measured separately.

D Anchorage Assemblies

Anchorage assemblies will be measured by the number of assemblies installed. Each assembly shall consist of the anchor and the fittings required to connect it to the end post.

E End Treatments

End treatments will be measured by the number of units of each type constructed complete-in-place.

2554.5 BASIS OF PAYMENT

Payment for the construction of traffic barriers at the Contract price per unit of measure for each design specified will be compensation in full for furnishing all required materials and constructing the barrier as specified, except that anchorage assemblies will be paid for as separate items, complete as shown in the Plans.

Payment for the construction of end treatments of each type at the Contract price per unit of measure will be compensation in full for furnishing and installing steel plate beam rail, all necessary posts, appropriate anchorage, offset blocks, hardware, and required materials as specified.

Payment for the construction of guide posts at the Contract price per unit of measure for each type specified will be compensation in full for all costs of furnishing and installing the posts as specified.

Payment for the installation of traffic barriers or guide posts at the Contract price per unit of measure will be compensation in full for all costs of constructing the work as specified, using materials furnished by the Department.

Payment for permanent barricades at the Contract price per unit of measure will be compensation in full for all costs of furnishing the required materials and constructing the barricades complete-in-place as specified.

Payment for traffic barriers and barricades will be made on the basis of the following schedule:

Item No.	Item	Unit
2554.501	Traffic Barrier, Design ____	meter (linear foot)
2554.505	Permanent Barricades.....	meter (linear foot)
2554.509	Guide Post, Type ____	each
2554.511	Install Traffic Barrier, Design ____	meter (linear foot)
2554.515	Install Guide Post, Type ____	each
2554.521	Anchorage Assembly.....	each
2554.523	End Treatment - ____	each

2557

2557

Fencing

2557.1 DESCRIPTION

This work consists of constructing fences.

2557.2 MATERIALS

If the type of material for metal products is not specified in the Contract, the Contractor may select the type of material. The Contractor shall use the same type of metal fence components on the entire Project.

All tubular metal posts shall be capped.

When coated metal posts are indicated in the Contract, the Contractor shall use the same coating on posts, post supports, rails, gate frames, expansion sleeves, and other hardware items or fittings. The Contractor shall use:

- (a) Zinc coating with zinc coated fence fabric.
- (b) Aluminum or zinc coating with aluminum coated steel fabric.
- (c) Vinyl coating with vinyl coated fence fabric. The vinyl coated posts, hardware, and fabric shall be black with a low to medium gloss, unless otherwise stated.

The Contractor shall use aluminum alloy posts, rails, frames, and other hardware items with aluminum alloy fence fabric.

A	Fence Wire	3376
B	Fence Gates	3379
C	Fence Posts	
C1	Rolled Steel Posts	3403
C2	Structural Metal Posts.....	3406
C3	Blank	
C4	Treated Wood Posts.....	3413
D	Hardware and Fittings	3406
E	Concrete	

Concrete shall meet the requirements for Grade B, Type 3 concrete as specified in 2461.

2557.3 CONSTRUCTION REQUIREMENTS

A General

All brush, trees, and other obstructions that interfere with construction of the fence shall be removed and disposed of according to the applicable provisions of 1405, 2101, and 2104.3C. A smooth ground profile shall be provided at the fence line. The work necessary to accomplish these purposes shall, unless the Contract specifically provides payment for any part or all of the work, be incidental to fence construction and no direct compensation will be made therefor.

In general, the bottom of the fence shall follow the contour of the ground. At small stream crossings, drainage ditches, and other location where it is impractical to conform the fence to the ground contour the fence shall span the depression and, unless the Plans or the Engineer require otherwise, the space below the bottom of the fence shall be closed with extra fabric or wire as the Engineer directs. If extra length posts are needed at such locations, the Contractor shall furnish and install the longer posts in lieu of the standard length posts, together with any intermediate posts, stakes, braces, extra fabric, or wires as may be required. All such work and materials will be incidental to fence construction and no direct compensation will be made therefor except where the Contract specifically provides payment for any part or all of such work under separate items.

The Contractor shall make field repairs according to the manufacturer's recommendations.

B Installing Posts, Rails and Braces

B1 General

Posts shall be set plumb except at locations where the Engineer deems it more practical for the posts to be set perpendicular to the slope of the ground.

Corner posts, pull posts, end posts, and gate posts shall be installed at locations shown in the Plans or designated by the Engineer. In general, corner post assemblies will be required at all horizontal angle points where the deflection exceeds 20 degrees. Where practical, pull posts shall be spaced to provide a braced post at all points where:

- (a) The vertical alignment deflects by more than 20 degrees.
- (b) The post anchorage is necessary to counteract wire uplift.
- (c) An abrupt grade change on short runs cannot be avoided by shaping the ground to a uniform contour.

When fence posts are driven, the post top shall be protected against damage. All posts that are damaged during installation shall be removed and replaced.

When posts are placed on concrete walls, curbs or other concrete structures, methods and materials used for anchoring posts shall be as specified in the Plans.

If solid rock is encountered above the required elevation of the bottom of a post, the post shall be set at least 300 mm (**12 inches**) into the rock or with its bottom at the required elevation, whichever requires the lesser excavation into the rock. In such cases, the post shall be cut off at the bottom to provide the required height above the ground surface. Holes in rock shall provide a minimum clearance of 25 mm (**1 inch**) around the post, and shall be filled around the post with grout consisting of one part Portland cement, 0.1 part hydrated lime (if

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desired) and 2 parts mortar sand, with sufficient water to give the proper consistency.

Concrete for setting posts and braces shall be thoroughly compacted around the posts and allowed to cure for not less than 3 days before the fence wire is installed.

The concrete may be poured into prebored holes without forming, provided the earth is firm enough to permit satisfactory placement and care is taken to prevent contamination of the concrete during placement.

Except as otherwise required for posts and braces set in rock or concrete, the annular space around all posts set in prebored holes shall be backfilled in layers using selected material from the excavation (unless special material is provided), with each layer thoroughly compacted to produce a rigid post setting.

All surplus excavated material shall be disposed of in low areas along the fence line, or as directed by the Engineer, and the adjacent area shall be finished neatly.

B2 Metal Post Installations

All posts for chain-link fabric fencing shall be set in concrete as provided for in the Plans, except that line posts may be driven provided that posts of sufficient extra length are furnished to allow drive setting at least 1.2 m (**4 feet**) into the ground.

Rolled steel line posts shall be driven.

Rolled steel end posts, corner posts and pull posts (together with the required braces) may be provided with anchor plates and brace plates and set in dug holes, or the anchor and brace plates may be omitted and the posts and braces set in concrete. All excavations around the posts and braces shall be backfilled, using the excavated material, and the backfill shall be thoroughly compacted.

Rolled steel gate posts shall be set in concrete.

At those locations where the Plans require the use of metal post extensions, the Contractor shall furnish and install posts of such extra length as may be directed by the Engineer. Where post splicing is necessary, the pipe ends at the splice shall be threaded and joined, employing a standard thread, coupling of the same material. Splices in the exposed upper portion of the post shall be avoided where practicable. A suitable plug shall be provided in the bottom end of each extended post.

B3 Wood Post Installations

Wood posts may be driven or set in prebored holes. In either case the larger end of the post shall be placed in the ground. When posts are driven, the end placed in the ground may be cut square or pointed. Except for holes in rock, the diameter of post holes shall be sufficiently large to provide a clearance of at least 75 mm (**3 inches**) around the post so as to permit proper backfill and compaction.

Wood braces shall conform to 3413, so far as they are applicable. The diameters of wood braces as shown in the Plans shall be construed to be the minimum permissible diameter at the small end, but the diameter at the small end shall be no greater than the top diameter of the smaller adjacent post.

C Installing Fence Wire

All fence wire shall be installed and pulled tight in accordance with standard practice and the recommendations of the manufacturer.

C1 Chain Link Fabric

Chain link fabric shall be placed in continuous runs between corner, end, and gate posts. The fabric shall be installed on the side of line posts that face away from the main road; except when the Engineer directs otherwise because of snow plowing or other concerns. Impacts from snow plowing should stress the posts rather than the fasteners.

At all ends of chain link fabric, a stretcher bar shall be threaded through the fabric loops and fastened to the posts by means of clamps as shown in the Plans.

Splices in the chain link fabric shall be made by weaving in a pre-bent wire of the same kind as that in the fabric.

C2 Barbed Wire and Woven Wire

Unless otherwise directed by the Engineer, barbed wire and woven wire to be installed on tangent alignment or on curves of 1 degree or less shall be placed on the side of line posts that faces away from the main roadbed. Where the fence is placed on horizontal curves exceeding 1 degree, the wire shall be placed on the side of line posts that is on the outside of the curve. At all corners the post shall be offset to the inside so that the wire will bear against the post.

Fence wire shall be fastened to end, corner, gate, or pull posts before being fastened to intermediate line posts. Woven wire shall be stretched until all longitudinal wires are taut and approximately 30 percent of the factory fabricated fence crimp (tension curves) has been removed.

At all major vertical grade changes, woven wire shall be cut and spliced at the pull post as may be necessary to obtain and maintain uniform tension in all horizontal wires. To the extent feasible, tension curves may be increased in number or depth, by use of a wire crimping tool, so as to accomplish the same objective.

Wires shall be fastened to metal line posts by means of approved wire clips or clamps and to wood posts by means of galvanized staples. Where the wire is looped around end, corner, or pull posts, the wire shall be wrapped around itself not less than 4 complete turns.

Wire staples of the U-shaped type shall be at least 45 mm (**1-3/4 inches**) long when used in pine posts and at least 50 mm (**2 inches**) long when used in cedar posts. L-shaped staples (with

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serrated, barbed or ring shanks) may be of a length not less than 38 mm (**1-1/2 inches**).

U-shaped staples shall be driven diagonally across the wood grain so that both points do not enter between the same grain. Staples shall be sloped slightly upward, against the pull of the wire, in depressions where wire up-lift occurs, and shall be sloped slightly downward on level ground and over knolls. Wires shall be stapled tightly at corner, end, and pull posts, but on line posts the staples shall not be driven so tightly as to prevent movement of the wire. In no case shall staples be driven so tight as to damage the wire.

Splicing of wire at locations between posts shall be accomplished with an approved type of splicing sleeve or by wrapping each wire end around the other wire a sufficient number of turns to ensure a lasting connection. From 4 to 6 turns will be required, depending on the splicing method used, the type of wire, and the quality of workmanship. The Engineer will require that a splicing tool be used to obtain uniformly tight wraps where hand wrapping is not satisfactory.

Where splicing sleeves are used on woven wire, the horizontal distance between vertical wires shall be maintained approximately the same as that in the wire as fabricated. When woven wire is spliced by the wrap method, the two end stay wires shall abut each other and be enclosed within the wrap.

D Installing Gates

Where the Plans require gates, each gate shall be equipped with a "padlock keeper" of a design that will permit locking the gate with a padlock. The padlock will be furnished by the Department.

E Electrical Grounds

Electrical grounds consisting of copper coated steel rods having a nominal diameter of 15 mm (**5/8 inch**) or more and a minimum length of 2.4 m (**8 feet**) shall be installed along each fence line at the staked locations.

Ground rods shall be driven to an elevation approximately flush with the ground surface, at points directly below or adjacent to the fence wire, and each ground rod shall be connected to the fence with a solid No. 6 copper wire. The ground wire shall be attached to the ground rod and to the fence wires with approved type metal clamps in such a manner that each longitudinal fence wire is electrically grounded. No more than one connection will be required on woven wire and chain link fabric, that being near the bottom at each ground rod.

Electrical grounds are to be installed at locations established in accordance with the following requirements:

- (1) An electrical ground shall be installed on each fence line at the approximate point of crossing of each electric power line, and two grounds shall be installed at each pedestrian gate, one on each side of the gate opening and as close to the gate post as practicable.

- (2) Additional grounds shall be installed on each fence line as necessary to maintain a desired maximum spacing between grounds of 450 m (1500 feet) on fences where metal posts are used and 300 m (1000 feet) on fences where wood posts are used.
- (3) A minimum of one electrical ground shall be installed on each separate section of fence. A separate section of fence shall be defined as a run on which the electrical continuity has not been broken by gates, terminal posts, etc.
- (4) On each separate section of fence, the spacing of electrical grounds shall be as uniform as practicable and such that a ground will be located within a distance from each end not greater than one-half the desired maximum spacing interval.

2557.4 METHOD OF MEASUREMENT

A Wire Fence

Fence of each design will be measured separately, by length along the bottom of the fence, from center to center of end posts, exclusive of the lengths of gates as measured between gate posts.

B Brace Assemblies

Brace assemblies of each kind (wood or metal) will be measured separately by the number of each kind constructed complete-in-place, regardless of length, design, or anchorage. A brace assembly shall consist of a single wood or metal brace, installed as either a leg brace or as a horizontal brace between two consecutive posts (brace assemblies for chain link fences shall consist of two brace bars and a truss rod), together with the required brace plate or concrete anchor, post anchorages, and guy wires or truss rods.

C Electrical Grounds

Measurement will be by the number of ground rods and connections furnished and installed complete-in-place.

D Gates

Measurement will be by the number of individual units constructed complete-in-place.

E Metal Post Extensions

Metal post extensions will be measured by length of extensions, determined as the difference between the standard driven post length and the actual post length as installed.

2557.5 BASIS OF PAYMENT

Payment for fence of each design at the Contract price per unit of measure will be compensation in full for all costs of the installation and materials except those that the Contract specifically designates as having been included for payment under separate items.

Payment for brace assemblies of each kind at the Contract price per unit of measure will be compensation in full for furnishing and installing

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the braces as specified, including the required brace plate or concrete anchor, post anchorages, and all guy wires or truss rods.

Payment for electrical grounds at the Contract price per unit of measure will be compensation in full for all costs of furnishing and - installing the ground rods as specified, complete with ground wire and connectors.

Payment for gates of each kind at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing the complete gate assembly as specified.

Payment for furnishing and installing metal fence post extensions as directed by the Engineer, at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing the post extensions as specified.

Payment for fencing will be made on the basis of the following schedule:

Item No.	Item	Unit
2557.501	Wire Fence, Design ____	meter (linear foot)
2557.516	Pedestrian Gate	each
2557.517	Vehicular Gate.....	each
2557.519	Metal Post Extensions	meter (linear foot)
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

2560

Highway-Railroad Grade Crossing Signals

2560.1 DESCRIPTION

This work shall consist of furnishing materials for and installing electrically operated highway-railroad grade crossing signals of the flashing light type, together with crossing gates and cantilever type signals if so required by the Contract.

2560.2 MATERIALS

A General Requirements

All materials and signal parts furnished by the Contractor shall meet the applicable requirements of the Association of American Railroads, the Railroad on whose line the signal will be installed, and the Rules and Specifications for Signs and Signals for Installations at Highway-Railroad Crossings contained within Chapter 8830 of Minnesota Rules, as last issued prior to the date of advertisement for bids.

2560.3

A1 Manufacturer's Drawings, Details, Catalog References and Specifications

The bidder shall furnish, with the Proposal, manufacturer's drawings, catalog references, and specifications for any and all materials and apparatus that may be required to furnish but that are not covered by these Specifications or the Plans. Materials and apparatus covered by such drawings, catalog references or specifications shall not be used unless approved, in writing, by the Engineer. No change or changes shall be made in any approved manufacturer's drawings without the written consent of the Engineer.

After award of the Contract, the Contractor shall furnish the Engineer 5 sets of all such drawings as have been approved. Any work done before the approval of these drawings will be done at the Contractor's own risk and expense. The Contractor shall not substitute any materials or apparatus for those specified herein without the written approval of the Engineer.

A2 Tests

The Contractor shall make, at the Contractor's expense, such tests as may be necessary to demonstrate to the satisfaction of the Department and the Railroad Company that the materials, apparatus and installation will meet the requirements of the Specifications.

The Contractor shall provide, without separate compensation therefor, such instruments, apparatus, tools, and labor as may be necessary to make the required tests. The instruments and apparatus shall remain the property of the Contractor.

2560.3 CONSTRUCTION REQUIREMENTS

A General

The location for the signal as shown in the Plans shall be considered as being approximate only. The exact location will be determined at the site, and shall be such that the clearance distances for the several units will conform to the rules and regulations established therefor.

A1 Inspection of Material, Apparatus and Workmanship

The Railroad Company on whose line the signal system is to be installed, although not a party to the Contract, shall be permitted, through its accredited representative, to inspect any or all of the materials, the apparatus and workmanship of installation, at any time during the construction or installation.

A2 Work by Railroad Company

Under a special agreement with the Department, the Railroad Company will, without cost to the Contractor, perform so much of the work described hereafter (in paragraphs A2a to A2f inclusive) as is specified in the Special Provisions and will furnish all labor and tools required therefor. However, the Contractor shall furnish all materials and apparatus shown in the Plans as being necessary to complete such work.

2560.3

- A2a Place switch rod insulation and insulated joints in the tracks, as shown in the Plans.
- A2b Make such rearrangements of existing wiring systems as may become necessary because of the signal installation.
- A2c Make such relocation of any existing signal apparatus or device as may become necessary because of the signal installation, as shown in the Plans.
- A2d Make all connections between the new signal installation and any existing signal system.
- A2e Remove and replace crossings if necessary for bonding the rails or installing underground cables.
- A2f Insulate metal crossings where necessary because of the signal installation.
- A3 Precaution and Traffic Provisions

Any information concerning traffic movements on the Railroad that the Contractor may need will be furnished at the Contractor's request by the Railroad Company's Dispatcher.

During construction operations when it becomes necessary for the Contractor to perform work that may interfere with traffic on the Railroad, the Contractor shall notify the Railroad Company through its Signal Engineer, Superintendent of Signals, or other authorized official, at least 48 hours in advance of starting such work. Such work shall not be started, however, until authorized by the Railroad Company.

The Contractor shall not place a colored glass signal light so that it will face an approaching train. Open flame torches shall be used in lieu of flashing lights in all places where such lights might confuse the crews of approaching trains.

Any or all openings or uncompleted work that may, after working hours, cause a hazard or unnecessary inconvenience to traffic, shall be suitably and substantially covered by the Contractor to protect traffic on either the Railroad or the highway.

The Contractor shall properly cover the signal or screen it from view, immediately after it is mounted, and shall maintain this covering or screening until authority is given to place the installation in service.

A4 Final Inspection of Installation

The final inspection, as provided for in 1516, shall be made in the company of the Department's Director of Railroad Administration and the Signal Engineer of the Railroad Company or their authorized representatives. Final acceptance will not be made until the Contractor has complied with 2560.3A5.

A5 Placing in Service

2564.2

The Contractor shall place the system in service when authorized to do so by the Engineer, and it shall be placed in charge of competent attendants for a period of not less than 24 hours after being placed in service.

2560.4 METHOD OF MEASUREMENT

The signal system (including crossing gates if required by the Contract) and the advance warning signs will be measured as an integral unit complete in place.

2560.5 BASIS OF PAYMENT

Payment for the signal system will be made on the basis of the following schedule:

Item No.	Item	Unit
2560.501	Highway-Railroad Grade Crossing Signal System	lump sum

2564

Traffic Signs and Devices

2564.1 DESCRIPTION

This work includes the fabrication, packaging, and delivery or installation of traffic signs and devices.

2564.2 MATERIALS

A General

Electrical materials and equipment shall conform to 2545.2. Where a particular material (fixture, device, or component) is specified, an alternate material, equal to or better than the material specified, may be used provided the Contractor obtains the written approval of the Engineer before incorporating such alternate material into the work.

B Structural Steel

All structural steel posts and trusses shall be fabricated from steel conforming to 3306, unless otherwise specified in the Contract.

Structural bolts, nuts, and washers shall conform to 3391.2B and 3392.

Bolt anchorages shall be as specified in the Contract or, if not so specified, as approved by the Engineer.

C Concrete (Mix 3Y43)..... 2461

D Reinforcement Bars..... 3301

All reinforcement bars, except spiral bars, shall be as indicated in the Contract and shall be epoxy coated.

E Spiral Reinforcement 3305

F Signs and Markers..... 3352

2564.2

All sign panels shall be fabricated in accordance with the following, unless otherwise specified in the Contract. Types of sign panels, route markers, and overlays contained in this Specification are referenced in the Mn/DOT Traffic Engineering Manual or the Mn/DOT Standard Signs Manual, or both.

F1 Sign base material for sign panels Type C, Type D, Type Overlay, delineators, markers and Type OH sign panels on sign supports shall be sheet aluminum in accordance with 3352.2A1b except the sign base material for cylinder style delineators shall be non-reflectORIZED black flexible plastic.

F2 Sign base material for sign panels Type A, Type EA, Type EO and Type OH sign panels on panel mounting posts shall be extruded aluminum in accordance with 3352.2A1c and covered with 1600 micro meters (**0.063 inch**) sheet aluminum conforming to Mn/DOT 3352.2A1b covering the extruded panel. Fasteners to attach the sheet aluminum to the extruded panel shall be 5 mm (**3/16 inch**) aluminum alloy pull through rivets. The sheet aluminum shall be butted tightly vertically and riveted to the extruded panel on 300 mm (**12 inches**) centers maximum vertically and horizontally. All edges and corners of each sheet shall be riveted. Rivets shall not be placed within 25 mm (**1 inch**) of the extruded panel joints. After being attached, the sheet aluminum shall be substantially free of any waviness.

F3 Sign face material for all sign panels, delineators and markers shall be Wide Angle Prismatic Retroreflective Sheeting for Visual Impact Performance (VIP) manufactured by 3M Company, except as specified below:

Sign face material for standard signs W11-1, W11-2, S1-1, S4-3 and S5-1 shall be Fluorescent Yellow-Green Wide Angle Prismatic Retroreflective Sheeting for Visual Impact Performance (VIP) manufactured by 3M Company. Sign face material for standard signs S2-P2, W20-100P and W13-1 shall be Fluorescent Yellow-Green Wide Angle Prismatic Retroreflective Sheeting for Visual Impact Performance (VIP) manufactured by 3M Company only when used with standard signs W11-1, W11-2, S1-1, S4-3, S5-1.

For the sign face material on the M1-5A Route Marker and the M1-5B Type Overlay, the gold color shall be obtained by means of screen processed color using a transparent gold paint. The blue color shall be obtained by means of screen processed color using a transparent blue paint. The overlap of the blue and gold screen processed colors shall not exceed 3mm (**3/32 inch**).

Sign face material for sign panels with brown background shall be white Wide Angle Prismatic Retroreflective Sheeting for Visual Impact Performance (VIP) manufactured by 3M Company.

Sign face material for cylinder style delineators shall be Tentative Standard Number 4 Reflective Sheeting (Flexible High Intensity).

2564.3

Sign face material for X4-2 Hazard Markers shall be non-reflectORIZED black or non-reflectORIZED yellow.

Sign face material for X4-11 End of Roadway Markers shall be non-reflectORIZED red or non-reflectORIZED black.

Sign face material for X4-5 Snow Plow Markers shall be direct applied conforming to the requirements of 3352.2A2b.

F4 Sign legend material for Type C sign panels, the numerals on M1-5A Route Markers and M1-5B Type Overlays, delineators and markers shall be Wide Angle Prismatic Retroreflective Sheeting for Visual Impact Performance (VIP) manufactured by 3M Company, except as specified below:

The sign legend material on sign panels with brown sheeting shall be brown (1179) electronic cuttable (EC) film manufactured by 3M Company. If applying brown EC film on sign panels requires splicing, splices shall be horizontal, butt spliced and spaced so that splices do not occur through letters or arrows.

The sign legend material for colors other than black (except the read and green colors on Standard Sign W3-3) may be screened in accordance with 3352.2A5c.

The sign legend material for black legend shall be in accordance with 3352.2A5c or 3352.2A5d.

G Anchor Rods..... 3385
H Flanged Channel Sign Posts..... 3401

2564.3 CONSTRUCTION REQUIREMENTS

A General

Fabrication and installation of traffic signs and devices shall conform to the Minnesota Manual on Uniform Traffic Control Devices (MMUTCD) for Streets and Highways and to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

The Contractor shall not perform work on the job site until all underground utilities are located in conformance with 1507. Electrical cable damaged due to the negligence of the Contractor shall be replaced at no expense to the Department. Damaged electrical cable shall be replaced, by the Contractor, from terminal point to terminal point.

Construction of any kind or type of electrical system or conduit system for the conveyance of electrical cables and conductors, or the required portions thereof, as specified in the Contract, shall conform to 1702 and 2545.3.

Sign locations and post lengths indicated in the Contract are approximate. Final determination of sign locations will be made in the field by the Engineer. The required post lengths for Type A and Type OH Signs will be determined by the Engineer. The required post lengths for all other signs shall be determined by the Contractor.

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If the legend on an existing sign is pertinent to traffic and the sign is to be refurbished, down time for the sign shall not extend beyond the 8-hour period from 8:00 a.m. to 4:00 p.m., unless a suitable replacement sign is provided by the Contractor at no expense to the Department.

If, in the opinion of the Engineer, the message on a sign panel is not pertinent to existing traffic, the Contractor shall delay installation of that sign panel until such time as the message does become pertinent or, in lieu thereof, the sign panel may be installed provided an effective covering is placed over the non-pertinent message. The cover shall be opaque, and shall prevent moisture from being held against the sign face.

Burlap will not be accepted as an effective covering for reflective signs. The Contractor shall install the sign panel with the required covering and the Department will assume the responsibility for maintaining and removing the cover after acceptance of the work. Unless the Contractor has arranged to reclaim the covering material, it shall become the property of the Department upon final acceptance of the work. The covering, maintaining, and uncovering of sign panels with non-pertinent messages shall be done by the Contractor with no direct compensation.

The removal and replacement of any existing guardrail solely for the convenience of the Contractor shall be considered as being incidental work.

The Contractor shall replace all topsoil, sodded, and seeded areas disturbed by the operations and dispose of any excess excavated materials in a manner satisfactory to the Engineer.

B Concrete Structures

Concrete for footings shall be produced in accordance with 2461 and meet the requirements for Grade Y, Type 3 Concrete as specified therein.

All exposed concrete surfaces shall be given a rubbed surface finish.

The Contractor shall not install sign posts on concrete footings until after a minimum 7 days of curing period has elapsed.

B1 Concrete Footings

The Contractor may substitute spread footings for drilled shaft footings or vice versa, subject to the approval of the Engineer.

Footings shall be constructed in accordance with the Contract requirements and there shall be no adjustment in Contract quantities and prices.

If the Contract specifies drilled shaft footings, the Contractor may submit, for approval by the Engineer, an alternate design in lieu of detailed in the Contract. If approved by the Engineer, the Contractor may elect to construct the shaft footing accordingly without adjustment of any Contract quantities and prices. Design details shall be in accordance with either of the following:

- (a) Use a constant diameter shaft at least 153 mm (**6 inches**) greater than the diagonal dimension of the column base plate. Use the planned

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longitudinal reinforcement bars without bending. Either spiral reinforcement or tie bars spaced at 153 mm (**6 inches**) centers may be used for the full length of the shaft, or

- (b) Install a horizontal construction joint at the bottom of the tapered section of the shaft (about 1.8 m (**6 feet**) below the top). Before placing new concrete above the construction joint, the surface of the old concrete shall be coated with an approved bonding agent. Vertical reinforcement bars shall be lapped 40 bar diameters.

The footings shall be constructed in accordance with 2401.3 except as modified by the following:

The Contractor may use undisturbed earth as the form for concrete placement, provided the earth is firm enough to permit satisfactory placement of the concrete and precautions are taken to prevent contamination of the concrete.

B2 Median Barrier Footing

The Contractor shall provide NMC conduit and fittings to connect to the non-metallic conduit in adjacent median barrier as required.

The surface finish and color shall match that of adjacent median barrier.

C Sign Support

The Contractor shall furnish and install a sign support in accordance with the Contract, current AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" and the following:

The concrete footings shall be as specified in the Contract. The Contractor shall determine the reinforcement steel and the anchor rods in accordance with the details in the Contract.

The Contractor shall furnish and install an Overhead Sign identification plate in accordance with 2564.3P.

D Overhead Sign Structure Repair

The Contractor shall repair an existing overhead sign structure in accordance with the applicable provisions of 2123 and the following:

The Contractor shall contact the Department's Structural Metals Inspection Unit (DSMIU) to schedule inspection of sign structures. This inspection shall be completed before removal of the sign structure from storage, or after the Contractor's salvage of the structure.

The following conditions, if encountered, shall be corrected as determined by the DSMIU: rusted or missing nuts, bolts or washers, defective shop and field splices on main chord angles, missing welds, cracking of welds or structural elements, section loss on post base plate, flame gouges on base plate or at bolt holes, cracks around post handhole, zinc coating loss or deterioration, and rusting. All repairs shall be performed in accordance with 2471.

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The Contractor shall verify that each locking pin will completely fit into the locking pin hole in the handrail hinge with the handrail in the raised position. For locking pins that do not fit, the Contractor shall drill out the handrail hinge to make a proper fit. Damage to galvanized surfaces shall be repaired in accordance with 2471.3L1

The Contractor shall obtain reinspection by the DSMIU after the repair has been completed and before installation.

E Structural Steel

The manufacture and fabrication of structural metals shall conform to 2471, subject to the following additional requirements and limitations:

Shop drawings for overhead sign structures and for Type A sign structures shall be furnished in accordance with 2471.3B.

Steel trusses shall be constructed true to dimensions and shall be uniform in appearance. The truss sections and posts shall be assembled in the shop before galvanizing; shall be checked for straightness, alignment and dimensions; and any variations shall be corrected. Warpage from galvanizing shall be corrected before installation of structural steel will be permitted.

All main chord angles for overhead sign structures 13 mm (**½ inch**) or greater in thickness shall meet a Charpy V-notch impact strength requirement of 20N-m (**15 foot-pounds**) at 40 degrees F (**5 degrees C**).

The overhead sign post base plate anchor rod holes shall be made by use of a drill or other mechanical cutting tool of proper size.

The Contractor shall lubricate the threads of nuts before installation. The following minimum torque values shall be used:

ANCHOR ROD DIAMETER	TORQUE
51 mm (2 inches)	400 N•m (300 foot/pounds)
57 mm (2.25 inches)	500 N•m (375 foot/pounds)
64 mm (2.5 inches)	600 N•m (450 foot/pounds)
70 mm (2.75 inches)	750 N•m (550 foot/pounds)
76 mm (3 inches)	950 N•m (700 foot/pounds)

The Contractor shall mar the threads of the anchor bolts in accordance with 2402.3H.

The Contractor shall furnish and install galvanized structural steel posts (H-Pile) as footings for Type A signs, unless otherwise specified in the Contract, in accordance with the applicable provisions of 2452, 2471, and the following:

The footing shall be constructed in accordance with the details in the Contract. The required 87-184 kN (**10-12 ton**) bearing capacity for each H-Pile shall be obtained in accordance with 2452. If the required bearing capacity is not obtained after driving the length of H-Pile specified in the Contract, the Contractor shall splice

additional length of H-Pile in accordance with 2452 and drive to the required bearing capacity. All damage to galvanized surfaces shall be repaired in accordance with 2471 before back filling.

F Flanged Channel Sign Posts

F1 Furnish Flanged Channel Sign Post

The Contractor shall fabricate, package, and deliver flanged channel sign posts in accordance with 2564, 3352, and 3401.

- (a) Posts of the same mass and length shall be banded together, with suitable banding materials, in lots of no more than 20 posts per bundle. Each bundle shall be plainly labeled with the post mass per meter, the name of the Contractor, the Project number, source of the material and the supplier's name.
- (b) The posts shall be delivered to the Department as specified in the Contract. The Contractor shall give at least 3 working days notice to the Engineer.
- (c) Posts shall be deposited where and as directed by Department. All damage detected during unloading shall be cause for immediate rejection of damaged materials. Final inspection and acceptance of the posts will be made by the Department within 14 days of the delivery date.

F2 Furnish and Install Flanged Channel Sign Posts

The Contractor shall install the posts plumb above ground and located and oriented as directed by the Engineer. Any post that is bent or otherwise damaged to the extent that, in the opinion of the Engineer, it is not acceptable, shall be removed from the site and replaced by the Contractor at no expense to the Department.

Posts shall be firm in the ground. After driving, the top of the post shall have the same cross-sectional dimensions as the body of the post.

When mounting a delineator on a bridge rail, a bracket as shown in the Contract shall be furnished and installed by the Contractor in lieu of a conventional steel post.

All costs and work of installing posts in surfaced medians or sidewalks shall be considered incidental to the installation.

G Modify Post

Splices will not be permitted in the lower 1.5 m (**5 feet**) of Type A sign posts.

The Contractor shall extend posts by welding a section (new or salvaged under this Contract of the same size) to an existing post in accordance with the applicable provisions of 2471. Only S100 x 11 (S4x7.7) posts may be extended by bolt splicing in accordance with the details in the Contract and with the applicable provisions of 2471. Post extensions shall be galvanized in accordance with 2471.

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When shortening a post, the removed section of post shall be disposed of in accordance with 2104.

Thermal cutting will be permitted in accordance with 2471. Galvanized areas marred due to cutting or welding shall be repaired in accordance with 2471.

H Sign Panels

Type Overlays are separate panels mounted on the face of signs to form a part of the legend. Type Overlays shall be attached to the sign panels with rivets spaced on 300 mm (**12 inch**) centers except the edges of each Type Overlay shall be attached with rivets spaced on 150 mm (**6 inch**) centers maximum. No rivets are to be installed within 25 mm (**1 inch**) of extruded panel joints.

The Contractor shall fabricate the sign panels in accordance with the standard sign drawings contained in the Mn/DOT Standard Signs Manual or as detailed in the Contract. For sign panels detailed in the Contract, sign panel layouts are dimensioned as follows:

Vertical dimensioning

The 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.

Horizontal dimensioning

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.

Sign Panel Recap

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.

The Contractor shall screen a fabrication sticker with the following information: Company name and address, the twelve months of the year in numeric order (1 thru 12) and the current and following 4 years (last two digits of each year). The Contractor shall affix the sticker to the backside of each new Type C (single post installations only) and Type D sign panels in the lower right corner (when facing the back of the sign panel). On installations of two or more posts for Type C sign panels, the Contractor shall install the sticker in the center at the bottom of the sign panel. The Contractor may indicate the month and year of fabrication of the sign panel on the sticker by either of the following methods:

Punch out the month and year of fabrication of the sign panel on the completed sticker.

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Block out the month and year of fabrication on the screen prior to applying the black ink so that the month and year of fabrication will not be displayed.

The Contractor shall provide a full size mockup (75 mm x 40 mm) (**3 inches x 1.5 inches**) of the sticker (black legend on a white reflectorized background) to the Department for approval.

All demountable sign legend, except Type Overlays, to be furnished and installed on Type A, Type EA, Type EO, and Type OH sign panels, shall be attached to the sign panel with rivets spaced on 150 mm (**6 inch**) maximum vertically and horizontally. No rivets are to be installed within 25 mm (**1 inch**) of extruded panel joints.

The Contractor shall torque each post clip to 16 to 19 N•m (**12 to 14 feet/pound**) when attaching all extruded sign panels to posts.

The Contractor shall package, deliver, store, and install sign panels in accordance with 1607, 3352, and the retroreflective sheeting manufacturer's recommendations.

For signs or sign panels being furnished and installed, the Contractor shall affix a Department furnished warning sticker to the backside of each sign panel directly above the fabrication sticker. Warning stickers are available at the State Sign Shop-Oakdale, telephone number 651-779-5131. Thirty calendar days advance notice shall be given prior to picking up the stickers.

For sign panels being furnished only, the Contractor shall group all sign panels by type (e.g. R1-2) and then by size. Each package shall contain only those sign panels destined for a specific location and no more than 20 sign panels per package. Each package shall be plainly labeled with the Sign Number (e.g. Sign R1-2), name of the Contractor, the Project number, source of the material, the supplier's name, quantity of sign panels, and the delivery location as specified in the Contract.

The Contractor shall give at least 3 working days notice to sign shop personnel before delivery of sign panels to the Department.

Sign panels shall be deposited where and as directed by Department personnel. Any damage detected during unloading shall be cause for immediate rejection of the damaged materials. Final inspection and acceptance of the sign panels will be made by the Department within 14 days of the delivery date.

I Blank

J Saw Sign Panels

The Contractor shall saw cut extruded aluminum sign panels straight and the resulting panel edge shall be smooth. Excess material shall be disposed of in accordance with 2104.

K Sign Panel Overlays

The Contractor shall furnish and install overlay panels on existing extruded aluminum sign panels, including legend. Fasteners to attach the

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overlay sheets to the extruded panel shall be 5 mm (**3/16 inch**) aluminum alloy pull through rivets.

The sign base material for overlay sheets shall be 1600 μm (**0.063 inch**) aluminum conforming to 3352.2A1b. The sign face material shall be VIP reflective sheeting. The sign legend material shall be VIP reflective sheeting, except where black legend is specified the sign legend material shall be Direct Applied conforming to 3352.2A5c or 3352.2A5d.

The Contractor shall remove the demountable legend on the existing sign panel and dispose of in accordance with 2104.

The Contractor shall butt the overlay sheets tightly vertically and rivet them to the existing panel on 300 mm (**12 inch**) centers maximum vertically and horizontally. All edges and corners of each overlay sheet shall be riveted. Rivets shall not be within 25 mm (**1 inch**) of the extruded panel joints. The overlay sheets after being attached to the existing panel shall be substantially free of any waviness.

L Install Sign Panel Type ___

The Contractor shall install a sign panel (either salvaged or Department furnished) of the type specified in the Contract in accordance with the details in the Contract and the following:

Type A and Type OH sign panels shall be installed using new post clips. The Contractor shall torque each post clip to 16 to 19 N•m (**12 to 14 foot-pounds**) when attaching all extruded sign panels to posts.

Type C and Type D sign panels shall be installed with new nuts, bolts and washers.

Type EA and Type EO sign panels shall be installed with new flanged channel posts and post clips.

Type OH sign panels, being installed on sign supports, shall include new sign bracket assemblies in accordance with the details in the Contract.

M Install Sign Type ___

The Contractor shall install Type A signs on breakaway supports at the locations indicated in the Contract salvaged or Department furnished Type A sign panels shall be installed using new post clips. The Contractor shall torque each post clip to 16 to 19 N•m (**12 to 14 foot-pounds**) when attaching all extruded sign panels to posts. Completed installations shall be in accordance with Contract requirements and details. A new friction fuse (includes friction fuse plate and hinge plate) new bolts, nuts and washers shall be furnished and installed on each post. Damage to galvanized surfaces shall be repaired in accordance with 2471.

The Contractor shall furnish and install a new sign structure for Type C and Type D signs and install the salvaged sign panel(s) in accordance with the details in the Contract using new nuts, bolts, and

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washers. The salvaged sign panel(s) shall be installed to the mounting height requirements specified in the Contract.

The Contractor shall furnish new flanged channel posts for Type EA and Type EO sign panel(s), and install the salvaged sign panel(s) with new post clips in accordance with details in the Contract. The Contractor shall torque each post clip to 16-19 N.m (**12-14 foot/pounds**).

The Contractor shall install the Type OH sign structure (either salvaged or from storage) on new concrete footing(s) in accordance with the torque requirements under 2564.3E and with the details in the Contract.

The Contractor shall remove the following and furnish and install new: safety chains and components of safety chain snap assemblies, safety rail locking pins, and chains welded to the locking pin heads (one chain/locking pin). This work shall be incidental to the installation of the sign structure. Items removed shall be disposed of in accordance with 2104.

The Contractor shall verify that each locking pin will completely fit into the locking pin hole in the handrail hinge with the handrail in the raised position. For locking pins that do not fit, the Contractor shall drill out the handrail hinge to make a proper fit. Damage to galvanized surfaces shall be repaired in accordance with 2471.3L1.

N Sign Legend Revision

The Contractor shall revise the sign legend of existing sign panels in accordance with the details in the Contract and the following:

Clean the sign faces with a mild detergent and water solution before installing the new sign legend.

New sign legend for Type A, Type EA, Type EO and Type OH sign panels shall be direct applied VIP sheeting, except where black legend is specified the sign legend material shall be direct applied non-reflectORIZED conforming to the 3352.2A5c or 3352.2A5d

O Blank

P Overhead Sign Identification Plate

The Contractor shall furnish and install an overhead sign identification plate for each overhead sign being installed under the Contract. The plate shall incorporate the overhead sign number appearing directly below the sign panel on the Plan layout and shall comply with the details in the Contract.

For post mounted signs, the plate shall be strap mounted to the overhead sign post in accordance with the details shown in the Contract. The plate shall be installed on the right post when looking in the direction of traffic flow. When signs face both directions of travel on a single structure, two plates will be required. The plate shall be installed at a height of 1.8 m (**6 feet**) above the base plate elevation and facing traffic.

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For bridge mounted signs, the plate shall be attached to the bridge to the right of the sign panel.

Q Extend Walkway Support

The Contractor shall extend each walkway support on existing Type OH sign structures in accordance with the details in the Contract.

R Friction Fuse

The Contractor shall furnish and install a friction fuse on each sign post of existing Type A sign installations in accordance with the details in the Contract and the following:

Remove the in place friction fuse (friction fuse plate, hinge plate, and all in place mounting hardware) and dispose of in accordance with 2104.

A new friction fuse (includes friction fuse plate and hinge plate), new bolts, nuts and washers shall be furnished and installed on each post in accordance with the details in the Contract. Damage to galvanized surfaces shall be repaired in accordance with 2471.3L1.

S Keeper Plate

The Contractor shall furnish and install a keeper plate on each sign post of existing Type A sign installations in accordance with the details in the Contract.

The Contractor shall verify the sign post dimensions in the field. Immediately before installing the keeper plates, the base connection plate shall be cleaned and be free of grit, dirt, etc. The post shall be reinstalled in accordance with the base connection bolting procedure. Missing,

damaged or rusty bolts, nuts and washers shall be replaced by the Contractor.

T Traffic Control

This work shall consist of furnishing, installing, maintaining, and removing traffic control devices.

All signs shall conform to the Mn/DOT Standard Signs Manual. All barricades shall conform to current Mn/DOT Standard Plate 8000. All other traffic control devices shall conform to the MMUTCD. Nylon washer spacers shall be installed between the temporary traffic construction sign panel(s) and the in place sign panel.

The Contractor shall provide all necessary traffic control devices (TCD's) as required by the Contract and the MMUTCD.

The Contractor shall install all TCD's where required, before the beginning of any work. The Contractor shall maintain all TCD's and remove them when not required.

U Scheduling of Work

The Contractor shall schedule the work in compliance with the following requirements:

- (1) One of the following signs shall be in service at all times for each exit:

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- (a) The Exit sign in the gore, or
 - (b) The Exit direction sign just in advance of the gore.
- (2) One directional sign shall be in service at all times for each exit. This may be the Advance guide sign or the exit directional sign.
- (3) Sign structures shall not be removed until permitted by the Engineer. The Engineer's approval for removing an existing sign is contingent upon Item 1 and 2 above and upon a satisfactory replacement being constructed and functional.

2564.4 METHOD OF MEASUREMENT

A General

Items modify post, install sign panel type __, sign legend revision, overhead sign identification plate, extend walkway support, friction fuse, and keeper plate will individually be measured by the each.

B Concrete Structures

All necessary excavation for a concrete structure will be considered as being incidental to construction of the structure and no measurement will be made thereof except under the following conditions:

- (1) Excavation required 300 mm (**12 inches**) below the bottom of the concrete structure will be measured as actual material removed within the limitations set forth in 2451.4A and the volume will be paid for as Extra Work.
- (2) Payment as Extra Work will be made where Class R excavation is encountered and cannot be avoided by adjustment of the concrete structure location.
- (3) All reinforcement bars in concrete structures will be incidental to the construction and with no measurement being made.

B1 Concrete Footings

Concrete footings for Type OH signs will be measured separately by volume, based on specified dimensions in the Contract with no deductions for the volume of metal reinforcement, anchorages, conduit, etc., except that the anchorage assemblies will be measured separately.

B2 Median Barrier Footing

Median barrier footing will be measured separately by the unit based on specified dimensions in the Contract with no deductions for the volume of metal reinforcement, anchorages, conduit, etc., except that the anchorage assembly will be measured separately.

C Sign Support

The sign support will be measured as a complete unit including the concrete footing(s) and overhead sign identification plate.

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D Overhead Sign Structure Repair

Overhead sign structure repair will be measured by the actual number of hours required to complete the repair, including use and operation of equipment, travel time within the Project limits, and work and materials involved. However, crane work and materials required to position and block the truss up off the ground shall be paid for under install sign type OH, with no additional compensation. Overhead sign structure repair is exempt from 1903 as no unit price adjustments will be made in the event of a quantity underrun or overrun.

E Structural Steel

The structural steel items: trusses for overhead signs (Design A); posts for overhead signs (Design A); trusses for overhead signs (Design B); posts for overhead signs (Design B); walkway supports for overhead signs (Design B); walkway grating for overhead signs (Design B); panel mounting posts for overhead signs (Design B); trusses for overhead signs (Bridge Mounted); posts and H-piles for Type A signs; and trusses for Type A signs; will be measured separately by computed mass (weight) of structural steel incorporated in each item in accordance with the measurement provisions of 2402.4A, subject to the following:

- (1) The mass (weight) measurement for trusses for overhead signs (Design A) will include the structural members of the truss, the lower chord juncture plate, cap plates, tie plates, collar, panel mounting posts, walkway grating, walkway supports, safety rail, and fixture mounting channel.
The mass (weight) measurement for posts for overhead signs (Design A) will include the posts, the base juncture plate, lower chord juncture post plate, gusset plates, baseplate, overhead sign identification plate, and the anchorage assembly.
The mass (weight) measurement for trusses for overhead signs (Bridge Mounted) will include the structural members of the truss, the panel mounting posts, walkway grating, walkway supports, safety rail, and fixture mounting channels. The mass (weight) measurement for trusses for Type A signs will include the structural members of the truss and the panel mounting posts.
- (2) The computed mass (weight) will be based on the quantity tables included in the Contract.
- (3) No measurement will be made of any bolts, nuts, rivets, washers, and shims used in the fabrication and erection of signs. The provisions of 402.4A providing a percentage increase in mass (weight) therefor will not apply.

F Flanged Channel Sign Posts

Flanged channel sign posts will be measured by computed mass (weight) for each size of post being furnished.

G Sign Panels

Sign panels of each type will be measured separately by area based on the nominal dimensions of the sign panels. All signs will be considered as being rectangular for the purpose of measurement except that, for triangular shaped sign panels, the measurement will be the actual area of the triangle. No deduction will be made for rounding of corners.

H Saw Sign Panels

Sawing of extruded sign panels will be measured by the length of the saw cut.

I Sign Panel Overlay Type __

Sign panel overlays will be measured separately by the area and type of sign panel(s) overlaid.

J Install Sign Type __

Signs of each type will be measured by the number of complete units in place as specified under 2564.3M, except that the posts and concrete footings or pile footings for Type A signs, and the footings for Type OH signs, will be paid for separately.

K Delineators and Markers

Delineators and markers of each type will be measured by the number of complete units furnished and installed. A complete unit will consist of the tubular or flanged channel sign post, mounting bracket or strap mounting hardware as specified in the Mn/DOT Traffic Engineering Manual and the Mn/DOT Standard Signs Manual.

2564.5 BASIS OF PAYMENT

The Department will pay for traffic signs and devices at the Contract price per unit of measure. The Contractor will accept the payment as compensation in full for all costs relating to furnishing and installing or furnishing the item except those costs that the Contract specifically designates as included for payment under a separate item.

Payment for concrete footings at the Contract price per cubic meter (cubic yard) will be compensation in full for all costs of constructing the footings and will include replacing all topsoil and sodded areas disturbed by the operations, dispose of any excess excavated materials in a manner satisfactory to the Engineer, except that anchorage assemblies will be paid for under Structural Steel - Post for OH Signs (Design __).

Payment for median barrier footing at the Contract price per unit of measure will be compensation in full for all costs of constructing

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the footing in place as specified, except that the anchorage assembly will be paid for under Structural Steel-Posts for OH signs (Design ___).

Payment for sign support at the Contract price per unit of measure will be compensation in full for furnishing and installing the sign support including the concrete footings) and overhead sign identification plate.

Payment for overhead sign structure repair at the Contract price per hour will include compensation in full for all costs involved in performing the work as specified in the Contract , except that the crane work and materials required to position and block the truss up off the ground shall be paid for under install sign type OH.

Payment for structural steel items by weight at the Contract price per mass (pound) of steel shall be compensation in full for all costs of fabricating and erecting the structural steel items as specified in the Contract.

Payment for flanged channel sign posts at the Contract price per kilogram (pound) will be made under structural steel, and will be compensation in full for all costs involved in manufacturing, packaging and delivering the posts as specified in the Contract.

Payment for furnishing and installing sign panels of each type separately at the Contract price per square meter (square foot) will be compensation in full for all costs of fabricating and erecting panels as specified, except for those components that are specifically noted as

Type Overlays. Payment for Type C and Type D sign panels will include compensation for furnishing and installing the tubular or flanged channel sign posts, stringers, brackets, and attachment angles or strap mounting hardware on which the sign panels are attached. Payment for Type EA and Type EO sign panels will include compensation for furnishing and installing the flanged channel sign posts . Payment for Type A Sign Panels will include compensation for the hardware required to assemble the panel sections and attach the assembled sign panels to the sign posts. Payment for Type OH Sign Panels will include compensation for the hardware required to assemble the panel sections and attach the assembled sign panels to the panel mountings posts or the sign support. Torquing post clips will be incidental to furnishing and installing extruded sign panels. Screening and installing fabrication stickers and installing warning stickers will be incidental to furnishing and installing Type C and Type D sign panels.

Payment for furnishing sign panels of each type separately at the Contract price per square meter (square foot) will be compensation in full for fabricating packaging, and delivering the sign panels as specified in the Contract.

Payment for sign panel overlay Type ___ at the Contract price per square meter (square foot) will be compensation in full for all costs involved in performing the work as specified in the Contract , including the removal and reinstallation of the existing sign panel, if necessary,

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except that furnishing and installing new Type Overlays will be paid for as sign panels Type Overlay.

Payment for install sign Type __ at the Contract price per unit of measure will be compensation in full for all costs of installing the signs as specified in the Contract, except that the posts and H-Piles for Type A signs will be paid for under Structural Steel Posts for Type A signs; the anchorage assembly(ies) will be paid for under Structural Steel Posts for Type OH Signs (Design __) and concrete footing(s) for Type OH signs will be paid for under Concrete Footings (Type Spread or Shaft) or median barrier footing(s).

Payment for furnishing and installing the required materials as specified for each overhead sign identification plate will be incidental to: Structural Steel - Posts for OH Signs, Structural Steel - Trusses for OH Signs Bridge Mounted or Install Sign Type OH installation.

Payment for traffic signs and devices will be made on the basis of the following schedule:

Item No.	Item	Unit
2564.511	Concrete Footings-Type	cubic meter (cubic yard)
2564.513	Median Barrier Footing	each
2564.515	Sign Support	each
2564.518	Overhead Sign Structure Repair	man-hour
2564.522	Structural Steel --- (Specify Item & Use)	kilogram (pound)
2564.524	Modify Post	each
2564.531	Sign Panels Type ____	square meter (square foot)
2564.533	Furnish Sign Panels Type ____ ..	square meter (square foot)
2564.534	Saw Sign Panel Type____	meter (linear foot)
2564.535	Sign Panel Overlay Type____	square meter (square foot)
2564.536	Install Sign Panel Type ____	each
2564.537	Install Sign Type ____	each
2564.538	Sign Legend Revision	each
2564.539	Overhead Sign 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 Post Marker	each
2564.552	Hazard Marker X4-2	each
2564.553	Clearance Marker X4-4	each
2564.554	Snowplow Marker X4-5	each
2564.555	End of Roadway Marker X4-11	each