# 2501 PIPE CULVERTS

## 2501.1 DESCRIPTION

This work consists of the construction of pipe culverts using plant-fabricated pipe and appurtenant materials or using preformed structural plates fabricated for field assembly, installed primarily for passage of surface water through embankments.

## 2501.2 MATERIALS

### A Pipe

Provide one of the following types of culvert pipe meeting the lowest strength class specified in the referenced specification, unless otherwise shown on the plans or specified in the special provisions. Provide special fabrication or jointing details as shown on the plans. Provide culvert pipe with the coating type shown on the plans or specified in the special provisions.

**A.1 Corrugated Aluminum (CA)..... 3225**

**A.2 Corrugated Steel (CS) ..... 3226**

**A.3 Corrugated Polyethylene (CP)..... 3247**

**A.4 (Blank)**

**A.5 (Blank)**

**A.6 Reinforced Concrete (RC)..... 3236**

**A.7 Polymeric Coated-Corrugated Steel (PC-CS) ..... 3229**

**A.8 Corrugated Aluminized Steel (CAS)..... 3222**

**A.9 Polyvinyl Chloride (PVC) ..... 3248**

### B Structural Plate

**B.1 Corrugated Aluminum (CA)..... 3233**

**B.2 Corrugated Steel (CS) ..... 3231**

### C Aprons

Provide aprons of the type required by the contract. The Contractor may provide and attach galvanized steel aprons to corrugated steel, corrugated polyethylene, and polymeric coated-corrugated steel pipe, unless otherwise specified on the plans. The Contractor may provide and attach galvanized steel aprons to corrugated aluminum and corrugated aluminized steel pipe, if the Contractor applies geotextile Type II or

other insulation material approved by the Engineer between the contact surfaces of the different materials.



## 2501.3 CONSTRUCTION REQUIREMENTS

Install pipe culverts using new or old material in accordance with the following requirements:

### A General

For prefabricated structures, excavate, construct foundations, and backfill the culvert in accordance with 2451, "Structure Excavations and Backfills," and the following:

## B Foundations

The Contractor may install entrance culverts without special foundation shaping, unless otherwise specified in 2451.3.C.2, "Prefabricated Structures," if installing the culvert in a trench or if special bedding is shown on the plans.

## C Laying Pipe

### C.1 General

Terminate pipes that connect with inlet structures flush with the inside of the structure wall.

Jack culverts through the existing earth structure into position as shown on the plans or as approved by the Engineer. Ensure the flow line elevation at the starting point for jacking is within 0.1 ft [30 mm] of the staked grade. Do not reverse the flow line grade at any point. Ensure the line and grade at any point within the pipe does not vary by greater than ½ ft [150 mm] from the line and grade designated on the plans.

### C.2 Metal Culvert

Lay corrugated metal pipes having circumferential joints with the outside laps pointing upgrade and with the longitudinal joints at the springlines.

Use metal connecting bands, centered over the joint, to join metal pipe sections. Place the pipe sections so that the pipe ends are abutting. Tighten the band to ensure a tight joint where the soil does not infiltrate into the pipe and the sections do nut pull apart.

Use approved fasteners, as defined in the applicable materials specifications, to assemble structural plate culverts as required by the manufacturer. Tighten bolts after assembly to a torque of 100 lbf•ft to 300 lbf•ft [135 N•m to 400 N•m]. Provide a calibrated torque wrench to demonstrate the adequacy of the bolt tightening, as approved by the Engineer.

Where beveled ends on metal pipe are shown on the plans or standard plates, cut the bevels at right angles to a vertical plane through the longitudinal axis of the pipe.

### C.3 Concrete Culvert

Lay concrete pipe with the female end of each section upgrade. Tightly join the pipe sections so that the interior of the pipe sections abut each other. Protect each joint against infiltration of backfill soil by filling the joint space with an approved sealer material as defined by the materials specification or by providing a full circumferential wrap of geotextile material extending at least 12 in [300 mm] on each side of the joint. Secure the circumferential wrap against the outside of the pipe by

metal or plastic strapping or by other methods approved by the Engineer. The Contractor may use a combination of sealer and geotextile materials.

Use preformed rubber, preformed plastic, or bituminous mastic elastic joint sealer material to provide flexible water-tight joint seals for concrete pipe at the locations required by the contract. Where the specified pipe is designed to accommodate preformed gasket type seals, seal the joints with the gasket type designed for that type of joint as shown on the plans and meeting the performance requirements of AASHTO M 198.

Apply mastic joint sealer materials as recommended by the manufacturer. Wipe joints clean on the inside after sealing. Plug lifting holes with a precast concrete plug, sealed, and covered with mastic or mortar.

Use approved fasteners shown on Standard Plate 3145 to tie together concrete culvert sections unless otherwise shown on the plans or specified in the special provisions.

**C.4 Plastic Culvert**

Make connections with bell and spigot joints using an elastomeric rubber seal (gasket) meeting the requirements of ASTM F 477 capable of passing a laboratory pressure test of at least 2 psi [14 kPa]. At a minimum, provide silt-tight joints that do not allow soil or silt to migrate through the joint unless otherwise shown on the plans or specified in the special provisions. Provide water-tight joints as shown on the plans and meeting the requirements of ASTM D 3212 as modified by the following:

(1) Perform the internal pressure test at a minimum of 10 psi [68 kPa] with the pipe in straight alignment and
(2) The Department will not require the vacuum test.

Submit to the Engineer a laboratory certification provided by the pipe manufacturer that the pipe coupler for each size pipe meets or exceeds the requirements in this section. Submit the shop drawings of each pipe coupler provided by the pipe manufacturer and any additional mechanical connections as required by the contract.

Install joints so connected pipe sections form a continuous surface free of irregularities in the flow line.

Place pipes and backfill in dry conditions by controlling the water conditions. Dewater groundwater and surface runoff to keep the water level below the pipe foundation.

Place pipes on the bedding starting at the downstream end.

Provide Class B bedding. Compact the zone immediately beneath the pipe to provide uniform support, unless otherwise approved by the Engineer. The Department defines the embedment envelope as the zone of structural backfill around the pipe. Embedment material includes 12 in [300 mm] of fill over the pipe and fill for a trench width as specified by the contract. If not specified by the contract, make the space between the pipe and trench wall wider than the compaction equipment used to compact the material in the pipe zone, but not be less then 1.5 times the outside pipe diameter plus 12 in [300 mm]. Provide embedment material in accordance with 3149.2.D, "Backfill Materials," modified to 100 percent passing the 1 in [25 mm] sieve. Compact embedment material to 100 percent maximum density in accordance with the specified density method in accordance with 2105, "Excavation and Embankment."

Before allowing vehicles or heavy construction equipment to travel over the pipe trench, maintain a minimum cover depth of material above the pipe of at least 2 ft [600 mm] and meeting the requirements of AASHTO LRFD *Bridge Design Specifications*, Section 30, Table 30.6-1.

Perform deflection testing at least 30 days after installation. Evaluate the pipe to determine if the specific internal diameter of the barrel has been reduced greater than 5 percent. Use a nine-point mandrel approved by the Engineer to perform deflection testing for pipes with an inside diameter no greater than 24 in [600 mm]. Ensure the mandrel has a diameter of 95 percent of the certified actual mean inner diameter of the pipe. Pull the mandrel through the pipe using non-mechanical means.

Use a mandrel or other method approved by the Engineer capable of making the deflection measurement to inspect deflection testing of pipes with an inside diameter greater then 24 in [600 mm]. If the Department allows direct measurements, the Engineer will randomly select locations, but take measurements at least every 10 ft [3 m] throughout the pipe length and at the pipe ends. Visually inspect the pipe and take additional measurements at any location of observed anomaly or deflection. Ensure personnel making direct measurements meet confined space entry requirements in accordance with 1706, "Employee Health and Welfare."

The Engineer will not accept pipe if the mandrel does not pass through it or if direct measurements indicate a deflection of more than 5 percent. Remove unacceptable pipe and reinstall new pipe or undamaged deformed pipe. Re-test the re-laid pipe for deflection after at least 5 calendar days.

**C.5 Extending In-Place Culverts**

Clear in-place culverts of obstructions to water flow before placing the extension pipe. The Engineer will only require the removal of sediment to the extent that improved flow is likely to be maintained.

If the pipe ends differ because of changed design, make the connection to the in-place culvert as shown on the plans or as approved by the Engineer.

Extend cast-in-place concrete box culverts with plant-fabricated pipe using the detailed connections as shown on the plans.

Use a transition section as shown on the plans if extending a box-type concrete cattle pass with precast concrete sections. Expose the ends of the in-place structure and remove concrete as shown on the plans. Construct the cast-in-place portion of the transition in accordance with 2411, "Minor Concrete Structures."

**D Culvert Appurtenances**

Provide and install appurtenant items such as aprons, safety aprons, and grates, diaphragms, dissipator rings, flap gates, and safety grates, including special grates for concrete pipe and large size pipe, trash racks and other similar devices requiring a special design, as shown on the plans or the special provisions.

**E Induced Trench Installation**

Construct backfill over the culvert if shown on the plans and in accordance with the following:

Construct the embankment in accordance with 2105, "Excavation and Embankment," for a width on each side of the installed culvert at least equal to three pipe widths and to an elevation over the top of the culvert equal to the pipe height plus 1 ft [300 mm]. When using the Specific Density Method, compact the embankment to a density not less than 100 percent of maximum density.

Excavate a trench to a level 1 ft [300 mm] above the top of the culvert, for the width and length of the pipe, and with vertical sides. Loosely fill the trench with highly-compressible soil before constructing the remaining embankment in accordance with 2105, "Excavation and Embankment."

**F Culvert Cleaning**

Before final acceptance, inspect culverts installed as required by the contract and clear culverts of sedimentation or other debris inside the pipe.

**2501.4 METHOD OF MEASUREMENT**

**A Culvert Excavation**

If the contract contains separate items for culvert excavation as specified in 2501.5, "Pipe Culverts, Basis of Payment," the Engineer will classify and measure excavations for culverts in accordance with 2451, "Structure Excavations and Backfills."

**B Culvert Pipe**

The Engineer will measure culvert pipe by length, as determined by summation of the nominal laying lengths of the individual pipe sections incorporated in each structure. The Engineer will separate measurements by size, type, kind, and strength class in accordance with the item name.

The Engineer will measure elbow, tee, and wye sections as pipe along the centerline of the culvert barrel. The Engineer will not measure the length of branch legs, except as included in the measurements for a connecting structure. The Engineer will measure transition sections as pipe of the larger or more costly size, except for special sections designated by the contact for measurement as a unit.

The Engineer will measure the length of metal pipe installations requiring special fabrication, such as skewed or sloped ends, to the extreme ends to include waste material, unless otherwise shown on the plans.

**C Culvert Appurtenances**

The Engineer will separately measure appurtenant items such as aprons, safety aprons, and grates, diaphragms, dissipator rings, flap gates, and other specially designed and identified units designated for payment on a per each basis by the number of units of each type and size incorporated in the culvert structures. The Department considers a safety apron and grate as one unit.

The contract unit prices for pipe culverts will include the cost of cast-in-place concrete work.

**D Granular Materials**

The Engineer will measure granular materials for special backfill or bedding in accordance with 2451.4.B, "Granular Materials."

**2501.5 BASIS OF PAYMENT**

The contract unit price for culvert pipe of each size, type, kind, and strength class includes the costs of providing and installing the pipe complete in place as required in the contract, except as otherwise specified in this section.

The Department will separately pay for aprons, safety aprons and grates, safety grates, flap gates, dissipator rings, diaphragms, and other specially designed and identified appurtenant items by type, size, and number of units incorporated in the structures as shown on the plans. The contract unit price for these items includes the cost of providing and installing the items complete in place.

The Department will separately pay for granular materials for special backfill or bedding in accordance 2451.5, "Structure Excavations and Backfills, Basis of Payment."

The Department will separately pay for culvert excavation at the contract unit prices included in the contract in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment." If not included in the contract, the Department will include excavating costs in the contract unit prices for culvert pipe and appurtenant items.

Surplus excavated materials not used for backfill shall become the property of the Contractor. Dispose of surplus material in accordance with the disposal form submitted to and approved by the Engineer. The contract unit price for the relevant culvert contract item includes the costs associated with the disposal of surplus material.

The Department will provide additional compensation for culvert elbows, tee or wye sections, and additional connectors directed by the Engineer, but not shown on the plans, in the amount of the actual invoice cost of the materials involved.

The Department will pay for installing culvert materials provided by the Department under the applicable installation items shown in the contract. The contract unit prices for installing culvert materials provided by the Department include the cost of work and additional materials required for the installation complete in place, except for extra work or work designated under other items.

If the Engineer allows installation by the jacking method and the contract does not contain a relevant contract item, the Department will pay for a jacking installation on the basis of contract unit prices relevant for the trenching method.

The contract unit price for the relevant pipe contract item includes the cost of culvert cleaning.

The Department will identify alternatives on the plans. The Department will include the costs associated with using an alternative, such as differences in installation requirements including deflection testing, trench width or embedment material specifications, and quantities in the contract unit prices of the relevant pipe pay items.

The Department will pay for pipe culverts on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2501.501 | Culvert Excavation, Class * | cubic yard [cubic meter] |
| 2501.511 | ___ in [mm] ‖ Pipe Culvert † | linear foot [meter] |

| Item No.: | Item: | Unit: |
|---|---|---|
| 2501.515 | ___ in [mm] ‖ Pipe Apron | each |
| 2501.517 | Anti-seepage Diaphragm for ‡ Pipe | each |
| 2501.519 | Flap Gate for ‡ Pipe | each |
| 2501.521 | ___ in [mm] Span ‖ Pipe-Arch Culvert † | linear foot [meter] |
| 2501.525 | ___ in [mm] Span ‖ Pipe-Arch Apron | each |
| 2501.527 | Anti-seepage Diaphragm for ‡ Pipe-Arch | each |
| 2501.531 | ___ in [mm] ‖ Elliptical Pipe Culvert # | linear foot [meter] |
| 2501.535 | ___ in [mm] ‖ Elliptical Apron | each |
| 2501.541 | ___ in [mm] High ‖ Cattle Pass Culvert † | linear foot [meter] |
| 2501.543 | ___ in [mm] High ‖ Cattle Pass Transition Section † | each |
| 2501.545 | ___ in [mm] High ‖ Cattle Pass Apron Culvert † | each |
| 2501.551 | ___ in [mm] ‖ Structural Plate Pipe Culvert † | linear foot [meter] |
| 2501.555 | ___ in [mm] Span ‖ Structural Plate Pipe-Arch Culvert † | linear foot [meter[ |
| 2501.561 | ___ in [mm] ‖ Pipe Culvert, Design § † | linear foot [meter] |
| 2501.565 | ___ in [mm] Span ‖ Pipe-Arch Culvert, Design § † | linear foot [meter] |
| 2501.567 | ___ in [mm] ‖ Safety Apron and Grate Design § | each |
| 2501.569 | ___ in [mm] ‖ ** | each |
| 2504.571 | Install ** | linear foot [meter] |
| 2501.573 | Install ** | each |
| 2501.575 | ___ in [mm] RC Dissipator Ring | each |

* Specify Class U, E, or R only – Se 2451.3B2
‖ Specify King – See 2501.2, if alternatives are allowed do not specify kind
† Specify Strength Class, if other than minimum requirement.
‡ Specify size and kind
# Specify HE or VE, and Strength Class, if other than minimum requirement.
§ Give Standard Plate Number for special pipe or joint designs
** Specify item name

## 2502 SUBSURFACE DRAINS

### 2502.1 DESCRIPTION

This work consists of constructing subsurface drains and installing plant-fabricated pipe and appurtenant materials to perform the following:

(1) Collect and discharge water infiltrating the pavement system (pavement edge drain),

(2) Collect and discharge water accumulated in the bottom of a granular-backfilled subcut, cut off, or intercept ground water flowing toward the roadway (subcut drain), and
(3) Collect and discharge water coming from a permeable aggregate base system (permeable aggregate base drain).

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

## 2502.2 MATERIALS

Provide one of the following types of drain pipe as shown or allowed as an option on the plans. Provide fittings connecting multiple lengths of drain pipe made of the same material as the pipe. Provide nonperforated pipe except where the perforated type is shown on the plans. The Contractor may use pipe meeting the lowest strength class listed in the referenced materials specification, unless higher strength pipe is shown on the plans or specified in the special provisions. Provide nonperforated Thermoplastic (TP) pipe for discharge pipe, radial connecting pipe, and associated fittings. Provide special fabrication or jointing details if shown on the plans or as approved by the Engineer. Provide appurtenances, geotextiles, metal oversleeves with rodent screens, and precast concrete headwalls with all subsurface drains for high bridge abutments, to intercept and carry off underground water in accordance with this section, 3245, "Thermoplastic Pipe," 3733, "Geotextiles," and as shown on the plans.

**A Drain and Discharge Pipe**

**A1 Thermoplastic (TP)..... 3245**

**A2 Corrugated Polyethylene (PE) Drainage Tubing..... 3278**

**B Precast Concrete Headwall (Drain Outlet).....Standard Plate 3131**

**C Granular Materials..... 3149**

**D Geotextile, Type I..... 3733**

**E Erosion Blanket, Category 1..... 3885**

**F Seed..... 3876**

**G Marking Tape..... 3354**

## 2502.3 CONSTRUCTION REQUIREMENTS

**A Excavation**

Excavate the trench to the lines and grades as shown on the plans. Provide a trench with a width, as measured at the bottom of the excavation, at least the nominal pipe width plus two times the pipe diameter. The Contractor may use corrugated PE drainage tubing when placed in a narrow, controlled-width trench constructed by a chain-type or wheel-type trenching machine designed and used for this application and as approved by the Engineer. Use other types of rigid pipe for other uses in narrow trenches where compaction is not controlled. Do not install PE tubing by plowing.

Remove rock encountered within the excavation to a width of at least the nominal pipe width plus two times the pipe diameter and to a depth of at least one pipe diameter below the pipe. Except for locations shown on the plans or specified in this specification that require granular material, the Contractor may backfill to the bottom of the pipe with suitable material, compacted uniformly to provide a proper foundation as approved by the Engineer.

**B Laying Drains**

Bed perforated pipe drains on fine filter aggregate. Provide aggregate in accordance with 3149.2.J, "Fine Filter Aggregate," with a thickness of at least one pipe diameter below the bottom of the pipe, and extending upwards under the haunches for the full width and length of the trench, to the elevation shown on the plans or specified in this specification for the specified foundation preparations. The Engineer will not require granular bedding on nonperforated pipe installations unless otherwise shown on the plans. Do not place stones greater than 1 in [25 mm] in diameter in the trench.

Shape the foundation for drains in the required bedding material to fit at least the lower 30 percent of the outside circumference of the pipe. Lay drains to line and grade shown on the plans, with uniform bearing along the drain and with the perforations down, unless otherwise directed.

Wrap perforated pipe with factory-seamed or factory-produced continuous knit weave geotextile. Place the fabric seam at the top of the pipe, opposite the perforations. For seams at fittings or connectors, mechanically fasten or overlap the adjoining geotextiles at least 6 in [150 mm].

Join pipe sections with the coupling bands or fittings. Cement solvent type joints unless otherwise shown on the plans or specified in the specification. Close upgrade ends of subdrain pipe with caps. Use wyes or bends at junctions and turns suitable for cleaning and inspection.

Where a drain connects with a structure or catch basin, make a connection through the wall of the structure that does not leak. Unless otherwise shown on the

plans or specified in the specifications, terminate drainage outfalls at a standard precast concrete headwall.

## C Backfill

Backfill drains while making the pipe installations. On perforated pipe installations, place fine filter aggregate adjacent to and to a height of at least 6 in [150 mm] above the top of the pipe and as shown on the plans. The Contractor may backfill with the disturbed in-place soils above the elevation shown on the plans and on nonperforated pipe installations. Do not use stones greater than 1 in [25 mm] adjacent to and for 6 in [150 mm] above the pipe.

Compact fine filter aggregate if shown on the plans. Compact other backfill material to a density equivalent to that of the adjacent soils or in accordance with 2105.3.F, "Compacting Embankments."

## D Drain Outlets

### D.1 Precast Concrete Headwall

Place precast concrete headwall outlet inverts at least 6 in [150 mm], 12 in [300 mm] (preferred), above ditch grades. Place the uppermost point of the headwall flush with the in-slope at a downward grade of at least 2 percent to provide for drainage. Shape the earthen side slopes adjacent to the headwall to conform to the sides and toe of the headwall. Compact the soils around and under the concrete headwall outlet as approved by the Engineer.

If headwalls are not placed during installation of discharge pipes, mark discharge points to locate in the future. Screen the drain opening, and allow the drain to remain open and operational after installation. Unless otherwise approved by the Engineer, place concrete headwalls on discharge pipes before the end of the construction season. For pipes without headwalls, leave screened pipe ends open and free-flowing.

### D.2 Discharge Pipe

Provide nonperforated rigid TP pipe in accordance with 3245, "Thermoplastic Pipe," for discharge pipe and connections. Use a 4 in [100 mm] diameter TP discharge pipe for 3 in [75 mm] and 4 in [100 mm] PE subsurface drains. Use a 6 in [150 mm] diameter TP discharge pipe for 6 in [150 mm] PE subsurface drains. Use a 3 in × 4 in [75 mm × 100mm] TP adapter to make the connection between the 3 in [75 mm] PE subsurface drain and the 4 in [100 mm] diameter × 12 in [300 mm] straight length of TP pipe. Connect the 4 in [100 mm] PE subsurface drain to the 4 in [100 mm] diameter × 12 in [300 mm] straight length of TP pipe with a TP connector. Use a 90 degree, solvent-weld, bell and spigot elbow with a radius of at least 3 ft [915 mm] to make the connection between the 12 in [300 mm] length TP pipe and the

variable length straight TP discharge pipe. The Contractor may use different configurations for similar size, radius and pipe quality as approved by the Engineer.

Construct the discharge pipe to the drain outlet while constructing the drains. Place the discharge pipe and the drains at right angles to the roadway centerline. Fully couple the discharge pipe to the headwall as approved by the Engineer. Make connections with one of the following:

(1) 3A Grout,
(2) Rubber gasket on the pipe,
(3) Rubber or plastic gasket cast into the headwall, or
(4) Solvent or gasket joint into a TP coupling cast into the headwall.

Ensure the coupling will secure the pipe and prevent separation caused by small movements of the headwall.

Provide a 12 in [300 mm] straight length of TP connecting pipe to connect the PE subsurface drain to the TP discharge pipe. Attach this connector pipe to the PE edge drain with a radius of at least 3 ft [900 mm] to provide entry for probes, cleaners, or video cameras. Secure connections and solvent joints to prevent soil intrusion and decoupling during backfilling. At joints with the possibility for soil intrusion, wrap connections with geotextile as directed by the Engineer. Tape joints to prevent separation as directed by the Engineer. Orient increasers with the "smooth flow" portion at the pipe invert. Use connection and coupling methods as approved by the Engineer.

Connect two drain runs that come together at a low point with a TP "Y" connection. Use a TP discharge pipe to outlet the "Y" connection to a single headwall.

Construct the discharge trench similar to the drains and backfill the discharge trench with the disturbed in-place soil.

Place discharge pipes at grades no less than the drain pipes and with at least 2 percent fall. The Engineer may approve trench widths greater than 10 in [250 mm] for the discharge pipes, if the Contractor meets the following requirements:

(1) Cradle the pipe invert,
(2) Compact soil adjacent to and above the pipe to prevent crushing the pipe, and
(3) Compact the backfill soil in accordance with 2105.3.F, "Compacting Embankments."

Use compaction equipment capable of compacting the material in the drain trench without compacting the adjacent soils. Use backfill layer uncompacted thicknesses no greater than 6 in [150 mm]. Correct shoulder settlement above the discharge pipe as

directed by the Engineer and at no additional cost to the Department. Replace crushed or deformed discharge pipes or connections at no additional cost to the Department.

If drains discharge to storm sewers rather than through headwalls, place the drain invert from 6 in [150 mm] to 12 in [300 mm] above the sewer invert using a connection method approved by the Engineer at no additional cost to the Department.

**D.3 Turf Establishment**

Use seed and an erosion control blankets at the drain outlets, except at locations designated for sod as required by the contract.

Place a Category 1 erosion control blanket in accordance with 3885, "Rolled Erosion Control Products," to a width of at least 6½ ft [2 m]. Center the headwall along the width of the blanket. Extend the blanket 3 ft [1 m] above the headwall, and 6½ ft [2 m] below the headwall or to the bottom of the ditch, which ever is the shorter distance. Place anchor staples at intervals no greater than 1½ ft [½ m] apart. If placing a headwall at a location that will be sodded as required by the contract, delete the seed and mulch. Water and maintain turf installations in accordance with 2575.3.L, "Turf Establishment." Place a seed mixture under the erosion control blanket at the same mixture and rate as shown on the plans for the adjacent area. If the plans do not show a seed mixture, place seed mixture 250 at the rate of 2 lb per sq. yd [1 kg per sq. m] before anchoring the blanket.

**D.4 Marking Outlet Locations**

Permanently mark the locations of outlets with a 6 in × 18 in [150 mm × 450 mm] strip of white marking tape in accordance with 3354, "Preformed Pavement Marking Tape for Permanent Traffic Lane Delineation and Legends." Place the tape at the outside edge of the bituminous shoulder, at right angles to the roadway, and roll the tape into the shoulder while the bituminous pavement surface temperature is from 120 °F to 150 °F [48.9 °C to 65.6 °C]. If two runs of drain pipe come together at a low point and discharge via a "Y" to a single outlet, place two markings side-by-side with a 6 in [150 mm] spacing. For locations with no bituminous shoulder, place the tape on the bituminous pavement or spray a white paint strip on concrete pavements. The Engineer may approve alternate methods to mark the edge drain outlets.

**D.5 Inspection and Cleanout**

Once installed, maintain the discharge pipe and headwalls to prevent trapping water in the pipe. Inspect the discharge pipe and headwalls for proper grade, cleanliness, proper landscaping, proper erosion control installation and maintenance, and satisfactory operating condition. Maintain the discharge pipe and headwalls until final inspection with the Engineer.

The Engineer will perform inspections using a probe mounted on the end of a flexible fiberglass rod 4 in [100 mm] long and with a diameter of one nominal pipe size smaller than the drain pipe being inspected. The Engineer will conduct the inspection through the discharge pipe, radius connection, and at least 3 ft [1 m] into the main drainage line. Clean or repair inoperative discharge pipe and connections as approved by the Engineer at no additional cost to the Department.

**E Permeable Aggregate Base Type**

Construct subsurface drains to collect and discharge water coming from the following permeable aggregate base systems:

(1) Permeable Asphalt Stabilized Base (PASB),
(2) Open Graded Aggregate Base (OGAB), or
(3) Permeable Asphalt Stabilized Stress Relief Course (PASSRC).

Provide geotextile for trench lining in accordance with 3733, "Geotextiles," Type I. Provide perforated corrugated PE drainage tubing in accordance with 3278, "Corrugated Polyethylene Drainage Tubing." Provide aggregate in accordance with 3149.2.I, "Medium Filter Aggregate."

**E.1 Trenching**

Use a machine trencher capable of cutting the trench and placing the pipe in a continuous operation to place the drains. Do not plow. If the off-set between the tracks or tires of the trencher is greater than 6 in [150 mm], use a self-leveling trenching machine. Provide trenching equipment designed and operated to prevent the excavated material from falling back into the trench. Construct a trench from 7 in [180 mm] to 10 in [250 mm] wide. Shape the bottom of the trench to cradle the lower one-third of the pipe. Place pipes in grades following pavement grades at the design depth shown on the plans. The Contractor may place the geotextile, pipe and medium filter aggregate while trenching or in a separate operation immediately after trenching. When using separate operations to place the pipe and medium filter aggregate, properly align the pipe in the cradle before placing the medium filter aggregate.

If the trench sides are sloughing or caving in, use a shield to place the medium filter aggregate.

The Contractor may trench drains constructed in conjunction with stabilized PASB immediately adjacent to the placed pavement. Place drains constructed in conjunction with unstabilized OGAB 6 in [150 mm] away from the pavement edge to minimize undercutting. The edge drain must intersect the PASB or OGAB.

Place drains constructed in conjunction with PCC pavement after pavement placement. Place drains constructed in conjunction with bituminous pavement after

placement of the wear/non-wear courses and before placement of the final wearing course to avoid damage to the finished pavement. Construct drains before placing the additional aggregate base in the shoulder area.

Dispose of materials removed by the trenching operation off the right-of-way unless otherwise approved by the Engineer. Do not contaminate the permeable aggregate base, the medium filter aggregate, or the aggregate base. Sweep trenching spoils off the bituminous pavement before placing the wearing course, as approved by the Engineer.

**E.2 Geotextile Trench Lining**

Line the bottom of the drainage trench with geotextile. Do not wrap the PE pipe with geotextile. On the pavement side of the trench, terminate the geotextile within the aggregate base located below the permeable aggregate base. Do not extend the geotextile up onto the permeable aggregate base or allow it to fall below the bottom of the aggregate base. Do not allow the geotextile to lap up onto the permeable aggregate base. On the side of the trench farthest from the pavement, the Contractor may terminate the geotextile within or above the aggregate base, but not below it.

**E.3 Compaction**

Moisten the medium filter aggregate to allow easy placement and vibratory compaction as approved by the Engineer. Do not use the tire-rolling method to compact medium filter aggregate. After placement and compaction, ensure the top of the medium filter aggregate is at least as high as the top of the permeable aggregate base.

**E.4 Maintenance**

After placing the drain and discharge pipe, do not allow construction equipment to travel over the drain or discharge pipe until the system is protected as approved by the Engineer.

Place aggregate base in the shoulder area over the compacted drain and backfilled trench, to avoid contamination. Remove and replace contaminated materials at no additional cost to the Department. Allow the drain to remain open and operative after installation to prevent water from collecting in the pipe.

**F Subcut Drain Type**

Construct subcut drains in accordance with this section and the option details shown on the plan. Use subcut drains to collect and discharge infiltration water that may accumulate in the bottom of granular-backfilled subcuts. The Contractor may also use subcut drains to control high groundwater conditions.

Unless otherwise shown on the plans or specified in the special provisions, the Contractor may construct the drains using one of the following design options:

(1) Place 4 in [100 mm] perforated TP pipe in accordance with 3245, "Thermoplastic Pipe," in the bottom corner of the subcut and then backfill the subcut or
(2) Backfill the subcut and then use a machine trencher to place 4 in [100 mm] perforated corrugated PE pipe in accordance with 3278, "Corrugated Polyethylene Drainage Tubing."

For both design options, wrap the pipe with geotextile in accordance with 3733, "Geotextiles," Type I. Provide Fine Filter Aggregate in accordance with 3149.2.J, "Fine Filter Aggregate."

The Contractor may directly connect subcut drains to permanent drainage structures or outlet the drains to the ditch using a discharge pipe and headwall. If shown on the plans, make connections to drainage structures as approved by the Engineer. The Department will include the cost of connections with other relevant contract pay items.

Place pipe as shown on the plans or as approved by the Engineer. Provide drain grades of at least 0.2 percent and place ditch outlets at low points or spaced no greater than 500 ft [152.4 m] apart. The Contractor may place structure outlets spaced no greater than 800 ft [243.8 m] apart if both ends of the pipe are tied to structures. If pipe grades do not follow the roadway profile at a constant depth, provide and use laser grade control equipment to place TP pipe and PE pipe.

**F.1 Design Option One**

Place 4 in [100 mm] perforated TP pipe in the bottom of the subcut in accordance with the design typical in the plans. Place at least 12 in [300 mm] of subcut backfill above the pipe before compacting.

The Contractor may provide pipe with either bell and spigot or sleeve couplings and either gasket or solvent joints. Leave solvent joints uncemented unless otherwise directed by the Engineer. Mark the depth on the ends of the bell or sleeve. Place the perforations down. Provide connections to drainage structures made of angle fittings no greater than 22½ degrees.

**F.2 Design Option Two**

Place 4 in [100 mm] perforated corrugated PE tubing after partially or totally backfilling the subcut.

Use a machine trencher capable of performing the following functions to place the drains:

(1) Cutting the trench,
(2) Shaping the trench bottom to cradle the lower one-third of the pipe,
(3) Laying the pipe, and
(4) Backfilling with filter aggregate in one simultaneous and continuous operation.

Do not plow. Equip the trenching head with a shield to prevent adjacent material from caving. Trench to a width from 8 in [200 mm] to 10 in [250 mm] and center the pipe in the trench.

Backfill the trench with fine filter aggregate. Provide free flowing filter aggregate and vibratory compaction as approved by the Engineer. In addition to the required trench compaction, make at least one pass of the roller as directed by the Engineer over the trench before placing the overlying pavement structure as shown on the plans.

Perform the trenching operation after placing and compacting at least 24 in [600 mm] of subcut backfill. If trenching after completely backfilling the subcut, only backfill the lowermost 24 in [600 mm] of the trench with Fine Filter Aggregate. Backfill the remaining trench with the same material used for the subcut and compact to the compaction requirements in 2105.3.F, "Compacting Embankments."

**G Pavement Edge Drain Type**

Construct 3 in [75 mm] diameter edge drains. Use pavement edge drains to collect and discharge water infiltrating into the pavement system from rain or snow melt, and spring-thaw seepage.

Provide perforated corrugated PE tubing for edge drain pipe in accordance with 3278, "Corrugated Polyethylene Drainage Tubing." Wrap the pipe with geotextile in accordance with 3733, "Geotextiles," Type I to prevent infiltration of fine filter aggregate into the perforated pipe. Trench backfill with fine filter aggregate in accordance with 3149.2.J, "Fine Filter Aggregate."

Place drains adjacent to new pavements after constructing the pavement to prevent damage to the drain or discharge pipe. Use a machine trencher capable of cutting the trench and laying the pipe in a continuous operation to place the drains. Do not plow. Provide trenching equipment designed and operated to prevent excavated material from falling back into the trench. Use a self-leveling trenching machine if the off-set between tracks or tires of the trencher is greater than 6 in [150 mm]. Trench to a width from 6 in to 10 in [150 mm to 250 mm]. Shape the bottom of the trench to cradle the lower one-third of the pipe. If pipe grades do not follow pavement grades at a constant depth, provide and use laser grade control equipment to place pipe.

Install the edge drains before pavement cracking where cracking in-place PCC pavement before overlay.

If placing drains in conjunction with pavement widening, place the drains before excavating the widening-trench. Use an approved device on the trenching machine to ensure that the pipe is located at the design distance from the edge of the in-place pavement. After compaction, ensure the filter aggregate in the drain extends at least 4 in [100 mm] above the bottom of the pavement widening trench.

For drains placed next to a PCC pavement, run the trenching head tight against the pavement to completely excavate all adjacent soil.

If placing the drain next to a new bituminous pavement, construct the drain after placing the pavement base and leveling courses, but before placing the wearing course, to avoid damage to the finished pavement. For new and retrofit construction, ensure the trenching head continuously intercepts and cuts-off the roll-over portion of at least the lower bituminous pavement course. Ensure the trenching spoils always show evidence of bituminous materials. Clean spoils from the pavement before placing the wearing course for new pavements or the first bituminous lift for overlays as approved by the Engineer.

For bituminous shoulders remaining in place after drain placement, use a coulter, saw, milling mandrel, or other method by the Engineer on the bituminous shoulder to leave a smooth edge and to prevent disturbance to the bituminous pavement.

For new construction, place the aggregate base before trenching, except for bituminous pavements, place the aggregate base to the height of the adjacent layer at the time of trenching.

Provide drains on grades at least 0.2 percent and place outlets to the ditch at a spacing no greater than 500 ft [152.4 m] and at low points as shown on the plans.

The Contractor may place the filter aggregate backfill simultaneously with the pipe or in a separate operation immediately following the trenching activity. If placing the pipe and filter aggregate in separate operations, align the pipe in the shaped cradle before placing the filter aggregate. If soil type or Contractor operations cause sloughing or caving from either side of the trench, use a shield on the trenching head and place filter aggregate within the shield as directed by the Engineer.

Surplus excavated materials not used for backfill shall become the property of the Contractor. Dispose of surplus material in accordance with the disposal form submitted to and approved by the Engineer.

Compact the filter aggregate with equipment capable of achieving a minimum of 95 percent of maximum density for the full depth of the trench.

Before beginning routine trenching and backfilling, construct a test trench at least 50 ft [15.2 m] long that has the same requirements as the production work. The Engineer will measure adequacy of compaction in the test trench with a Department-supplied Dynamic Cone Penetrometer (DCP).

The Department defines successful compaction as penetration resistances no greater than 3 in [75 mm] per DCP hammer blow. The Engineer will base successful compaction on the average of three DCP readings for similar depths in three tests taken 10 ft [3 m] apart. Unless otherwise directed by the Engineer, begin penetration readings from the point where the DCP equipment stabilizes after setup in the trench.

Do not compact greater than 24 in [600 mm] of filter aggregate in any one layer. The Contractor may use smaller lifts or make more than one pass of the compactor to achieve a minimum of 95 percent of maximum density throughout the compacted depth, unless otherwise directed by the Engineer. Do not run the compactor at a rate greater than 60 ft per min [18.3 m per min] unless otherwise approved by the Engineer based on DCP test results. Stop the trenching operation if the compaction method or source of trench backfill changes, or compaction effort yields insufficient density, until the Engineer performs additional DCP testing and approves corrections. After compaction and leveling, extend the filter aggregate up onto the adjacent pavement as shown on the plans.

If capping filter aggregate trench with another type of granular material or bituminous mixture as shown on the plans, place and compact the materials separately from the filter aggregate and do not compact with future placement of similar material. Heap bituminous caps at least 1 in [25 mm] and roll. Place granular caps at least 1 in [25 mm] high and roll. Place caps to provide support for overlying material and to incorporate a second compaction effort in the trench.

Do not contaminate the filter aggregate. Do not deposit or mix aggregates or other soils on the adjoining concrete or bituminous pavement. Remove material spilled on the pavement surface by sweeping.

After placing the drain and discharge pipe, do not allow construction equipment to travel over the drain or discharge pipe until the system is covered as approved by the Engineer. Allow the drain to remain open and operational after installation to prevent water from collecting in the pipe.

## 2502.4 METHOD OF MEASUREMENT

### A Subsurface Drains

The Engineer will measure subsurface drains by the length of the provided and installed subsurface drain and discharge pipe approved by the Engineer. The Engineer will measure drain and discharge pipes by installed length along the centerline of the

pipe. The Engineer will begin and end measurement at the pipe end at free outlets, at the point of junction with in-place pipe, or at the center of structures, catch basins, or multiple junction points.

Where the contract requires subsurface drains, the Engineer will separately measure the lengths of each size and type of pipe.

**B Granular Materials**

The Engineer will measure granular materials for special backfill or bedding in accordance with 2451.4.B, "Granular Materials."

If measuring on the basis of compacted volume, the Engineer will limit the measurement to the dimensions as shown on the plans.

**C Precast Concrete Headwalls**

The Engineer will measure the number of provided precast concrete headwalls.

**D CS Oversleeve with Rodent Guard**

The Engineer will measure CS oversleeves with rodent guard by the number of CS oversleeves with rodent guard provided, installed, capped, and marked.

## 2502.5 BASIS OF PAYMENT

The contract unit prices for subsurface drains and outlets of each size, type, kind, and strength class include the cost of providing and installing the item as shown on the plans, except as otherwise specified in this subsection.

The Department will pay for subdrain elbow or wye sections and additional connectors directed by the Engineer but not shown on the plans at the invoice cost of the materials provided.

Unless otherwise shown on the plans, the Department will separately pay for special bedding or backfill in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment."

The contract unit price for contract item No. 2502.502 includes the cost of connecting pipe footage and couplings.

The contract unit price for drain outlet consisting of precast concrete headwall and discharge pipe includes the cost of providing and placing the unit, erosion control blanket and seed, marking, inspecting, and all other associated work. For required sodding, the Engineer will include the cost of the sod with relevant contract pay items.

The contract unit prices for the relevant subsurface drain contract items include the cost of geotextiles and other joint wrapping or sealing materials.

The contract unit price for contract item No. 2502.501 includes the cost of providing and placing tape or paint for marking outlet locations.

The contract unit price for the relevant subsurface drain contract item includes the costs associated with the disposal of surplus material.

The Department will pay for trench excavation required below an elevation greater than 12 in [300 mm] below the bottom of the pipe or tile as shown on the plans as extra work in accordance with 1402, "Contract Revisions."

Unless otherwise shown on the plans, the Department will pay for the removal of ledge rock or rocks larger than ½ cu. yd [0.4 cu. m] from the excavation as extra work in accordance with 1402, "Contract Revisions."

The Department will pay for subsurface drains based on the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2502.501 | ___in [mm] Precast Concrete Headwall | each |
| 2502.502 | Drainage System Type ___ | lump sum |
| 2502.521 | ___in [mm] * Pipe Drain ‖ | linear foot [meter] |
| 2502.541 | ___in [mm] Perforated * Pipe Drain ‖ | linear foot [meter] |
| 2502.571 | ___in [mm] Install † | linear foot [meter] |
| 2502.573 | ___in [mm] Install † | each |

* Specify kind in accordance with 2502.2.A, "Drain and Discharge Pipe."
‖ Specify strength class if other than the minimum requirement.
† Specify item name.

## 2503 PIPE SEWERS

### 2503.1 DESCRIPTION

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

Construct manholes and catch basins in accordance with 2506, "Manholes and Catch Basins." Provide aprons as shown on the plans and in accordance with 2501, "Pipe Culverts."

### 2503.2 MATERIALS

**A Pipe**

Provide one of the following types of sewer pipe as specified or allowed as an option on the plans or in the special provisions. Use pipe meeting the lowest strength class specified or greater, unless a higher strength pipe is shown on the plans or specified in the special provisions. Perform special fabrication or jointing as shown on the plans. Provide pipe sewers with the coating type shown on the plans or specified in the special provisions.

**A.1 (Blank)**

**A.2 Reinforced Concrete (RC)..... 3236**

**A.3 Corrugated Aluminum (CA)..... 3225**

**A.4 Corrugated Steel (CS) ..... 3226**

**A.5 Corrugated Aluminized Steel (CAS)..... 3222**

**A.6 (Blank)**

**A.7 (Blank)**

**A.8 (Blank)**

**A.9 Corrugated Polyethylene (CP)..... 3247**

**A.10 Plastic Truss (PT)..... 3241**

**A.11 (Blank)**

**A.12 Polymeric Coated-Corrugated Steel (PC-CS) ..... 3229**

**A.13 Thermoplastic (TP)..... 3245**

**A.14 Polyvinyl Chloride (PVC)..... 3248**

**B Flap Gates..... 3399**

**C Pipe Joint Sealer Materials**

**C.1 Hot-Poured Sealing Compound..... 3724**

**C.2 Preformed Rubber, Type A ..... 3726**

**C.3 Preformed Plastic, Type B ..... 3726**

**C.4 Bituminous Mastic..... 3728**

**D Granular Materials..... 3149**

**2503.3 CONSTRUCTION REQUIREMENTS**

**A General**

Construct sewer installations in accordance with 2451, "Structure Excavations and Backfills," for excavation, foundation construction, and backfilling of prefabricated structures and in accordance with the following requirements:

## B Excavation

For locations with cover over the top of the pipe at least 15 ft [4.5 m], ensure the excavation dimensions meet the following:

(1) For the portion of the required excavation below a point 1 ft [300 mm] above the top of the pipe, provide nearly vertical side slopes, and
(2) Excavate the width of the trench meeting the requirements specified in Table 2503-1:

**Table 2503-1**
**Maximum Trench Width for Pipe Sewer**

| **Pipe Diameter, *in [mm]*** | **Maximum Trench Width*** |
|---|---|
| < 42 [1,050] | Outside diameter plus 24 in [600 mm] |
| 42 – 54 [1,050 – 1,350] | 1.5 times outside diameter |
| > 54 [1,350] | Outside diameter plus 36 in [900 mm] |

* 1 ft [300 mm] above pipe

If the Contractor excavates the trench to a width greater than the values specified in Table 2503-1, the Engineer may direct the Contractor to provide a higher class of bedding, a higher strength pipe, or both, than that required by the contract, at no additional cost to the Department.

## C Laying Pipe

### C.1 General

Lay the pipe to the line and grade shown on the plans.

Use standard or specially manufactured fittings for pipe junctions and turns.

At sewer connections with an existing manhole or catch basin, make a suitable connection as approved by the Engineer through the wall of the manhole or catch basin.

Use vitrified clay or concrete stoppers sealed in place to plug branch openings or service connections provided for future use.

### C.2 Metal Culvert

Lay corrugated metal pipes containing circumferential joints with the outside laps pointing upgrade and with the longitudinal joints on the sides.

Use approved metal connecting bands shown on the standard plate, centered over the joint, to join metal pipe sections. Place the metal pipe joints as close together as possible. Tighten the band to ensure a tight joint.

**C.3 Concrete Culvert**

Lay concrete pipe with the bell or grooved ends upgrade. Provide joints meeting the requirements of AASHTO M 198.

Use rubber gasket, preformed plastic, or bituminous mastic elastic joint sealer material to seal joints in concrete pipe to provide a flexible water tight joint. Use gasket type joint sealer material to seal pipe designed to accommodate preformed gasket type seals, as shown on the plans.

Apply mastic joint sealer as recommended by the manufacturer. Wipe joints clean on the inside after sealing. Use precast concrete plugs to plug lifting holes. Seal and cover concrete plugs placed in lifting holes with mastic or mortar.

Use approved fasteners shown on Standard Plate 3145 to tie concrete pipe sections together as required by the contract, unless otherwise shown on the plans or specified in the special provisions.

**C.4 Plastic Culvert**

Make connections with bell and spigot joints using an elastomeric rubber seal (gasket) meeting the requirements of ASTM F 477 and capable of passing a laboratory pressure test of at least 2 psi [14 kPa]. Provide silt-tight joints unless otherwise shown on the plans or specified in the special provisions. Provide water-tight joints as shown on the plans and meeting the requirements of ASTM D 3212 as modified by the following:

(1) Perform the internal pressure test at a minimum of 10 psi [68 kPa] with the pipe in straight alignment, and
(2) The Department will not require the vacuum test.

Submit to the Engineer a laboratory certification provided by the pipe manufacturer that the pipe coupler for each size pipe meets or exceeds the requirements in this section. Submit the shop drawings of each pipe coupler provided by the pipe manufacturer and any additional mechanical connections as required by the contract.

Install joints so connected pipe sections form a continuous surface free of irregularities at the flow line.

Place pipes and backfill in dry conditions by controlling the water conditions. Dewater groundwater and surface runoff to keep the water level below the pipe foundation.

Place pipes on the bedding starting at the downstream end of the pipe installation.

Provide Class B bedding. Compact the zone immediately beneath the pipe only to provide uniform support, unless otherwise approved by the Engineer. The Department defines the embedment envelope as the zone of structural backfill around the pipe. Provide embedment material in accordance with 3149.2.D, "Backfill Materials," modified to 100 percent passing the 1 in [25 mm] sieve. Use the embedment material to provide 12 in [300 mm] of fill over the pipe and fill for a trench width as specified by the contract. Modify the trench width as required by the contract. Use compaction equipment in the pipe zone that is capable of compacting the embedment material to the required compaction. Compact embedment material to 100 percent maximum density in accordance with specific density method in 2105, "Excavation and Embankment."

Maintain a minimum cover depth of material above the pipe of at least 2 ft [600 mm] and meeting the requirements of AASHTO LRFD *Bridge Construction Specifications*, Section 30, Table 30.6-1 before allowing vehicles or heavy construction equipment to travel over the pipe trench.

Perform deflection testing at least 30 days after installation. Evaluate the pipe to determine a reduction of greater than 5 percent in the internal diameter of the barrel. Use a nine-point mandrel approved by the Engineer to perform deflection testing for pipes with an inside diameter no greater than 24 in [600 mm]. Ensure the diameter of the mandrel is 95 percent of the certified actual mean inside diameter of the pipe. Use non-mechanical means to pull the mandrel through the pipe.

Use a mandrel or other method approved by the Engineer to perform deflection testing of pipes with an inside diameter greater then 24 in [600 mm]. If the Department allows direct measurements, the Engineer will randomly select locations. Take measurements as selected, at least every 10 ft [3 m] throughout the pipe length, and at the pipe ends. Visually inspect the pipe and take additional measurements at points of observed anomalies or deflections. Ensure personnel making direct measurements meet confined space entry requirements in accordance with 1706, "Employee Health and Welfare."

The Engineer will consider pipe unacceptable if the mandrel cannot pass through the pipe or if the direct measurements show a deflection of greater than 5 percent in the pipe. Remove unacceptable pipe and install new pipe or undamaged deformed pipe. Re-test the re-laid pipe for deflection after at least five days.

**D Backfill**

Backfill sewer installations as shown on the plans and in accordance with 2451, "Structure Excavations and Backfills."

Surplus excavated materials not used for backfill shall become the property of the Contractor. Dispose of surplus material in accordance with the disposal form submitted to and approved by the Engineer.

**E Installation by Jacking**

Install pipe by jacking in accordance with 2501.3.C.1, "Laying Pipe, General."

**F Cleanout**

Clean sediment and debris from sewers before final acceptance.

## 2503.4 METHOD OF MEASUREMENT

**A Excavation**

The Engineer will measure excavation specified or directed as extra work in accordance with 2451.4, "Structure Excavations and Backfills, Method of Measurement," for prefabricated structures.

**B Sewer Pipe**

The Engineer will separately measure each type of pipe by length along the center line of the sewer. The Engineer will begin and end measurements at the following locations:

(1) Pipe end at free outlets,
(2) Point of junction with in-place pipe, or
(3) Center of manholes, catch basins, or multiple junction points.

The Engineer will measure pipe transition sections as the larger size of pipe.

The Engineer will classify sections of metal pipe at the outlets of clay or concrete sewers as metal sewers.

The Engineer will measure Department-provided sewer materials required by the contract by the length of installed sewer, separated by type but not by size.

**C Sewer Appurtenances**

The Engineer will separately measure flap gates and other specially identified appurtenant items with a contract each price by the number of units of each type and size incorporated in the sewer structures.

**D Granular Materials**

The Engineer will measure granular materials for special backfill and bedding in accordance with 2451.4.B, "Granular Materials."

The Engineer will measure compacted volume of granular materials based on the maximum trench widths specified in accordance with 2503.3, "Pipe Sewers, Construction Requirements."

## 2503.5 BASIS OF PAYMENT

The contract unit price for the contract items for sewer pipe of each size, type, kind, and strength class include the costs of providing and installing the pipe complete-in-place as required by the contract, except as otherwise specified in this section.

The Department will pay for elbow, tee, or wye sections and additional connectors directed by the Engineer, but not shown on the plans, by the invoice cost of the materials.

The Department will pay for installing Department-provided sewer materials including all work and additional materials used to complete the sewer installation by the relevant install only contract pay item, except for "Extra Work" or work included in other relevant contract pay items.

The Department will include the cost of granular materials for special bedding or backfill with relevant pay items in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment."

The contract unit prices for excavation contract items include the cost of disposing of surplus excavated material.

If the Engineer approves of sewer pipe installation by the jacking method and contract item does not exist, the Department will pay for a jacking installation on the basis of contract unit prices relevant for the trenching method.

The Department will include the cost of aprons required in connection with the sewer construction with relevant pay items in accordance with 2501.5, "Pipe Culverts, Basis of Payment."

The Department will pay for required excavation greater than 1 ft [300 mm] below the bottom of the pipe as shown on the plans as extra work in accordance with 1402, "Contract Revisions."

If the plans do not include a contract pay item, the Department will pay for the removal of ledge rock or rocks larger than ½ cu. yd [0.4 cu. m] in volume from the excavation as extra work in accordance with 1402, "Contract Revisions."

The Department will include the cost of alternatives as shown on the plans, including cost differences in installation requirements, deflection testing, trench width, or embedment material specifications and quantities, in the contract unit price of the pipe.

The Department will include the cost of trench excavation with the relevant contract pay item for sewer installation.

The Department will pay for sewers on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2503.511 | ___ in [mm]* Pipe Sewer‖ | linear foot [meter] |
| 2503.519 | Flap Gate for Pipe† | each |
| 2503.521 | ___ in [mm] Span* Pipe-Arch Sewer‖ | linear foot [meter] |
| 2503.531 | ___ in [mm] Span* Elliptical Pipe Sewer‡ | linear foot [meter] |
| 2503.541 | ___ in [mm]* Pipe Sewer, Design# ‖ | linear foot [meter] |
| 2503.571 | Install § | linear foot [meter] |
| 2503.573 | Install § | each |

* Specify kind in accordance with 2503.2.A, "Pipe."
‖ Specify strength class if other than minimum requirement
† Specify size and kind
‡ Specify HE or VE, and strength class, if other than minimum requirement
# Specify pipe or joint designs and provide standard plate number
§ Special item name

## 2506 MANHOLES AND CATCH BASINS

### 2506.1 DESCRIPTION

This work consists of constructing or reconstructing brick or concrete block masonry, cast-in-place concrete, precast sectional concrete, or pipe structures for access and drainage into underground drainage or other systems.

The Department defines precast concrete median drains as casting assemblies.

### 2506.2 MATERIALS

**A Concrete..... 2461**

Use 3B43 concrete for drop inlet surface block.

Use 3Y43 concrete for all other cast-in-place structures.

**B Mortar**

**B.1 Mortar (Type S or M)..... 3106**

**B.2 Masonry Cement (Type S or M)..... 3107**

**B.3 Mortar Sand..... 3128**

**C Clay Brick..... 3612**

**D Concrete Brick ..... 3616**

**E Concrete Masonry Units ..... 3621**

**F Sectional Concrete Manhole and Catch Basin Units ..... 3622**

**G (Blank)**

**H (Blank)**

**I (Blank)**

**J Reinforced Concrete Pipe ..... 3236**

**K Corrugated Steel Pipe..... 3226**

**L Metal Drainage Castings..... 3321**

**M Concrete Drainage Castings ..... 3622**

**N Granular Materials..... 3149**

**O (Blank)**

**P Corrugated Aluminum Pipe ..... 3225**

**Q Corrugated Aluminized Steel (CAS)..... 3222**

## 2506.3 CONSTRUCTION REQUIREMENTS

### A General

### A.1 Combination Construction

The Engineer may allow a combination of cast-in-place and prefabricated concrete construction, if the contract does not specify the type of construction for a structure and if the Contractor maintains the structural strength and continuity.

### A.2 Intercepting Existing Facilities

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

**A.3 Abandoned Pipes**

When abandoning a pipe that enters a structure that will not be abandoned, detach the pipe from the structure wall and permanently plug the wall opening and the upgrade end of the abandoned pipe with concrete or masonry.

**A.4 Excavation, Bedding, and Backfill**

Excavate, bed, and backfill in accordance with 2451, "Structure Excavations and Backfills."

**A.5 Inspection Before Construction**

Do not place mortar in any unit or section of work before the Engineer has inspected and approved the foundation preparations, materials, and provisions for cold weather protection.

**A.6 Temperature Restrictions**

Do not place mortar on a frozen foundation or against any surface with a temperature below freezing.

Do not start or continue production of concrete or mortar when the ambient air temperature at the construction site, away from artificial heat, is less than 36 °F [2 °C]. The Engineer may otherwise approve in accordance to the following:

(1) When the air temperature is rising and has reached 34 °F [1 °C], or
(2) If the Contractor makes provisions for cold weather protection in advance, as approved by the Engineer.

Do not use masonry units or aggregate in temperatures 32 °F [0 °C] or less, except as directed by the Engineer.

Maintain concrete and mortar mixes at a temperature from 50 °F to 90 °F [10 °C to 32 °C] until incorporated into the work.

The Engineer may approve heating of masonry units, mix materials, or mortar. Do not spot heat these materials using steam jets or direct application of combustion heating devices as the work progresses.

Provide masonry in accordance with the requirements in this section if at least part of the structure is constructed using clay brick or concrete masonry units. The Department defines "unit" as the brick or concrete block unless otherwise qualified in this section.

Do not moisten concrete masonry units before placement in the work. Moisten all other types of masonry units before placement.

Place units in a full mortar bed, in horizontal courses, using the "shove joint" method, as described in this section. Fill joints with mortar. Strike joints on the inside of the structure, providing a joint width no greater than ½ in [13 mm] wide. Plaster the outside of the structure with mortar to a smooth surface.

Install steps, pipes, or other fixtures required by the contract, as the work progresses. Fit the units around pipes that penetrate the structure, using only part of the unit to form a neat juncture at the pipe as approved by the Engineer. Bond attachments to the structure using mortar to fill voids.

For manholes or catch basins constructed of brick, meet the following additional requirements:

(1) In circular type structures, lay the bricks flat and radially with the ends exposed on the inside of the structure. Where the thickness of the wall is greater than the length of one brick, the Contractor may lay the outside bricks circumferentially using full header construction in at least each sixth course.
(2) In rectangular type manholes, lay the bricks in regular courses of stretchers using full header construction in at least each sixth course. Do not use bats or spalls except for shaping around openings or for finishing out a course. When shaping around openings or finishing out a course, place full bricks in the corners and the bats in the interior of the course. Ensure the least dimension of the exposed faces of bats is at least 50 percent of the width of a brick.

When using the alternate method of constructing the tapered portion of a manhole with concrete block as shown on the plans, use concrete units specifically shaped to transition between the vertical and the sloped walls.

**D Sectional Concrete**

Set the bottom pre-cast section in a full mortar bed and fill the joints between sections and around pipes with mortar or a plastic cementing compound approved by the Engineer.

**E Pipe**

Construct metal or concrete pipe manholes as shown on the plans.

**F Castings**

Set the frame or ring castings to the designated elevation on a full mortar bed. If using metal pipe construction, set casting as shown on the plans, as specified in the specifications, or as approved by the Engineer.

Place a 4 in [100 mm] thick concrete encasement around the outside of the manhole or catch basin as detailed in Mn/DOT Standard Plate 4026. Place this encasement at the time of final casting placement.

If the plans shown castings not bonded to the manhole or catch basin, finish the mortar bed to the required grade and allow the mortar bed to set. After the mortar bed sets, apply a lubricant approved by the Engineer to the bed and install the casting.

**G Adjusting Frame or Ring Castings**

Provide vertical adjustment of access castings made to the planned elevation on the existing structure. Meet the criteria that full support for the casting is obtained above the cone section and ensure that structure construction above the cone does not exceed 2 ft [600 mm]. If these criteria cannot be met by vertical adjustment work, reconstruct the structure.

For upward adjustment of castings, the Contractor may use any of the structure materials or applicable construction methods specified in this subsection, provided they are compatible with the in-place construction. The Contractor may use auxiliary ring castings and adjusting rings as shown on the plans.

**H Reconstructing In-Place Structures**

If the plans require reconstructing the manhole or catch basin or if raising or lowering the frame or ring casting beyond the limits specified in 2506.3.G, "Adjusting Frame or Ring Castings," reconstruct the structure as shown on the plans or directed by the Engineer.

Perform reconstruction to be consistent with the type of construction used for the in-place structure meeting the requirements specified in this section for new construction. The Contractor may use salvaged material, if approved by the Engineer. Thoroughly bond new work to the in-place structure.

**I (Blank)**

**J Construction in Conjunction with Pavement Construction**

If constructing, reconstructing, or adjusting manholes and catch basins in connection with the construction of a concrete pavement or base, use the telescoping type of ring unless otherwise shown on the plans.

If using the telescoping type of ring, set the frame or ring casting to the proper elevation before placing the pavement.

**K Backfilling**

If the structure consists of cast-in-place concrete or of bricks or blocks laid in mortar, do not place the backfill until the concrete or mortar has cured for at least 3 days.

Excavated materials not required for backfill shall become the property of the Contractor. Dispose of the excavated material off the right-of-way in accordance with 2105, "Excavation and Embankment," at no additional cost to the Department.

**2506.4 METHOD OF MEASUREMENT**

The Engineer will measure manholes and catch basins as drainage structures.

**A Constructing Drainage Structures**

If the plans specify measurement by length for vertical structures constructed on a concrete base, the Engineer will measure the height as the difference in elevation between the bottom of the casting and the invert elevation of the outlet pipe, plus an allowance of 0.70 ft [0.20 m] for the depth of the concrete base, regardless of its actual thickness.

If the plans specify measurement by length for pipe structures designed with a "tee" section in the sewer or culvert line, the Engineer will measure the length as the difference in elevation between the bottom of the casting and the flow line elevation of the sewer or culvert pipe for vertical construction, or as shown in the plans for other special designs not constructed vertically. The Engineer will measure the "run" of the pipe structure "tee" section as culvert or sewer pipe.

If the plans specify the measurement of each structure complete in place, the Engineer will separately measure drainage structures of each design as individual units complete in place, including any castings provided and installed.

**B Reconstruction**

The Engineer will measure reconstruction to the nearest $^{1}/_{10}$ ft [30 mm], of the height from the bottom of the reconstructed portion to the bottom of the newly set casting, regardless of type.

**C Castings**

The Engineer will measure casting assembly by the number of casting assemblies provided and installed.

The Engineer will measure install casting by the number of castings installed.

The Engineer will not measure castings for structures measured as a unit. The Engineer will consider all castings required for an individual structure as one assembly.

**D Adjusting Castings**

The Engineer will measure adjusting castings by the number of casting assemblies adjusted. The Engineer will consider all castings required for an individual structure as one assembly.

## 2506.5 BASIS OF PAYMENT

The contract unit price for constructing or reconstructing drainage structures includes all costs for completing the work, including the cost of excavation, except for the cost of specific contract items, in accordance with the following:

(1) The Department will pay for excavation in ledge rock and the removal of boulders or detached rocks with a volume greater than ½ cu. yd [0.4 cu. m] as extra work in accordance with 1402, "Contract Revisions," unless the existence of the rock is shown on the plans.
(2) The contract unit price for reconstructing drainage structures includes the cost of removing the existing casting, but does not include placement of a casting on the reconstructed structure.
(3) The contract unit price for reconstructing drainage structures includes the costs of removing and replacing all or a portion of the structure as shown on the plans, adjacent pavement aggregate base, and excavation if, except for the structure construction, the surface would not otherwise have been disturbed. The Department will pay for the cost of this work at the contract unit price based on the area to the nearest $^{1}/_{10}$ sq. yd [0.1 sq. m] within a rectangle with sides that lie 1½ ft [½ m] outside the structure limits. The Department will include the cost of removing and replacing pavement outside of these limits or for replacing any other type of surfacing with other applicable pay items.
(4) The contract unit price for drainage structure construction by the structure as individual units complete in place includes the cost of providing and installing any castings required.
(5) The contract unit price for adjust frame and ring castings will include the cost of the removing and replacing concrete surfacing in connection with the item of adjust frame and ring castings.
(6) The casting encasement detailed in Standard Plate 4026 will be placed at the time of final casting placement, with no additional cost to the Department.

(7) The Department will pay for granular materials for special bedding or backfill in accordance with 2451.5, "Structure Excavations and Backfills, Basis of Payment."
(8) The contract unit price for *Adjust Frame and Ring Casting* includes the cost of salvaging and installing the in-place casting; removing deteriorated rings; and providing and installing all sewer blocks, bricks, rings and grout necessary to raise or lower in-place castings to the elevation shown on the plans or directed by the Engineer.

The Department will pay for manholes and catch basins as drainage structures based on the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2506.501 | Construct Drainage Structure, Design ___ | linear foot [meter] |
| 2506.502 | Construct Drainage Structure, Design ___ | each |
| 2506.503 | Reconstruct Drainage Structure | linear foot [meter] |
| 2506.516 | Casting Assembly | each |
| 2506.521 | Install Casting | each |
| 2506.522 | Adjust Frame and Ring Casting | each |

## 2507 CULVERT LINER

### 2507.1 DESCRIPTION

This work consists of inserting a polyethylene (PE) or polyvinyl chloride (PVC) pipe liner inside an in-place culvert.

### 2507.2 MATERIALS

**A Pipe**

Provide one of the following types of culvert liner pipe as shown on the plans or specified in the special provisions:

**A.1 Polyethylene (PE)..... 3249**

**A.2 Polyvinyl Chloride (PVC) ..... 3249**

### 2507.3 CONSTRUCTION REQUIREMENTS

**A General**

The Department will specify the diameter of the in-place pipe to be lined in the contract item. Follow liner dimensions as shown on the plans and as specified by the special provisions.

Use slings, boom-type trucks, or an equivalent approved by the Engineer to unload liners at the project. Do not dump liners from the truck or use chains or wire rope for handling. The Contractor may use a winch truck or equivalent equipment approved by the Engineer, to install the liner.

The Department will consider any damaged culvert liner pipe to be unacceptable.

## B Installing Pipe

### B.1 General

Use jet rodding equipment or other methods approved by the Engineer to clean and dry the liner pipe before inserting the culvert liner. Remove debris or other materials from the existing pipe culvert to prevent the inserted liner from resting on or against, or be irregularly supported by, these materials.

The Contractor may use a flange connector or a full encirclement with neoprene connects and stainless steel clamps to make final connection. Allow the pipe liner to stabilize from 8 h to 10 h before tying the last joint or pressure grouting the annular space between the in-place culvert and the inserted liner.

Use fasteners, blocks, or multiple grout layers to secure pipe liners equal to or greater than 24 in [600 mm] in diameter to the invert of the existing culvert to prevent the pipe liner from floating during the grouting operations.

### B.2 Inserting Liner

The Contractor may pull or push pre-fused lengths of solid wall PE pipe into place. The Contractor may combine the push and pull techniques to insert the liners.

#### B.2.a Pull Technique

Use a cable or winch arrangement to pull the pipe liner pipe into place. Feed the cable from the winch through the existing pipe culvert. Fasten the cable to the liner pipe to allow the liner pipe to be pulled through the existing pipe and into place. The Contractor may fabricate the pulling head out of a few extra feet of the liner pipe by cutting out evenly spaced wedges from the leading edge, collapsing the fingers towards the center, and fastening the cable to the fingers.

#### B.2.b Push Technique

Place a choker strap around the liner outside the access point. Use a tractor mounted backhoe, backhoe, or an equivalent piece of equipment approved by the

Engineer to pull the choker, thus pushing the liner through the existing culvert. Ensure that with each stroke of the backhoe, the choker grips the pipe and pushes the leading edge of the liner further into the existing culvert. The Contractor may use a front-end loader or bulldozers to simultaneously push on the trailing end of the liner segment.

**B.3 Pipe Joints**

Use heat fusion or grooved press-on joints approved by the Engineer to join PE pipe meeting requirements of ASTM F 714 (SDR 32.5). Heat fuse pipe joints as recommended by the pipe manufacturer, using an experienced operator of the heat fusion equipment.

Use a threaded joint to join closed-profile PE pipe with an ASTM D 3350 cell classification of 345464C as approved by the Engineer.

Use a PVC coupling with elastomeric sealing gaskets to join PVC pipe meeting the requirements of ASTM F 949. Provide elastomeric seals meeting the requirements of ASTM F 477. Determine the length of pipe required before ordering the pipe to ensure the correct numbers of joints.

**C Grout**

Block off culvert ends before filling the annular space between the culvert liner and the host pipe. Provide CLSM Low Density or CLSM High Density grout in accordance with 2519, "Cellular Concrete Grout – Controlled Low Strength Material (CLSM)," and as shown on the plans or as required by the contract. Use CLSM High Density grout if the plans or the contract do not specify the grout type. Do not allow grouting pressure to exceed the external hydrostatic collapse resistance of the liner.

**D Culvert Cleaning**

Inspect and clear culverts of sedimentation and debris before final acceptance of the project.

**2507.4 METHOD OF MEASUREMENT**

**A Culvert Pipe Liner**

The Engineer will measure culvert pipe liner by length, as determined by summation of the nominal laying lengths of the individual pipe sections incorporated in each structure. The Engineer will separately measure culvert pipe liner by size, type, and kind in accordance with the contract items.

**B Culvert Appurtenances**

The Engineer will separately measure aprons or other appurtenances required to the installation of the culvert lining in accordance with 2501, Pipe Culverts."

**C Grout**

The Engineer will measure grout in accordance with 2519, "Cellular Concrete Grout – Controlled Low Strength Material (CLSM)."

### 2507.5 BASIS OF PAYMENT

The contract linear foot [meter] price for *Lining Culvert Pipe* will include the cost of excavating, cleaning, inserting the pipe liner, backfilling, and providing pipe liner, fittings, seals, and joint system.

The Department will pay for grouting with the contract unit price for contract item No. 2519.501, "CLSM Low Density," or No. 2519.502, "CLSM High Density," as shown on the plans and in accordance with 2519, "Cellular Concrete Grout – Controlled Low Strength Material (CLSM)."

The Department will pay for culvert appurtenances in accordance with 2501, "Pipe Culverts."

The Department will pay for culvert liner on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2507.501 | Lining Culvert Pipe ___ in [mm]* | linear foot [meter] |

* Specify kind in accordance with 2507.2, "Culvert Liner, Materials." If the contract allows alternatives, do not specify kind.

## 2511 RIPRAP

### 2511.1 DESCRIPTION

This work consists of providing and placing stone riprap, with or without grouting, as a protective covering on earth slopes, piers, abutments, walls, or other structures, where the soil is susceptible to erosion.

The Department classifies riprap by type as random riprap or handplaced riprap, depending on the method of placement and the stone size specified.

### 2511.2 MATERIALS

**A Riprap Materials..... 3601**

**B Filter Materials**

## 2511.3 CONSTRUCTION REQUIREMENTS

### A General

Provide and place stone riprap as shown on the plans or as directed by the Engineer.

Excavate and shape the foundation for the riprap, with or without filter material, to the cross-sections as shown on the plans, unless otherwise directed by the Engineer. Compact loose foundation material before placing the riprap or filter material.

If the contract requires, place a layer of riprap at least a 1 ft [300 mm] thick on a filter material, unless otherwise required by the contract or directed by the Engineer.

Grout riprap as required by the contract or as directed by the Engineer. Place the riprap on a filter layer consisting of granular material or geotextile.

### B Filter Material

Place filter material under the riprap unless otherwise required by the contract. The Contractor may choose the type of filter material, except as required by the contract.

### B.1 Granular Filter

Spread granular filter material to a minimum thickness of at least 6 inches [150 mm] over the prepared foundation, or as required by the contract. Deposit granular material, placed under water, directly on the foundation using a bucket or similar container. Do not discharge the granular material above the water surface.

### B.2 Geotextile Filter

When placing geotextile filter material ensure that the foundation surface is relatively smooth and free of stones, sticks, and other debris or irregularities that might puncture the fabric. Place the filter material and conduct construction operations without tearing, puncturing, or shifting the fabric.

Place the fabric with the longest dimension parallel to the direction of water flow. If using fabric that is not seamed, overlap splices and joints at least 18 in [0.5 m], except overlap splices and joints placed under water 36 in [1 m]. Provide shingled joint laps in the flow direction and from top to bottom of a slope to direct water flow over the joint without undermining the geotextile filter. The Contractor may sew

multiple fabric pieces together, as specified in 3733, "Geotextiles," in lieu of joint overlapping. Bury the upgrade edges of the fabric a minimum of 6 in [150 mm] to direct water flow over the fabric and prevent undermining. If not seamed, place washered steel pins, edge stakes, stones, or other material at locations and in quantities as approved by the Engineer, to prevent movement of the geotextile filter during placement of the riprap.

Do not dump stone at the top of the slope and roll stone down the slope. If placing stones directly on the geotextile filter without a granular cushion, do not operate equipment on top of the stones after placement. Do not operate construction equipment directly on top of the geotextile.

Do not use geotextile filter material under handplaced or grouted riprap, unless otherwise required by the contract.

The Contractor may place geotextile filter on slopes no steeper than 1:3. For slopes steeper than 1:3, retrench the geotextile at least every 15 ft [4.6 mm] or as required by the contract. Do not use geotextile filter on slopes steeper than 1:2.

**C Riprap Stone**

Do not drop stones on the fabric from a height greater than 1 ft [0.3 m] unless the fabric is covered with a 6 in [150 mm] thick granular cushion course. If covered, the Contractor may drop riprap stones from a height no greater than 3 ft [1 m].

When placing riprap, start at the lowest elevations and work upwards.

Before placement of riprap stone on geotextile, the Engineer may require the Contractor to demonstrate that the placement methods will not damage the fabric. The Engineer may order the removal of at least 4 sq. yd [3 sq. m] of riprap to inspect for fabric damage in accordance with 1511, "Inspection of Work."

**C.1 Random Riprap**

Position random riprap to provide a uniform distribution of the various sizes of stone and produce a dense, well-keyed layer of stones with the least practical voids volume. Level the surface flush with the surrounding ground to produce a reasonably uniform appearance and the thickness required by the contract.

Wash riprap clean before placing underwater.

**C.2 Hand-Placed Riprap**

Embed the stones for hand-placed riprap in the foundation material, with the axis of the stone that most nearly approximates the contract-required thickness of riprap laid perpendicular to the foundation slope. Lay stones with the least practicable space

between them. Position the stones to stagger the joints up the slope. Place each stone to allow the foundation material and adjacent stones to carry its mass.

Use selected stones set to line and grade to define the ends and edges of each riprap area.

After laying the larger stones, fill the spaces between the stones with firmly seated, smaller stones to produce a uniform surface.

Wash riprap clean before placing underwater.

**D Grouting**

For grouted riprap, ensure that grout fills the spaces between stones throughout the entire thickness of the riprap.

Immediately before placing the grout for grouted riprap, thoroughly wet the stones with water. Do not pour grout over stones that have become surface dry. Sweep the surface of the grouted riprap with a stiff broom to finish.

**E Thickness Requirements**

Ensure the riprap placed on each separate area has a minimum thickness of at least 80 percent of the thickness required by the contract and an average thickness of at least 95 percent of the thickness required by the contract when measured at right angles to the face.

## 2511.4 METHOD OF MEASUREMENT

**A Riprap**

If measuring riprap of each type and class by volume, the Engineer will calculate the volume based on the actual surface dimensions as staked and the thickness shown on the plans or specified in the special provisions.

If measuring riprap of each type and class by mass, the Engineer will calculate the mass based on scale tickets of materials delivered and placed within the staked areas.

**B Filter Materials**

If measuring filter materials by weight, the Engineer will calculate the weight based on scale tickets of material delivered and placed within the staked areas.

If measuring filter materials by volume, the Engineer will calculate the volume based on the actual surface dimensions as staked and the thickness as shown on the plans.

The Engineer will measure geotextile filter material by area based on the actual surface dimensions as staked, with no allowance for overlaps or seams.

### 2511.5 BASIS OF PAYMENT

The contract unit price for riprap of each type and class includes the cost of providing the materials, excavating and preparing the foundations, and placing the riprap stone, grouting, and filter materials as required by the contract.

The Department will pay for filter materials of the type specified, if included in the contract.

The Department will pay for riprap and filter material based on the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2511.501 | Random Riprap, Class ___ | cubic yard [cubic meter] |
| 2511.502 | Random Riprap, Class ___ | ton [metric ton] |
| 2511.505 | Hand-placed Riprap | cubic yard [cubic meter] |
| 2511.507 | Grouted Riprap | cubic yard [cubic meter] |
| 2511.511 | Granular Filter | cubic yard [cubic meter] |
| 2511.513 | Granular Filter Material | ton [metric ton] |
| 2511.515 | Geotextile Filter, Type ___ | square yard [square meter] |

## 2512 GABIONS AND REVET MATTRESSES

### 2512.1 DESCRIPTION

This work consists of constructing gabions and revet mattresses at the locations shown on the plans or as directed by the Engineer.

### 2512.2 MATERIALS

**A Riprap Materials..... 3601**

**B Filter Materials**

**B.1 Granular Filter..... 3601**

**B.2 Geotextile Filter ..... 3733**

**C Gabions..... 3602**

**D Revet Mattresses..... 3602**

## 2512.3 CONSTRUCTION REQUIREMENTS

**A General ..... 2511.3**

Excavate, shape, and compact the foundation to the elevation and alignment as required by the contract.

Provide and place filter material, unless otherwise required by the contract.

Provide and place gabions and revet mattresses.

**B Filter Material**

Place filter material over the entire area before placing the gabions and revet mattresses.

**B.1 Granular Filter..... 2511.3**

**B.2 Geotextile Filter ..... 2511.3**

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

**C Baskets and Fasteners**

**C.1 Documentation**

Provide the following:

(1) Certification that the baskets and fasteners meet the requirements of this section (2512),
(2) Manufacturer's drawings of the baskets and fasteners, and
(3) Manufacturer's assembly recommendation and instructions for the baskets and fasteners.

**C.2 Construction**

Install the baskets to the dimensions, profile, and alignment as required by the contract or as directed by the Engineer.

Assemble the baskets in accordance with the manufacturer's recommendations unless otherwise specified in this section (2512), 3602, "Gabions and Revet Mattresses Materials," or as shown on the plans.

Place and fasten the diaphragms in the baskets to the side and bottom mesh to create cell dimensions no greater than 3 ft [1 m].

Fasten adjoining empty baskets together at their perimeters.

Place stones in the cells of baskets in a manner that will minimize voids, does not allow sharp edges to protrude through the mesh, and maintains the basket dimensions as shown on the plans. Hand place stones as necessary.

Fill cells in 12 in [300 mm] layers. Fill cells no greater than 12 inches [300 mm] in one layer. Fill cells no greater than 18 in [450 mm] in two equal layers. Do not fill cells greater than 12 in [300 mm] higher than stone layers in adjacent cells or baskets.

For twisted wire gabions, place horizontal connecting wires on top of the stone layer in both directions if no supporting basket exists, to prevent the sides from bulging. For welded wire gabions, install preformed stiffeners across the corners of the gabions before filling. Provide two rows of stiffeners, four per cell, for the front face and the side faces. Provide a single row of stiffeners, two per cell, on the back face. The Department will not require stiffeners in interior cells. Provide preformed stiffeners with a nominal length of 18 in [450 mm]. Hook the stiffeners at crossing wires. The Contractor may use lacing wire as a stiffener.

After filling the basket, fold the top of baskets shut and fasten to the ends, sides, diaphragms, and adjacent baskets.

Stack empty baskets on filled baskets and fasten to the filled baskets at front, exposed sides, and back before filling.

Stagger the vertical joints between the baskets of adjacent rows and layers unless otherwise required by the contract.

Backfill behind a gabion structure simultaneously with the cell filling operation.

### C.3 Fasteners

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

#### C.3.a Lacing Wire

Place lacing wire at each joint alternating single and double loops every 3 in to 6 in [75 mm to 150 mm].

#### C.3.b Alternative Fastener

Place alternative fasteners at each joint at every mesh opening. Adequately secure spiral binders at the ends to prevent unwinding.

### D Acceptance

The Engineer may consider the work as unacceptable if visible baskets vary by greater than 6 in [150 mm] from the profile or alignment as shown on the plans or as directed by the Engineer.

### 2512.4 METHOD OF MEASUREMENT

**A Gabion and Revet Mattress**

The Engineer will measure gabion and revet mattress construction by volume based on the nominal basket dimensions and the number of baskets incorporated into the work.

**B Filter Materials ..... 2511.4**

### 2512.5 BASIS OF PAYMENT

The contract unit price for *Gabions* and *Revet Mattresses* includes the cost of providing the materials as required by 3601, "Riprap Material," and 3602, "Gabions and Revet Mattresses Materials," excavating and preparing the foundations, providing and installing filter materials, and constructing and filling the gabions and revet mattresses.

The Department will separately compensate for filter materials if the contract contains the relevant contract items as listed in 2511, "Riprap."

The Department will pay for gabions and revet mattresses based on the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2512.517 | Gabion | cubic meter [cubic yard] |
| 2512.519 | Revet Mattress | cubic meter [cubic yard] |

## 2514 SLOPE PAVING

### 2514.1 DESCRIPTION

This work consists of paving embankment slopes and waterways with portland cement concrete or crushed aggregate to provide erosion protection.

### 2514.2 MATERIALS

**A Concrete ..... 2461**

Provide concrete meeting the requirements for Mix Designation 3A34, except that the Contractor may adjust the slump requirement as approved by the Engineer.

**B Reinforcement Bars ..... 3301**

Provide reinforcement bars meeting the following requirements:

(1) Either Grade 40 [Grade 300] or Grade 60 [Grade 420],
(2) Deformed billet steel, and
(3) Meeting the requirements of ASTM A 615/ASTM A 615M.

**C Preformed Joint Filler ..... 3702**

**D Bituminous Material..... 3151**

Provide liquid asphalt, Grade MC-250, MC-800, or emulsified asphalt, Grade CSS-1, CSS-1H, RS-1, or CRS-2 for bituminous material for stabilizing aggregate slope paving.

**E Aggregate**

Provide aggregate for slope paving in accordance with Table 2514-1 for gradation class CA-1, CA-2, or CA-3, and in accordance with the quality requirements in 3137.2.D, "Quality."

**Table 2514-1**
**Coarse Aggregate Fraction Size,**
***percent by weight passing square opening sieves***

| | Aggregate Designation | | |
|---|---|---|---|
| | **CA-1** | **CA-2** | **CA-3** |
| **No.4 [4.75 mm]** | 0 – 5 | 0 – 5 | 0 – 5 |
| **⅜ in [9.5 mm]** | — | — | — |
| **½ in [12.5 mm]** | — | — | — |
| **⅝ in [16.0 mm]** | — | — | — |
| **¾ in [19.0 mm]** | 5 – 30 | 5 – 35 | 5 – 35 |
| **1 in [25.0 mm]** | — | — | — |
| **1¼ in [31.5 mm]** | — | — | 85 – 100 |
| **1½ in [37.5 mm]** | 80 – 100 | 90 – 100 | 100 |
| **2 in [50 mm]** | 100 | 100 | — |

## 2514.3 CONSTRUCTION REQUIREMENTS

**A Foundation Preparations**

Prepare the foundation to the dimensions and elevations shown on the plans or directed by the Engineer. Excavate the high spots, and fill and compact low spots of the foundation to meet the elevation and slope requirements. Prepare the foundation with a uniform density meeting 2105.3.F.2, "Quality Compaction Method."

For rough grading performed by others under another contract, if the Engineer determines that a material shortage or excess exists to construct the planned

foundation elevations, the Engineer may require one of the following to achieve acceptable foundation elevations:

(1) Make minor adjustments to the grade to balance out the available material,
(2) Order the placement of additional material from other sources, or
(3) Order the removal and outside disposal of excess material.

**B Aggregate Slope Paving**

Use mechanical or hand methods to deposit, spread, consolidate, and shape the aggregate to provide a uniform depth and density and to produce a uniform surface appearance. Apply liquid asphalt at a rate of 1.8 gal per sq. yd [8 L per sq. m] and only when the ambient air temperature is at least 40 °F [5 °C]. Apply emulsified asphalt at a rate of 2.5 gal per sq. yd [11 L per sq. m] and only when the ambient air temperature is at least 50 °F [10 °C]. Ensure bituminous materials penetrate to a depth of at least half the thickness of the aggregate slope paving as shown on the plans. Protect adjacent structure surfaces from bituminous splatter.

**C Concrete Slope Paving**

Construct concrete slope paving in accordance with 2401, "Concrete Bridge Construction." Place, consolidate, strike-off, and hand float the concrete to provide a dense pavement relatively free of voids and cavities, and to produce a uniform surface appearance. Set and support side forms and finish the concrete so surfaces do not deviate from a true plane and the grade shown on the plans by greater than ±½ in [13 mm]. Place metal reinforcement and preformed filler material shall as shown on the plans. Support the metal reinforcement and preformed filler material as shown on the plans to maintain correct position during concrete placement.

Form and cast toe walls and side walls before placing concrete for contiguous slope paving. Moisten the subgrade at the time of concrete placement. Take care to prevent subgrade displacement and contamination of the concrete. Place the slope paving either in equally spaced alternate strips running in the direction of maximum slope or in full width sections with mechanical equipment capable of placing and finishing the slope paving.

Immediately after placing, consolidate and strike off the concrete. When the concrete is capable of maintaining shape, perform the following to the concrete:

(1) Strike off the surface again,
(2) Hand float with a cork or wood float to provide a final finish, and
(3) Broom to produce a uniform texture and appearance.

After the final floating, finish edges not formed with v-strip inserts with an edging tool and cut panel lines with grooving tools. The Contractor may saw the panel lines

as directed by the Engineer. Float edging and grooving flange trails to secure uniform surface appearance.

Provide curing protection to exposed surfaces after completing the concrete finishing operations in accordance with 2401.3.G, "Concrete Curing and Protection," and maintain until the concrete attains a strength gain of at least 30 percent.

### 2514.4 METHOD OF MEASUREMENT

The Engineer will separately measure slope paving of each type by area of top surface, bounded by the outside edges of abutment faces, toe walls, side walls or timber planks, as constructed and accepted for payment.

### 2514.5 BASIS OF PAYMENT

The contract unit price for slope paving of each type includes the cost of constructing the work complete in place.

The Department will pay for the cost of providing and placing additional material, or the removal and outside disposal of excess material requiring loading and hauling, directed by the Engineer, as extra work in accordance with 1402, "Contract Revisions." The Department will include the cost of excess material disposed on areas adjoining the slope paving without loading and hauling, as directed by the Engineer, with the contract unit prices for slope paving.

The Department will pay for slope paving based on the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2514.501 | Concrete Slope Paving | square yard [square meter] |
| 2514.503 | Aggregate Slope Paving | square yard [square meter] |

## 2515 REVETMENT SYSTEMS

### 2515.1 DESCRIPTION

This work consists of providing and placing closed or open cell precast block or articulated concrete mat revetment systems as a protective covering for earth slopes, river channels, vehicle accesses, spillways, and susceptible soil erosion areas.

Articulated concrete consists of hand placed Articulated Interlocking Block or Articulated Block Mat (cabled blocks).

## 2515.2 MATERIALS

**A Precast Articulated Concrete..... 3604**

**B Geotextile Filter ..... 3733**

**C Bedding Material ..... 3149**

**D Concrete..... 2461**

## 2515.3 CONSTRUCTION REQUIREMENTS

### A General

Excavate for the foundation for the articulated concrete revetments, with geotextile filter, using toe, terminal, and upper bank trenches. Shape the foundation excavation to the cross-sections as shown on the plans unless otherwise directed by the Engineer. Grade and compact termination trenches, embankment crests, and toes to prevent water from migrating under the block and geotextile material. Grade final subgrade smooth before placing the base course material to allow uniform contact with the geotextile and articulated concrete.

### B Subgrade Preparation

Prepare the subgrade in accordance with 2112, "Subgrade Preparation." Provide subgrade material free of stones, sticks, and other debris or irregularities that might puncture the geotextile fabric or create other system failures. If the system is subject to vehicle loading, install a geogrid for extra support, as shown on the plans.

### C Bedding Material

Provide bedding material consisting of at least 6 in [152 mm] of cohesive soils spread evenly over the compacted subgrade, made of the following materials as approved by the Engineer:

(1) Common borrow in accordance with 2105, "Excavation and Embankment,"
(2) Granular borrow in accordance with 3149, "Granular Material," or
(3) Granular bedding, avoiding sand, in accordance with 3149, "Granular Material."

Compact the material to the specified density method in accordance with 2211.3.C, "Placing and Compacting."

### D Geotextile Filter

Place a geotextile filter under the articulated concrete unless otherwise required by the contract. Place the geotextile filter material on the entire area supporting the articulated concrete. Secure the geotextile filter material with 6 in [152 mm] steel pins

or staples, unless otherwise shown on the plans. If installing anchors, cut the geotextile to allow the anchors to penetrate the geotextile.

Place and compact prepared subgrade and bedding material, and place geotextile filter material without tearing, puncturing, or shifting the fabric. The Contractor may place a 1 in [25 mm] sand layer on the geotextile fabric before placing the block.

Place the required multiple fabric widths or lengths with the longest dimension parallel to the direction of water flow. Place unseamed fabric with splices and joints overlapped at least 18 in [0.5 m], except overlap splices and joints underwater at least 36 in [1 m]. Shingle the joint laps in the flow direction and from top of slope to bottom to direct water flow over the joint without undermining. As an alternative to joint over-lapping, the Contractor may sew multiple fabric pieces together to meet the seam breaking strength requirements of 3733, "Geotextiles." Bury upgrade edges of the fabric area to direct water flow over the fabric without undermining. For unseamed geotextile, place steel pins with washers or staples at locations and in quantities as approved by the Engineer to prevent movement of the geotextile filter during placement of the articulated concrete revetment system.

Do not operate construction equipment directly on top of the geotextile.

## E Precast Articulated Concrete

### E.1 Articulated Block Mat

Place the mats in accordance with the appropriate manufacturer recommendations. Place the mats no greater than 2 in [51 mm] apart. After cable clamping and anchoring, use Type 3A grout in accordance with 2461, "Structural Concrete," to close gaps greater than 2 in [51 mm]. Entrench and bury the outside edges of the mat system at least one block into the ground filled with compacted fill. Do not allow mats to overlap and blocks to project vertically greater than 1 in [25 mm] beyond the adjacent block. Fasten the protruding longitudinal and transverse cable connections together along the adjacent sides of the mats.

### E.2 Articulated Interlocking Block

Install articulated interlocking blocks by hand. Do not overlap blocks and allow blocks to project vertically by greater than 1 in [25 mm] beyond the adjacent blocks. Place anchors through cuts in the geotextile and position the anchors on the concrete block to maximize the pull out resistance.

## F Clamps

Use wire rope clamps to join cable loops of horizontal and vertical adjoining concrete revetment mats as specified by the manufacturer, unless otherwise directed by the Engineer.

### G Anchors

Provide helical or duckbill type anchors. Install anchors at 8 ft [2.4 m] intervals at lead edge and around perimeter of the revetment system, and as shown on the plans, as specified by the manufacturer, or as directed by the Engineer. Embed anchors at least 3½ ft [1.0 m] deep. Fasten the exposed cables of the concrete mats to the anchors driven into the anchor trench.

### H Filling and Vegetation

If vegetating is shown on the plans, fill voids with topsoil borrow in accordance with 3877, "Topsoil Borrow," and with mesic general roadside mix in accordance with 3876, "Seed," unless otherwise shown on the plans, after installing the mat or block system. Place the surface application after the Engineer completes inspection of the clamping and anchoring systems.

## 2515.4 METHOD OF MEASUREMENT

The Engineer will measure precast articulated concrete of each type by area on the basis of actual surface dimensions as staked.

The Engineer will measure geotextile filter material by area on the basis of actual surface dimensions as staked. The Engineer will not include allowance for overlaps or seams in the measurement for geotextile filter.

## 2515.5 BASIS OF PAYMENT

The contract unit prices for revetment systems include the cost of excavating and preparing the foundations, providing system materials, geotextile filter, base, and bedding materials, placing the precast articulated concrete, grouting, clamping, and anchoring.

The Department will pay for revetment systems on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2515.501 | Articulated Block Mat Open Cell, Type ___ | square yard [square meter] |
| 2515.502 | Articulated Block Mat Closed Cell, Type ___ | square yard [square meter] |
| 2515.503 | Articulated Interlocking Block Open Cell, Type ___ | square yard [square meter] |
| 2515.504 | Articulated Interlocking Block Closed Cell, Type ___ | square yard [square meter] |
| 2515.515 | Geotextile Filter, Type ___ | square yard [square meter] |

# 2519 CELLULAR CONCRETE GROUT – CONTROLLED LOW STRENGTH MATERIAL (CLSM)

## 2519.1 DESCRIPTION

This work consists of pressure grouting the area and voids between the existing pipe culvert and the inserted liner pipe.

## 2519.2 MATERIALS

**A Cement ..... 3101**

**B Fly Ash ..... 3115**

**C Fine Aggregate ..... 3126**

**D (Blank)**

**E Water ..... 3906**

**F Admixtures ..... 3113**

## 2519.3 CONSTRUCTION REQUIREMENTS

### A Mix Design

Submit a mix design on the Mn/DOT Concrete Mix Design Submittal Sheet to the Engineer for review and approval, in conjunction with the Concrete Engineer, at least 15 days before placing the grout. Design the CLSM in accordance with Table 2519-1 or Table 2519-2 and meeting the requirements of ASTM C 403.

### A.1 CLSM Low Density

Use the CLSM low density design when no water is present and no water intrudes during the setting process based on the following proportions per unit batch:

**Table 2519-1**
**CLSM Low Density Design**

| Materials | Proportions per unit batch and mix parameters |
|---|---|
| Portland cement | ≥100 lb [45 kg] |
| Total cementitious (portland cement and Class C fly ash) | ≥500 lb [300 kg] |
| Water/cementitious ratio | 0.50 |
| Pre-formed foam* | 20 cu. ft [0.60 cu. m] |
| Grout (cast density) | 30 lb ±3 lb per cu. ft [480 kg ±48 kg per cu. m] |

| Table 2519-1<br>CLSM Low Density Design | |
|---|---|
| **Materials** | **Proportions per unit batch and mix parameters** |
| Slump | 10 in ± 1 in [250 mm ± 25 mm] |
| 28-day compressive strength | 75 psi – 400 psi [0.5 mPa – 2.8 mPa] |
| * Provide foaming agent meeting the requirements of ASTM C 869 when tested in accordance with ASTM C 796. The Contractor may use other admixtures, if approved by the mix designer and the Engineer, in conjunction with the Concrete Engineer. Provide cementitious material from the Approved/Qualified Products List. The Engineer, in conjunction with the Concrete Engineer, will review the concrete mix design submittal and approve if the concrete mix design meets contract requirements. The Engineer will base final approval for payment on satisfactory field placement and performance. | |

## A.2 CLSM High Density

Use the CLSM high density design when it is not possible to dewater, keep water out of the annular space during grouting, or both, based on the following proportions per unit batch:

| Table 2519-2<br>CLSM High Density Design | |
|---|---|
| **Materials** | **Proportions per unit batch and mix parameters** |
| Portland cement | ≥150 lb [90 kg] |
| Total cementitious (portland cement and Class C fly ash) | ≥500 lb [300 kg] |
| Fine aggregate | 1,100 lb [650 kg] |
| Water/cementitious ratio | 0.50 |
| Pre-formed foam* | 13.5 cu. ft [0.50 cu. m] |
| Grout (cast density) | 70 lb ±3 lb per cu. ft<br>[1,120 kg ±48 kg per cu. m] |
| Slump | 10 in ±1 in [250 mm ±25 mm] |
| 28-day compressive strength | 75 psi – 400 psi [0.5 mPa – 2.8 mPa] |
| * Provide foaming agent meeting the requirements of ASTM C 869 when tested in accordance with ASTM C 796. The Contractor may use other admixtures, if approved by the mix designer and the Engineer, in conjunction with the Concrete Engineer. Provide cementitious material from the Approved/Qualified Products List. The Engineer, in conjunction with the Concrete Engineer, will review the concrete mix design submittal and approve if the concrete mix design meets contract requirements. The | |

| Table 2519-2<br>CLSM High Density Design | |
|---|---|
| **Materials** | **Proportions per unit batch and mix parameters** |
| Engineer will base final approval for payment on satisfactory field placement and performance. | |

**B Grouting Procedure**

Selected grouting pressures external to the liner pipe may collapse the liner pipe. Design a grouting procedure to fill voids between the existing culvert and the liner pipe, but will not collapse the liner pipe. Provide a pressure gauge to measure the grouting pressure and a method to measure the volume of injected grout. Submit a grouting plan to the Engineer for approval.

**C Placement**

Use grout to fill voids between the existing culvert and pipe liner, including breaks or holes in the existing culvert.

Secure the pipe liner to the invert of the existing culvert by fasteners or blocks, or construct multiple grout lifts to prevent the pipe liner from floating during the grouting operations.

After the grouting the liner to the inplace culvert, encapsulate the remaining length of liner with Mix No. 3Y43 concrete at least 6 in [150 mm] thick.

Finish the inlet end with a 45° mitered fillet-transition between the inplace culvert and the inside of the liner.

Use cylindrical wooden plugs, or other equivalent material approved by the Engineer, to plug grout holes. After the grout has set, remove the plugs and fill with concrete.

## 2519.4 METHOD OF MEASUREMENT

The Engineer will measure by the volume of grout injected into the void between the existing pipe culvert and the liner pipe. The Engineer will deduct accountable waste from the quantities measured for payment.

## 2519.5 BASIS OF PAYMENT

The contract cubic meter [cubic yard] price for CLSM includes the cost of dewatering, cement for securing the pipe liner to the existing culvert, and inlet bevel construction.

The Department will pay for CLSM on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2519.501 | CLSM Low Density | cubic yard [cubic meter] |
| 2519.502 | CLSM High Density | cubic yard [cubic meter] |

## 2520 LEAN MIX BACKFILL

### 2520.1 DESCRIPTION

This work consists of placing a lean cementitious, controlled-density backfill into utility and culvert trenches, or other excavations, where the use of conventional compacting equipment is impractical.

### 2520.2 MATERIALS

**A Cement ..... 3101**

**B Fly Ash ..... 3115**

**C Fine Aggregate ..... 3126**

**D Coarse Aggregate ..... 3137**

Provide coarse aggregate in accordance with 3137, "Coarse Aggregate for Portland Cement Concrete," except for 3137.2.D.2, "Coarse Aggregate for Bridge Superstructure," and 3137.2.D.3, "Coarse Aggregate for Concrete Pavement."

**E Water ..... 3906**

**F Admixtures ..... 3113**

### 2520.3 CONSTRUCTION REQUIREMENTS

#### A Mix Design and Control

Create lean mix backfill designs using the absolute volume relationships and basic mix proportions specified in this section (2520) for the control of cement, fly ash, water, and aggregate content and workability necessary for proper placement.

#### A.1 Tentative Material Proportioning

Proportion the material to obtain the flow-ability, workability, and consistency necessary for placement. Submit the source of materials to the Engineer. The Engineer, in conjunction with the Concrete Engineer, will provide a mix design based on the following table:

| Table 2520-1<br>Lean Mix Backfill Mix Design | |
|---|---|
| **Materials** | **Design per Unit Batch (1 cu. yd [1 cu. m])** |
| Cement | 125 lb [75 kg] |
| Fly ash | 250 lb [150 kg] |
| Water | 375 lb [225 kg] |
| Fine aggregate* | 50% |
| Coarse aggregate*‖ | 50% |

* After adding the specified quantities of cement, fly ash, and water, provide the remaining volume consisting of fine aggregate and coarse aggregate. To increase flow-ability, the Contractor may replace no greater than 30 percent of the aggregate by volume with foam. Provide foam produced from a foaming agent meeting the requirements of ASTM C 869 when tested in accordance with ASTM C 796. When using a foaming agent, submit a mix design to the Engineer for review and approval, in conjunction with the Concrete Engineer, at least 15 days before placement. Base the mix design on the proportions specified in Table 2520-1, including the foaming agent per unit batch. The Contractor may use other admixtures as approved by the mix designer and by the Engineer, in conjunction with the Concrete Engineer. Supply cementitious material from the Approved/Qualified Products List. The Engineer, in conjunction with the Concrete Engineer, will review the concrete mix design submittal and, if the mix design meets contract requirements, will approve. The Engineer will base final approval for payment on satisfactory field placement and performance.

‖ Meeting the gradation range 6 as shown in 2461.2.F.3.d, "Coarse Aggregate (CA) Designation."

## A.2 Mix Requirements

| Table 2520-2<br>Lean Mix Backfill Design | |
|---|---|
| **Testing** | **Requirements** |
| Slump | 10 in ±1 in [250 mm ±25 mm] |
| 28-day unconfined compressive strength | 75 psi [500 kPa] – 400 psi [2,750 kPa] |

## A.3 Job Mix Proportions

The Engineer will design the tentative job mix as specified in Table 2520-2.

## A.4 Mix Adjustments

The Department may adjust the mix at any time to maintain the consistency and strengths specified in Table 2520-2.

**B Production Controls**

Provide production controls in accordance with 2461.3.C, "Handling and Storing Materials," and 2461.3.G, "Concrete Placement," except replace the word "concrete" with "lean mix."

**C Batching and Mixing Requirements**

**C.1 Proportioning Methods**

Proportion lean mix batch materials by weight [mass]. The Contractor may proportion lean mix batch material by volume as approved by the Engineer in writing.

**C.2 Other Batching and Mixing Requirements**

Batch and mix lean mix materials in accordance with 2461, except replace the word, "concrete" with "lean mix."

**D Ready-Mixed Lean Mix Backfill**

Provide ready-mixed lean mix backfill in accordance with 2461, "Structural Concrete," except replace the word "concrete" with "lean mix."

**E Construction Requirements**

Plug openings below the level of the desired backfill that would allow the mix to escape. Place the lean mix so that it flows around and beneath footings, foundations, walls, pipes, or other structures that it was designed to support. The Department will not require compaction or mechanical vibration when lean mix backfill is placed as approved by the Engineer. Vent or eliminate air pockets that water would normally fill to preclude voids remaining in the completed backfill.

**E.1 Curing and Protection**

Maintain the air in contact with lean mix backfill surfaces at temperatures above freezing for at least 72 h.

The Department will not require additional curing after the evaporation of the substantial water gain on the surface.

**2520.4 METHOD OF MEASUREMENT**

If the contract specifies *Lean Mix Backfill* as a contract item, the Engineer will measure lean mix backfill as the computed, theoretical volume based on the weight of

the individual batch ingredients. The Engineer will deduct the volume of accountable waste from the measurement of lean mix backfill.

### 2520.5 BASIS OF PAYMENT

The Department will include the cost of lean mix backfill and common backfill with other relevant contract items unless otherwise shown on the plans.

The contract cubic yard [cubic meter] price for *Lean Mix Backfill* includes the cost of providing the lean mix backfill and the cost of forming, plugging, placing, venting, and protecting.

| Item No.: | Item: | Unit: |
|---|---|---|
| 2520.501 | Lean Mix Backfill | cubic yard [cubic meter] |

## 2521 WALKS

### 2521.1 DESCRIPTION

This work consists of constructing concrete or bituminous walks.

### 2521.2 MATERIALS

**A Concrete ..... 2461**

**A.1 Concrete Walk ..... Mix No. 3A32**

**A.2 Concrete Walk, Exposed Aggregate Finish ..... Mix No. 3A36EX**

**B Preformed Joint Filler ..... 3702**

**C Bituminous ..... 2360**

**C.1 Bituminous Walk ..... Mix No. SPWEB230B**

**D Curing Materials**

**D.1 Burlap Curing Blankets ..... 3751**

**D.2 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound .. 3754**

**D.3 Linseed Oil Membrane Curing Compound ..... 3755**

**D.4 Plastic Curing Blankets ..... 3756**

**E Granular Materials ..... 3149**

## 2521.3 CONSTRUCTION REQUIREMENTS

### A Foundation Preparations

Excavate, shape, and compact the foundation to a firm, uniform bearing surface to the dimensions and grade as shown on the plans and in accordance with 2105, "Excavation and Embankment."

### B Sawing Concrete Walk

Saw existing concrete walk to produce a neat line for the new work.

### C Forms

Provide forms made of non-reactive metal or wood, or other material in accordance with 1805, "Method and Equipment," capable of maintaining the concrete until the concrete can retain the molded shape. Provide forms with a height at least equal to the walk thickness of the formed concrete shown on the plans. Support the forms on the foundation to maintain the line and grade shown on the plans.

Before placing the concrete, coat the contact surfaces of the forms with form treating material in accordance with 3902, "Form Coating Material."

### D Placing and Finishing Concrete

Wet the foundation and forms before placing the concrete.

Prevent segregation of the concrete during placement. Consolidate the concrete to fill voids using hand tamping or internal vibrating. Strike-off the concrete to the grade shown on the plans, and float the surface smooth. After the water sheen disappears, edge the joints and lightly brush the surface to a uniform texture.

The Engineer will use a 10 ft [3 m] straight edge to measure the surface. The Department considers deviations in the surface greater than $^{3}/_{16}$ in [5 mm] and deviations in formed concrete greater than ½ in [13 mm] from the required location as unacceptable work. Remove and replace unacceptable work as directed by the Engineer.

Leave forms in place for at least 12 h after placing the concrete unless otherwise approved by the Engineer.

### D.1 Exposed Aggregate Finish

Provide concrete Mix No. 3A36EX with multi-colored rounded stone, modified for exposed aggregate construction.

Use surface retardation, meeting the Type B requirements in 3113, "Admixtures for Concrete," to produce a medium to deep exposure on the aggregate finish making the aggregate the dominant surface feature. Do not embed or top seed the aggregate.

Apply retardant coating immediately after completion of the concrete surface screeding, edging, and jointing. Apply retardant as recommended by the manufacturer to produce a ¼ in ± ⅛ in [6 mm ± 2 mm] etch of mortar removal after final concrete set.

Use pressurized water to remove surface mortar. Do not loosen individual aggregate particles with the pressurized water.

After the Engineer approves the exposed aggregate finish, apply a 10 percent muratic acid solution to the exposed aggregate surfaces. Allow the acid solution to interact with the exposed aggregate surface for 5 min to 10 min before flushing the surface with water.

Cover the concrete with white polyethylene sheeting to continue curing. Before applying sealer, remove staining or streaking from the exposed aggregate surface resulting from the moist curing.

Seal the exposed aggregate finish with two coats of a clear acrylic based compound with at least 18 percent solids meeting the requirements of ASTM C 309.

**D.2 Joint Construction**

Divide the walk into square panels of uniform size no greater than 36 sq. ft [3 sq. m] and outlined with contraction or expansion joints as shown on the plans.

Provide vertical and straight joints parallel with or at right angles to the walk centerline. Align the joints with joints in adjoining work unless isolated by a ½ in [13 mm] preformed joint filler.

The Contractor may form or saw the joints in walking surfaces as approved by the Engineer. If forming the joints, round joints within the walking surface with a ¼ in [6 mm] radius grooving tool and round edges of the walk with an edging tool having a radius no greater than ½ in [13 mm].

Extend contraction joints to a depth of at least 30 percent of the walk thickness. If sawcutting, provide ⅛ in [3 mm] wide contraction joints.

Provide joint filler in accordance with 3702, "Preformed Joint Fillers," that is ½ in [13 mm] wide and equal in depth to the full thickness of the walk.

Modify joint construction if a fixed object or structure extends through the walk, as directed by the Engineer. Place preformed joint filler material ½ in [13 mm] thick adjacent to fixed objects to separate the object from the abutting concrete edges.

## E Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces for at least 72 h. When using fly ash or cementitious substitutions as defined in 2461.2.A.6, "Cementitious Substitutions," extend the minimum curing period to 96 h. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 minutes of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2521.3.E.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets, unless the contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2521.3.E.1.b, "Curing Blanket Method."

Failure to comply with these provisions will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the contract does not contain a separate contract item for *Structural Concrete*, the Department will apply a monetary deduction of $50.00 per cubic yard ($65.00 per cubic meter) or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

### E.1 Curing Methods

#### E.1.a Membrane Curing Method

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound with an approved airless spraying machine in accordance with the following:

(1) At a rate of 1 gal per 150 sq. ft (1 L per 4 m²) of surface curing area.
(2) Apply homogeneously to provide a uniform solid white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper). Some Mn/DOT approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.

The Engineer will approve the airless spraying machine for use if it is equipped with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

If the Engineer determines that the initial or corrective spraying may result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method, at no additional cost to the Department.

### E.1.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

### E.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

### E.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 34 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plans.

Protect the concrete from damage, including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

**E.3.a Cold Weather Protection Plan**

Submit a proposed time schedule and plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plans.

**F Bituminous**

Place the bituminous mixture in accordance with 2360.

**G Backfill Construction**

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Perform vibratory operations and backfilling 72 h after placing the concrete or after the concrete reaches a compressive strength of at least 3,000 psi [20.7 Mpa]. The Engineer will cast, cure, and test the concrete control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens." If damage results from any of these operations, the Engineer will suspend all operations until the Contractor takes corrective action and obtains the Engineer's approval of a new method. The Engineer may require removal and replacement of the damaged concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may hand operate concrete consolidation equipment and walk behind vibratory plate compactors 24 h after placing the concrete, and other equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

As soon as possible after the curing is complete and without subjecting the concrete work to damaging stresses, perform the backfill or embankment construction to the elevations shown on the plans. Use suitable grading materials from the excavation for backfill material in accordance with 2105, "Excavation and Embankment," unless otherwise required by the contract. Place and compact the backfill material in accordance with 2105, "Excavation and Embankment."

Dispose of surplus excavated materials in accordance with 2105, "Excavation and Embankment."

**2521.4 METHOD OF MEASUREMENT**

The Engineer will measure each uniform thickness item separately by top surface area.

### 2521.5 BASIS OF PAYMENT

If the plans do not include a contract pay item for granular materials, the Department will pay for granular material provided and placed as directed by the Engineer with other relevant contract unit prices in accordance with 2105, "Excavation and Embankment."

The Department will pay for walks on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2521.501 | Concrete Walk ___ in [ ___ mm] | square foot [square meter] |
| 2521.511 | Bituminous Walk ___ in [ ___ mm] | square foot [square meter] |

## 2531 CONCRETE CURBING

### 2531.1 DESCRIPTION

This work consists of constructing cast-in-place concrete curbs, curb and gutter, medians, driveway pavement, pedestrian ramps, and other similar traffic delineation or service items.

### 2531.2 MATERIALS

**A Concrete..... 2461**

For each method of placement, use the following mix designations:

**A.1 Manual Placement .....Mix No. 3A32**

**A.2 Slip-form Placement .....Mix No. 3A22**

**B Reinforcement Bars..... 3301**

**C Steel Fabric..... 3303**

**D Preformed Joint Filler..... 3702**

**E Curing Materials**

**E.1 Burlap Curing Blankets..... 3751**

**E.2 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound .. 3754**

**E.3 Linseed Oil Membrane Curing Compound..... 3755**

## 2531.3 CONSTRUCTION REQUIREMENTS

### A Foundation Preparations

Excavate, shape, and compact the foundation to a firm, uniform bearing surface that conforms to the dimensions and grade shown on the plans and in accordance with 2105, "Excavation and Embankment."

### B Forms

Provide forms, made of metal, wood, or other materials in accordance with 1805, "Methods and Equipment," capable of maintaining the concrete until the concrete can retain its molded shape. Provide side forms with a depth at least equal to the edge thickness of the concrete being formed. Support the forms on the foundation and restrain at the line and grade as shown on the plans.

For curves with a radius no greater than 100 ft [30 m], use flexible or curved forms approved by the Engineer.

Before placing concrete, coat the contact surfaces of forms with form treating material in accordance with 3902, "Form Coating Material."

### C Placing and Finishing Concrete

Immediately before placing the concrete wet the foundation and the forms.

Place the concrete in a manner that will prevent segregation. Consolidate the concrete to fill voids using hand tamping or internal vibrating. Strike-off the concrete to the grade shown on the plans, and float the surface smooth.

After the water sheen has disappeared, round joints and edges to the radii shown on the plans. Lightly brush concrete surfaces exposed to view to a uniform texture.

Keep side forms in place for at least 12 h after casting the concrete.

### D Slipform Machine Placement

Instead of using fixed forms, the Contractor may use a slipform machine capable of placing and forming concrete to the dimensions, quality, workmanship, and appearance as required by the contract. Hand finish the surface to the finish and texture as required by the contract.

### E Joint Construction

Place transverse expansion joints, filled with ½ in [13 mm] preformed joint filler material, at the ends of curved sections and at the ends of the curved portions of entrance and street returns. Place longitudinal expansion joints as shown on the plans. Place expansion joints with filler material at locations where the concrete surrounds or adjoins an existing fixed object, such as a fire hydrant, building foundation, or other rigid structure.

Provide contraction joints at the following intervals, except as otherwise shown on the plans:

(1) Adjacent to bituminous mainline, every 10 ft [3.0 m],
(2) Adjacent to concrete mainline, every 15 ft [4.6 m], and
(3) In solid median construction, every 10 ft [3.0 m].

Form or saw the contraction joints, as approved by the Engineer, to a depth of at least 2 in [50 mm] from exposed surfaces.

Construct joints perpendicular to the subgrade. Align joints with joints in adjoining work unless a ½ in [13 mm] preformed joint filler isolates the work. Place transverse joints at right angles to the longitudinal axis of the work, unless otherwise required by the contract.

Use an edging tool with a radius no greater than ½ in [13 mm] to round edges of longitudinal construction joints between a concrete median or gutter section and a concrete pavement.

Do not saw or seal longitudinal construction joints between a concrete median and concrete pavement, or between a gutter section and concrete pavement.

**F Metal Reinforcement**

Provide and place metal reinforcement as shown on the plans and in accordance with 2472, "Metal Reinforcement."

**G Concrete Curing and Protection**

After completing final finishing operations, cure all exposed concrete surfaces for at least 72 h. When using fly ash or cementitious substitutions as defined in 2461.2.A.6, "Cementitious Substitutions," extend the minimum curing period to 96 h. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 min of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2531.3.G.1.a, "Membrane Curing Method." Place the

membrane curing compound on the edges within 30 min after permanent removal of the forms or curing blankets, unless the contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2531.3.G.1.b, "Curing Blanket Method."

Failure to comply with these provisions will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the contract does not contain a separate contract item for *Structural Concrete*, the Department will apply a monetary deduction of $50.00 per cu. yd [$65.00 per cu. m] or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

**G.1 Curing Methods**

**G.1.a Membrane Curing Method**

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound with an approved airless spraying machine in accordance with the following:

(1) At a rate of 1 gal per 150 sq. ft [1 L per 4 $m^2$] of surface curing area.
(2) Apply homogeneously to provide a uniform solid white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper). Some Mn/DOT approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.

The Engineer will approve the airless spraying machine for use if it is equipped with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

If the Engineer determines that the initial or corrective spraying result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method at no additional cost to the Department.

### G.1.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

### G.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

### G.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 34 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plan.

Protect the concrete from damage including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

### G.3.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plans.

## H Backfill Construction

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Perform vibratory operations and backfilling at least 72 h after placing the concrete or after the concrete reaches a compressive strength of at least 3,000 psi [20.7 Mpa]. The Engineer will cast, cure, and test the concrete control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens." If damage results from any of these operations, the Engineer will suspend all operations until the Contractor takes corrective action and obtains the Engineer's approval of a new method. The Engineer may require removal and replacement of the damaged concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may hand operate concrete consolidation equipment and walk behind vibratory plate compactors 24 h after placing the concrete, and other equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

As soon as possible after the curing is complete and without subjecting the concrete work to damaging stresses, perform the backfill or embankment construction to the elevations as shown on the plans. Use suitable grading materials from the excavations in accordance with 2105, "Excavation and Embankment," unless the contract requires otherwise. Place and compact the backfill material in accordance 2105, "Excavation and Embankment."

Dispose of surplus excavated materials in accordance with 2105, "Excavation and Embankment."

**I Workmanship and Finish**

Ensure the surface contour and texture of the completed concrete work is uniform and meets the lines and grades as shown on the plans. Finish the flow line surface of gutters to eliminate low spots and avoid entrapment of water.

The Engineer will use a 10 ft [3 m] straightedge to measure the surface. The Engineer will consider concrete work with deviations $^{3}/_{8}$ in [10 mm] or greater in any 10 ft [3 m] length of finish curb and gutter, either horizontal or vertical, as unacceptable work. Remove and replace unacceptable work as directed by the Engineer.

If the Engineer does not direct the removal and replacement of unacceptable work, the Engineer will reduce the contract unit price for the unacceptable concrete work in accordance with the following:

(1) For deviations from ⅜ in to $^{9}/_{16}$ in [10 mm to 14 mm], payment at 75 percent of the contract unit price; and
(2) For deviations greater than $^{9}/_{16}$ in [14 mm], payment at 50 percent of the contract unit price.

## 2531.4 METHOD OF MEASUREMENT

The Engineer will not make deductions for castings or minor fixtures in the work.

### A Length

For curbs and curb and gutter, including the curb returns, the Engineer will measure the length along the face of the curb at the gutter line. In the case of transitions from one size or design to another, the Engineer will measure the entire transition for payment under the item with the higher contract unit price.

For solid medians and other construction with uniform widths and symmetrical cross sections, the Engineer will measure the length along the center of the longitudinal axis. Unless a variance from the basic design results in an increased cross-sectional area, the Engineer will include the measurements of short sections of modified design, such as tapers and depressions, for payment with the basic design if the contract does not contain a separate pay item for the modified design.

### B Area

For area measurements, the Engineer will measure the staked length and the extreme width between the outside faces as shown on the plans. The Engineer will disregard variations in concrete thickness caused by integral construction. The Engineer will separately measure driveway pavement of each specified thickness.

### C Pedestrian Curb Ramps

The Engineer will measure pedestrian curb ramps by the number of pedestrian curb ramps constructed.

The Engineer will measure the surface area of each type of pedestrian curb ramps using the outer most edge of the concrete walk, curb, or curb and gutter.

## 2531.5 BASIS OF PAYMENT

The Department will pay for concrete curbing on the basis of the following schedule:

| Item No. | Item: | Unit: |
|---|---|---|
| 2531.501 | Concrete Curb and Gutter, Design | linear foot [meter] |
| 2531.502 | Concrete Curb, Design | linear foot [meter] |
| 2531.503 | Concrete Median | square yard [square meter] |
| 2531.505 | Concrete Median | linear foot [meter] |
| 2531.507 | ____ in [mm] Concrete Driveway Pavement | square yard [square meter] |
| 2531.530 | Concrete Entrance Nose, Design 7107 | each |
| 2531.531 | Concrete Entrance Nose, Design 7108 | each |
| 2531.532 | Pedestrian Curb Ramp (Type ___) | each |

| Item No. | Item: | Unit: |
|---|---|---|
| 2531.533 | Pedestrian Curb Ramp (Type ___) | square yard [square meter] |

## 2533 CONCRETE MEDIAN BARRIERS

### 2533.1 DESCRIPTION

This work consists of constructing or reconstructing cast-in-place or precast median barriers for traffic lane separation.

### 2533.2 MATERIALS

**A Concrete..... 2461**

**A.1 Fixed Form Cast-In-Place.....Mix No. 3Y32**

**A.2 Slipform Placement ..... Mix No. 3Y12 or 3Y16**

**A.3 Precast.....Mix No. 3Y32**

**B Reinforcement Bars..... 3301**

**C Dowel Bars..... 3302**

**D Precast Concrete Median Barrier ..... 3630**

**E Curing Materials**

**E.1 Burlap Curing Blanket..... 3751**

**E.2 Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound .. 3754**

**E.3 Linseed Oil Membrane Curing Compound..... 3755**

**E.4 Plastic Curing Blankets..... 3756**

**F Granular Materials..... 3149**

### 2533.3 CONSTRUCTION REQUIREMENTS

**A General**

The Contractor may combine cast-in-place and precast concrete construction as approved by the Engineer if the plans do not specify the construction type and if the construction maintains structural strength, continuity, or both.

Use a tongue and groove joint with tied dowels or reinforcement bars or other positive connection to interlock the connection between a new median barrier and an existing barrier to prevent movement, as approved by the Engineer.

Excavate, shape, and compact the foundation to a firm, uniform bearing surface and grade as shown on the plans and in accordance with 2105, "Excavation and Embankment."

**B Cast-In-Place Fixed Form Construction**

Provide forms made of non-reactive metal, wood, or other material in accordance with 1805, "Methods and Equipment," capable of maintaining the concrete until the concrete can retain the molded shape. Provide side forms with a depth at least equal to the edge thickness of the formed concrete. Support the forms on the foundation to maintain the concrete line and grade as shown on the plans. Before placing the forms, coat the contact surfaces of the forms with form treating material in accordance with 3902, "Form Coating Material."

Wet the foundation and forms immediately before placing the concrete.

Prevent segregation during placement of concrete. Use internal vibration to consolidate the concrete and fill voids. Strike-off the concrete to the grade as shown on the plans and float the surface smooth. When the concrete can retain the molded shape, remove the forms from the roadway face of the median barrier. Keep non-roadway face forms in place for at least 12 h after casting the concrete.

Round concrete edges to the radii as shown on the plans after removing the roadway face forms.

**C Cast-In-Place Slipform Construction**

Rather than using fixed forms, the Contractor may use a slipform machine capable of placing and forming concrete to the dimensions, quality, workmanship, and appearance as required by the contract. Hand finish the concrete surface to the finish and texture as required by the contract.

**D Surface Finishes**

**D.1 Cast-In-Place**

Apply an ordinary surface finish in accordance with 2401.3.F, "Finish of Concrete," on cast-in-place concrete median barriers.

**D.2 Precast**

Place the barrier in its final location. Obtain the Engineer's approval of the surface condition of the barrier before applying the special surface finish treatment on precast concrete median barrier in accordance with 2401.3.F, "Finish of Concrete."

**E Concrete Curing and Protection**

When the contract requires additional surface finishing (ie. painting), the Engineer will not allow membrane curing compounds.

After completing final finishing operations, cure all exposed concrete surfaces for at least 72 h. When using fly ash or cementitious substitutions as defined in 2461.2.A.6, "Cementitious Substitutions," extend the minimum curing period to 96 h. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 min of concrete placement or once the bleed water has dissipated, unless otherwise directed by the Engineer in accordance with 2533.3.E.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 min after permanent removal of the forms or curing blankets, unless the contract requires otherwise.
(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2533.3.E.1.b, "Curing Blanket Method."

Failure to comply with these provisions will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the contract does not contain a separate contract item for *Structural Concrete*, the Department will apply a monetary deduction of $50.00 per cubic yard [$65.00 per cubic meter] or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, expedite the application of a curing method or temporarily suspend the mixing and placing operations, as the conditions require.

If necessary to remove the coverings to saw joints or perform other required work, and if the Engineer approves, remove the covering for the minimum time required to complete that work.

**E.1 Curing Methods**

**E.1.a Membrane Curing Method**

Before application, agitate the curing compound as received in the shipping container to obtain a homogenous mixture. Protect membrane curing compounds from freezing before application. Handle and apply the membrane curing compound in accordance with the manufacturer's recommendations.

Apply the curing compound with an approved airless spraying machine in accordance with the following:

(1) At a rate of 1 gal per 150 sq. ft [1 L per 4 m²] of surface curing area.
(2) Apply homogeneously to provide a uniform solid white opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper). Some Mn/DOT approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform solid opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.

The Engineer will approve the airless spraying machine for use if it is equipped with the following:

(1) A re-circulating bypass system that provides for continuous agitation of the reservoir material,
(2) Separate filters for the hose and nozzle, and
(3) Multiple or adjustable nozzle system that provides for variable spray patterns.

If the Engineer determines that the initial or corrective spraying result in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method, at no additional cost to the Department.

### E.1.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor. After the concrete has cured, apply membrane curing compound to the concrete surfaces that will remain exposed in the completed work.

### E.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

### E.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 34 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plan.

Protect the concrete from damage including freezing due to cold weather. Should any damage result, the Engineer will suspend operations until the Contractor takes corrective action, and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

### E.3.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plans.

### F Workmanship and Finish

The Engineer will use a 10 ft [3 m] straight edge to measure the surface. The Engineer will consider horizontal or vertical irregularities of $^{5}/_{16}$ in [8 mm] or greater in the surface of any 10 ft [3 m] length of the finished concrete median barrier as unacceptable work. Remove and replace extensive (more than 10 percent of the median barrier length) with deviations greater than ½ in [13 mm]. Remove and replace unacceptable work as directed by the Engineer.

If the Engineer does not direct removal of unacceptable work, the Contractor may leave the work in place and the Department will make the following adjustments to the contract unit prices:

(1) For deviations from $^{5}/_{16}$ in [8 mm] to ½ in [13 mm], 75 percent of the contract unit price, and
(2) For minor areas (equal to or less than 10 percent of the median barrier length) with deviations greater than ½ in [13 mm], 50 percent of the contract unit price.

## 2533.4 METHOD OF MEASUREMENT

The Engineer will measure the concrete median barrier on the top of the barrier, along the centerline for Type A barriers, and 3 in [75 mm] behind the front face for Type AA barriers. The Engineer will measure transitions, and special and modified barriers by the length on the top of the barrier and 3 in [75 mm] behind the front face.

The Engineer will separately measure each type of concrete median barrier.

### 2533.5 BASIS OF PAYMENT

The Department will pay for concrete median barrier on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2533.501 | Concrete Median Barrier, Design ___* Type ___‖ | linear foot [meter] |
| 2533.506 | Concrete Median Barrier and Glare Screen, Design ___* Type ___‖ | linear foot [meter] |
| 2533.507 | Portable Precast Concrete Barrier, Design ___* | linear foot [meter] |
| 2533.508 | Relocate Portable Precast Concrete Barrier, Design ___* | linear foot [meter] |

* Current standard plate
‖ Type A, Type AA, Type AL, Transition, A Step, or AA Step

## 2535 BITUMINOUS CURB

### 2535.1 DESCRIPTION

This work consists of constructing a curb using bituminous material.

### 2535.2 MATERIALS

Use the same type of bituminous mixture for the curb as the type specified for the pavement wearing course in accordance with 2360, "Plant Mixed Asphalt Pavement."

### 2535.3 CONSTRUCTION

#### A Tack

Apply a tack coat as specified in 2357, "Bituminous Tack Coat," on the pavement wearing course beneath the curb.

#### B Equipment

Place bituminous curb using an automatic curb machine that shapes and compacts the mixture to the profile shown on Standard Plate 7065. The Contractor may only manually place the bituminous curb in locations unreachable by the machine, if approved by the Engineer.

#### C Finishing

Place curb uniform in appearance and texture, and true to line and grade.

### 2535.4 METHOD OF MEASUREMENT

The Engineer will measure bituminous curb by length along the face of the curb at gutter line.

### 2535.5 BASIS OF PAYMENT

The contract linear foot [meter] price for *Bituminous Curb* includes the cost of construction and providing the bituminous mixture.

The Department will pay for bituminous curb on the basis of the following schedule:

| Item No.: | Item: | Unit: |
|---|---|---|
| 2535.501 | Bituminous Curb | linear foot [meter] |

## 2545 ELECTRIC LIGHTING SYSTEMS

### 2545.1 DESCRIPTION

#### A General

This work consists of constructing electric lighting systems, electric power systems, and sign lighting systems as specified in the contract.

#### B Definitions

Refer to the National Electric Code, article 100 for the definition of the term "Listed."

Use a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. Ensure the testing laboratory is listed by OSHA in its scope of recognition for the tests conducted as required by this section (2545).

Refer to 1101, "Abbreviations," 1103, "Definitions," this section (2545), or the special provisions for abbreviations and definitions of words and phrases pertaining to electric lighting systems or related work.

#### C Electrical Distribution System

Provide a distribution circuit of the electric lighting system consisting of three conductors plus equipment ground. Configure the conductors to constitute two photoelectric controlled 120 V or 240 V circuits as shown on the plans. Install the complete lighting circuits and the equipment ground to each standard.

Open the cabinet to allow the Power Company to perform a visual inspection before making the service connection. Ensure the Contractor's electrician is present when the Power Company makes the visual inspection.

## 2545.2 MATERIALS

### A General

### A.1 Regulations and Code

Provide electrical equipment in accordance with 2565.2, "Traffic Control Signals, Materials," and meeting the applicable requirements of IES, ANSI, ICEA, AASHTO, or ASTM.

Provide copper electrical conductors for electric lighting systems as specified in the contract. Provide wire sizes based on the American Wire Gage (AWG).

**A.2 Materials and Electrical Equipment ..... 2565.2**

**A.3 Material Samples for Testing..... 2565.2**

**A.4 Tests ..... 2565.2**

### A.5 Warranties, Guarantees, and Instruction Sheets

In addition to the individual warranties provided by product manufacturers, provide warranties, guarantees, and instruction sheets in accordance with 2565.2, "Traffic Control Signals, Materials," warrant and guarantee in-service operation of all materials and electrical equipment for 1 year beginning with the "turn-on" of the electrical lighting system. The Department defines "turn-on" as the time when the complete and operational electric lighting system meets all installation, operational, and testing requirements specified in the contract.

### A.6 Approved/Qualified Products List

Access lighting system materials listed on the Approved/Qualified Products List.

### B Hardware

Galvanize ferrous metal hardware, except stainless steel, in accordance with 3392, "Galvanized Hardware."

**B.1 Fasteners..... 3391**

**B.2 Anchor Rods..... 3385**

### B.2.a Lighting Service Cabinet Anchorages

Provide high strength bolts, nuts, and washers for lighting service cabinet installation in accordance with 3391, "Fasteners," and the following requirements:

(1) Galvanized in accordance with 3392, "Galvanized Hardware," and
(2) Sized as required by the contract.

**B.2.b Lighting Unit Anchorages**

Provide anchor rods, nuts, and washers for lighting unit installation on concrete foundations meeting the following requirements:

(1) 3385, "Anchor Rods;" Type A – Carbon Steel Anchor Rods,
(2) Galvanized on the top 1 ft [300 mm] of the anchor rod and nuts; and
(3) Sized as required by the contract.

Provide threaded studs and nuts for lighting unit installation on steel screw-in foundations in accordance with 3391, "Fasteners," and meeting the following requirements:

(1) Galvanized in accordance with 3392, "Galvanized Hardware," and
(2) Sized as required by the contract.

**B.2.c Anti-Seize Lubricant**

Coat the threaded portions of anchor rods above concrete foundations with a brush-on anti-seize lubricant before installing lighting service cabinets, lighting units, or other cabinets on the anchor rods.

**B.3 Cap Screws, Set Screws, and Tap Bolts**

Provide commercial brass or bronze cap screws, set screws, and tap bolts. Provide galvanized steel or commercial brass washers.

**C Conduit and Accessories**



**C.4 Conduit Fixtures**

Provide cast or malleable iron fixtures with threaded connections for metal conduit galvanized in accordance with 3394, "Galvanized Structural Shapes," where shown on the plans. Provide access covers made of the same material as the fixture and ensure that they provide a watertight fit.

Provide non-metallic fixtures listed by the NRTL for use with rigid PVC conduit.

**C.5 Expansion Fittings ..... 3839**

**D Electrical Cables and Conductors**

Provide No. 8 or larger conductors for main circuits. Provide No. 10 or larger conductors for single lamp branch circuits.

**D.1 Direct Buried Lighting Cable ..... 3815**

**D.2 Electrical Conductors ..... 3815**

**D.3 Overhead Light Cable ..... 3815**

**E Light Standards ..... 3811**

Provide light standards of the style and type required by the contract.

**F Luminaires**

Provide luminaires as specified below.

If using extended life, self-starting lamps, remove the plug-in lamp ignitor module from the 3-position socket during luminaire installation. Securely tie wrap the ignitor module to the inside of the luminaire housing.

**F.1 Cobra Head Luminaires**

Provide cobra head luminaires listed on the Approved/Qualified Products List under "Lighting."

**F.2 Sign Luminaries ..... 3810**

**F.3 Underpass Luminaires**

Provide underpass luminaires listed on the Approved/Qualified Products List under "Lighting."

**F.4 Lamps**

Provide lamps listed on the Approved/Qualified Products List under "Lighting" in the wattage and of the type specified for the luminaires in the contract.

**G Concrete ..... 2461**

**G.1 General**

Provide Mix No. 3Y43 concrete for light standard foundations.

Provide Mix No. 3A32 concrete for equipment pad foundations.

Provide concrete meeting the requirements for Type 3, Grade A for specific mix designations not specified in the contract.

Construct or replace concrete pavement or base removed because of trenching or construction operations with Mix No. 3Y43 high early strength concrete.

**G.2 Reinforcement Bars ..... 3301**

**H Service Equipment ..... 3837**

**I (Blank)**

**J Lighting Service Cabinet ..... 3850**

**K Electrical Junction Boxes ..... 3838**

**L Wood Poles ..... 3840**

**M Handholes**

Provide handholes specified in the contract and listed on the Approved/Qualified Products List under "Signals."

**N Photoelectric Control**

Provide photoelectric controls listed on the Approved/Qualified Products List under "Lighting."

**O (Blank)**

**P Miscellaneous Materials**

If the contract does not specify requirements for materials and electrical equipment, provide these materials and equipment as approved by the Engineer.

**Q Safety Switch ..... 3837**

**R Lighting Units**

Provide lighting units consisting of a light standard, mast arms, 2 in [50 mm] slipfitters, luminaires, lamps, wire holder, and miscellaneous equipment required for installation as specified in the contract and in accordance with 3810, "Lighting Luminaires," 3811, "Light Standards," and 3812, "Photoelectric Control."

Provide written evidence that orders have been placed for components of the lighting units required on the project to the Engineer within 15 calendar days after the contract approval notice mailing date.

## 2545.3 CONSTRUCTION REQUIREMENTS

**A General**

The contract indicates approximate locations of component parts. The Engineer will establish the exact locations on the project.

Do not perform work on the project until all underground utilities have been located in accordance with 1507, "Utility Property and Service." Replace electrical cable damaged due to the Contractor's negligence between handholes and light poles within 24 hours at no additional cost to the Department. Do not splice damaged electrical cable underground.

Keep highways, streets, and roads open to traffic during construction in accordance with 1404, "Maintenance of Traffic." Protect any openings or uncompleted work that may cause a hazard to vehicle or pedestrian traffic as approved by the Engineer.



Except during any periods of work suspension approved by the Engineer, maintain the existing lighting system within the limits of the project in accordance with 1514, "Maintenance During Construction," until the Engineer accepts the project in writing as specified in 1716, "Contractor's Responsibility for Work." Maintenance of the existing lighting system includes the following:

(1) Lighting units,
(2) Luminaires,
(3) Lamps (after at least 30 percent of the lamps burn out),
(4) Lighting service cabinets,
(5) Photoelectric controls,
(6) Concrete or steel foundations,
(7) Cable, and
(8) Damage and knockdowns resulting from Contractor operations.

The Department considers maintenance of the lighting system as incidental work, included in the unit prices of the pay items that are part of the lighting system.

If the Engineer determines that others, not the Contractor, have damaged the work, maintain and repair damage as directed by the Engineer. The Department will pay for the maintenance and repair the damage as extra work in accordance with 1402, "Contract Revisions."

Provide the Department with the names and phone numbers of contact personnel for both day and night operation for the maintenance of the existing lighting system.

**C Excavation and Backfill..... 2565.3**

**D Conduit and Fitting Installation..... 2565.3**

**E Handhole Installation..... 2565.3**

Install a handhole within a direct buried cable run if required by the contract. Install a PVC stubout with the following characteristics for each cable entering and exiting the handhole:

(1) 2 in [50 mm],
(2) At least 36 in [1 m] long, and
(3) Non-metallic bell ends on each open end to prevent damage to the direct buried cable.

**F Concrete Foundation Installation**

**F.1 General**

Construct light bases and equipment pads in accordance with 2565.3, "Traffic Control Signals, Construction Requirements," as specified in the contract, and in accordance with following:

**F.2 Light Bases**

In addition to the extra conduit elbows specified in the contract, provide light bases with one 2 in [50 mm] rigid PVC conduit 90 degree elbow for each direct buried cable that enters the base. Provide one spare 2 in [50 mm] rigid PVC conduit 90 degree elbow, capped at each end, for expansion of the lighting system.

Where light bases are located in a cut section or a fill section, shape the backslope or mound the foundation excavation around the base to ensure that the light base breakaway supports meet AASHTO *Stub Height Requirements for Breakaway Supports*.

Where the required ground rod electrode is separated from the light base, install rigid PVC elbow with bushings at each end to carry the grounding wire as specified on the Standard Plates. Install the electrode from 3 in [75 mm] to 6 in [150 mm] below the ground line and within 1 ft [300 mm] of the foundation.

Where the ground rod electrode is in the concrete foundation, install so the top of the electrode extends from 2 in to 3 in [50 mm to 75 mm] above the foundation.

**F.3 Equipment Pad**

Where the required ground rod electrode is separated from the equipment pad, install NMC elbows in the size specified in the contract with threads and bushings at each end to carry the grounding wire. Install the electrode from 3 in to 6 in [75 mm to 150 mm] below the ground line and within 1 ft [0.3 m] of the foundation.

Where the required ground rod electrode is in the concrete foundation, install so the top of the electrode extends from 2 in to 3 in [50 mm to 75 mm] above the foundation.

## G Wiring and Conductor Installation

### G.1 General

Install wiring and conductors in accordance with 2565.3, "Traffic Control Signals, Construction Requirements," and the following:

Run service conductors in a separate conduit system from other conductors.

The Contractor may place separate lighting branch circuits in a single conduit, maintaining the electrical independence of the circuits. Run conductors of a lighting branch circuit in a single conduit.

### G.2 Underground Wiring

Trench or plow to install direct buried lighting cable to a depth of at least 2 ft [0.6 m]. If plowing, provide a vibratory plow with a feed blade that is capable of performing the following:

(1) Breaking the ground,
(2) Placing the cable to a predetermined depth,
(3) Guiding the cable into the bottom of the break through the guide blade chute so that little or no stress is placed on the cable during installation to avoid damage,
(4) Not pulling the cable in place, and
(5) Closing the break in the ground.

Feed the cable through the plow blade chute and ensure the plow blade does not pull the cable. Obtain the approval of the Engineer for the plowing method before installing the cable. If encountering solid rock or other obstructions, the Contractor may install the cable at least 18 in [460 mm] deep if the Contractor places a 2 in [50 mm] thick concrete slab in the trench over the cable. If running the cable through conduit and if placing a 2 in [50 mm] thick concrete slab above the cable and conduit, the Contractor may install the cable at least 6 in [153 mm] deep.

Install direct buried lighting cable at the same distance behind the bituminous shoulder or back of curb as the light bases. Install an additional 2 ft [600 mm] of slack

direct buried lighting cable near the light base in an "S" shape before the cable enters the base conduit.

Extend direct buried lighting cable at least 2 ft [600 mm] above the light base foundation with at least 4 in [100 mm] of the outer jacket extending above the conduit.

Install wiring in conduit with sufficient slack to allow for contraction.

Run an independent grounding wire through all non-metallic conduit systems. Electrically connect the independent grounding wire to all metal fixtures and equipment along the run.

Install a No. 8 grounding jumper internally between conduit sections for all expansion sleeves in metallic conduit.

Pull wires through conduit or raceways by hand to prevent damage to the wires or their covering. Ensure the conduit is clean and dry when installing the wiring. Ensure the cable or conductors are clean and dry. The Contractor may use powdered graphite, soapstone, or liquid wire pulling lubricant to ease the pulling.

**G.3 Above Ground Wiring**

Within roadway lighting standards provide 12-2 UF cable with ground and a cartridge type fuse to connect the luminaire to the underground cable or base mounted ballast unless otherwise required by the contract. Mount the fuse in an inline molded fuse holder listed on the Approved/Qualified Products List under "Lighting," with casing. Place the fuse holder in a position that allows easy access from the light standard door when removed. Properly connect the conductors to the "load" and "line" sides of the fuse. Do not use splicing on either side of the fuse holder other than approved terminal appliances.

Use a 6 A cartridge fuse on 240/480 VAC systems and an 8 A cartridge fuse on 120/240 VAC systems.

After conductors have been crimped to the fuse holder apply two lawyers of protective vinyl electrical tape over the breakaway fuse holder in the area where the conductors are crimped to the fuse holder. Cover any uninsulated portion of the fuse holder barrel and extend the wrap at least one (1) inch over the incoming conductor insulation.

Provide excess length of conductors to allow withdrawal of the connected fuse holder. Do not fuse the neutral and grounding wires.

The Contractor may use neutral-supported aluminum cable meeting the requirements of 3815, "Electrical Cables and Conductors," to provide temporary

power distribution through aerial lines. Attach the overhead cable to the poles as approved by the Engineer. Do not support overhead light cable by the luminaires.

**G.4 Splices ..... 2565.3**

**G.4.a Above Ground Splices**

The Contractor may substitute insulated wire splice connector blocks approved in the roadway lighting standards and listed on the Approved/Qualified Products List under, "Lighting" for the specified split bolt connector specified in 2565.3.J.4, "Splices."

Apply two layers of protective vinyl electrical tape over the insulated wire splice connector block in the area where the conductors enter the block. Extend the wrap at least one (1) inch over the incoming conductor insulation.

**G.4.b Under Ground Splices**

Unless specified in the contract or approved in writing by the Engineer, do not use underground splices. Provide power cable splice encapsulation kits listed on the Approved/Qualified Products List under "Lighting" if the contract specifies or Engineer approves the use of underground splices

**G.5 Terminal Blocks ..... 2565.3**

**G.6 Labeling of Lighting Cable**

Label all conductors in service cabinets and light pole bases indicating the next termination point. For example, in the lighting service cabinet the label would read "TO POLE #1"; in pole No. 1 the label would read "TO LIGHTING SERVICE CABINET" and "TO POLE #2".

Provide labels that consist of white vinyl adhesive tape wrapped around the cable. Hand write the labeling on the vinyl adhesive tape or produce with a label maker. If label marking is handwritten, accomplish the labeling by using a black permanent marker, in such a manner, that the markings are legible to the satisfaction of the Engineer. Labels produced with a label maker shall be suitable for use in wet locations, and this label must wrap around the cable one complete revolution with some overlap.

**H Lighting Standard Installation**

Set light standards plumb with balanced luminaires. Use a backward rake to counterbalance lateral deflection for standards with unbalanced luminaries or bracket arms, or standards that act as supports for overhead wires or guy lines.

Use shims or double nuts to adjust standards to the plumb position before anchoring in position. Only use shims for leveling if installing aluminum light standards on light bases.

Where leveling nuts are allowed, securely tighten the leveling and top nuts against the light standard base plate. If using shims, securely tighten the top nuts against the light standard base plate. Tighten leveling nuts and top nuts as follows:

(1) Lubricate the nuts with brush on anti-seize lubricant and torque the nuts to at least 125 ft-lbs [17.29 m-kgs] for anchorages 1 in [25 mm] in diameter.
(2) Lubricate the nuts with brush on anti-seize lubricant and torque the nuts to at least 240 ft-lbs [33.1 m-kgs] for anchorages 1¼ in [32 mm] in diameter.

Repair damaged lighting standards, mast arms, brackets, or other appurtenances to the light standard as approved by the Engineer.

## I (Blank)

## J Sign Lighting Installation

### J.1 General

Provide sign lighting as specified in the contract.

Use trench laid cable to provide power distribution to the sign structure unless otherwise required by the contract.

### J.2 Safety Switch

Install the safety switch in a vertical upright position.

### J.3 Safety Switch Wiring

Install No. 12 conductors in ¾ in [21 mm] RSC between the switch and the luminaire. Use a wire nut and waterproof coating to splice. Make conduit connections rain tight.

Install a No. 12 green conductor in ¾ in [21 mm] RSC between safety switch and luminaries to provide ground. Connect the No. 12 conductor to the grounding lug attached to the safety switch enclosure and isolated from the neutral terminal, and the grounding screw attached to each luminaire housing.

Run ¾ in [21 mm] RSC wiring between the sign post and the safety switch. Install No. 12 conductors between the switch and the sign base.

Splice the existing or new power conductors to the conductors from the safety switch with split bolt type connectors as specified in the contract. Insulate the splices to the same insulation level as for the power conductors. Waterproof the splices.

Dress the splices in the center of the post and up from the base plate with enough excess conductor length to allow withdrawal the splices through the access opening cover.

Perform a burn test as specified in 2545.3.K.2, "12-Hour Burn Test," after completing the new sign lighting systems for each feed point.

**J.4 Feed Point Identification Plate**

Provide and install a feed point identification plate that incorporates the feed point identification number appearing in parenthesis directly below or along side the sign number in the contract for each new lighted overhead sign as specified in the contract.

Strap mount the plate to the overhead sign post as specified in the contract. Install the plate on the right post when looking in the direction of traffic flow. If signs face both directions of travel on a signal structure, install two plates. Install plates 7 ft [2.2 m] above the base plate elevation and facing traffic.

For bridge mounted signs, install the feed point identification plate on a 2 lb per ft [3 kg per m] delineator post in accordance with 3401, "Flanged Channel Sign Posts." Install the feed point identification plate and post as close to the bridge as possible and behind the guardrail. If no guardrail is in place, install the plate and post at least 12 ft [3.7 m] outside the edge of the shoulder or face of curb. Place the bottom of the plate 7 ft [2.2 m] above the edge of the pavement.

**J.5 Safety Cable**

Provide and install brackets, aircraft cable, and hardware required to assemble and attach a safety cable as specified in the plans in accordance with 2564, "Traffic Signs and Devices."

**K Electrical System Testing and Acceptance**

Test the entire system for unwanted grounds and conduct a 12-hour burn test for each feed point before completing the work.

**K.1 Megohm meter test (Test for unwanted grounds)**

Perform a megohm meter test, at 500 VDC, indicating the insulation resistance of each circuit. Energize the megohm tester for 15 s on the circuits to check for breakdown of the circuits. Submit a written report of the megohm meter readings for the permanent record with the following information to the Engineer:

(1) Project number.
(2) Project location.
(3) Feedpoint number as shown in the plans.

(4) Branch circuit that identifies each lighting branch circuit being tested by indicating the number of the first light connected to that circuit, as shown on the plans.
(5) Phase conductor insulation resistance. Determine the phase conductor insulation resistance by measuring the resistance between the phase conductors, and the resistance between each phase conductor and the equipment ground bar in the service cabinet. Remove the fuses from the inline fuse connectors in the lighting poles before measuring. The Engineer will not allow a resistance less than 100 MΩ.
(6) Neutral conductor insulation resistance. Determine the neutral conductor insulation resistance by measuring the resistance between each neutral conductor and the equipment ground bar in the service cabinet. Remove the fuses from the inline fuse connectors in the lighting poles before measuring. The Engineer will not allow a resistance less than 100 MΩ.
(7) Circuit insulation resistance. Determine the circuit insulation resistance by measuring the resistance between each phase conductor and the equipment ground bar in the service cabinet. Leave the fuses in place in the lighting poles when measuring. The Engineer will not allow a resistance less than 100 MΩ.

Perform tests at the service cabinet, in the presence of the Engineer, with all grounding connections in place. Disconnect the phase and neutral conductors at the service cabinet for the insulation resistance tests.

If the tests indicate faulty insulation or a faulty connection within the circuit, correct and retest circuits at no additional cost to the Department. Replace circuits or circuit parts to make the circuits meet the test requirements at no additional cost to the Department.

**K.2 12-Hour Burn Test**

After completing the feed point and before the Department pays for greater than 90 percent of the feed point cost, energize the service cabinet and ensure the entire electrical system can successfully operate without interruption for 12 h during daylight. The Department considers the cost of power as incidental and will not separately pay for power costs to energize the electrical system for the 12-hour burn test.

**L Service Equipment Installation**

Install components of each lighting service cabinet and include miscellaneous hardware required for a complete lighting service cabinet installation. Coordinate the connection of power to each lighting service cabinet with the power company.

**L.1 Lighting Cabinets Type A or Type B**

Attach service cabinets Type A and Type B to wood poles or mounting bracket assemblies as required by the contract. Provide and install service equipment including the following:

(1) Meter socket in accordance with 3837, "Electrical Service Equipment,"
(2) Mounting brackets as shown on the plans,
(3) Conduit fittings,
(4) Wiring as shown on the plans, and
(5) Other items incidental to a complete meter socket installation.

**L.2 Lighting Service Cabinets Type L1 and Type L2**

Securely bolt pad mounted lighting service cabinets to the concrete foundation using anchor rods, nuts, and washers supplied by the cabinet manufacturer. Anchor rods shall extend above the concrete foundation to accommodate the ½ in [13 mm] thick gasket. Install the supplied rubber gasket sections between the bottom of each cabinet base and the concrete foundation. Leave one ½-inch [13-millimeter] gap in the basket to ensure proper water drainage.

Position the cabinet door from 90 degrees to 180 degrees to the roadway, away from traffic.

**L.3 Lighting Service Cabinets Type Rural Lighting and Flasher (RLF)**

Securely bolt pad-mounted lighting service cabinets to the concrete foundation using anchor rods, nuts, and washers supplied by the cabinet manufacturer. Anchor rods shall extend above the concrete foundation to accommodate the ½ in [13 mm] thick gasket. Install the supplied rubber gasket sections between the bottom of each cabinet base and the concrete foundation. Leave one ½-inch [13-millimeter] gap in the gasket to ensure proper water drainage. Position the cabinet door from 90 degrees to 180 degrees to the roadway, away from traffic.

**M Painting**

Paint non-galvanized ferrous metalwork, except for stainless steel, in accordance with 2478, "Organic Zinc-Rich Paint System."

Paint galvanized ferrous metalwork in accordance with 2478, "Organic Zinc-Rich Paint System."

Brush or spray two dark green field coats meeting the requirements of 3532, "Exterior Polyurethane Paint," for finish coats on steel lighting service cabinets, unless otherwise specified in the contract.

The Department will not require the Contractor to paint the inside of light standard shafts.

Provide anodized aluminum service cabinets meeting the requirements of MIL-A-8625 for Type II, Class I Coating except:

(1) The outer surface coating is 0.0007 in [0.018 mm];
(2) The coating weighs 27 mg per 645 mm²;
(3) Immerse the coating in a 212 °F [100 °C] aqueous 5 percent nickel acetate solution for 15 min, or submerge the coating in a room temperature fluoride-based sealant for at least 8 min and then immediately dip in water at a temperature of at least 162 °F [72 °C] for 5 min to seal the coating.

Protect the factory applied finish when erecting a painted pole. Provide a felt lined collar to handle the pole and leave the protective wrapping on the pole at the lift point area to protect the painted finish. Repair and restore damage to the finish as directed by the Engineer.

**N Restoration and Cleanup..... 2565.3**

**O (Blank)**

**P Light Standard, Luminaire, and Lighting Service Cabinet Numbering**

Number the light standards or light units, and the outside of lighting service cabinets as shown on the plans with labels listed on the Approved/Qualified Products list under, "Lighting."

Label the service cabinets 4 ft [1.8 m] above the concrete base with the feed point numbers on the front door and the side of the cabinet that faces traffic.

Label light standards with feed point numbers and letters immediately above the pole number, 6 ft [1.8 m] above the base, and 45 degrees facing oncoming traffic.

Submit a sample label to the Engineer for approval before installing the labels.

Lightly sand the pole shaft to remove oxidation. Wipe the pole shaft with isopropyl alcohol before applying numbers and letters.

Number wood pole lighting standards as approved by the Engineer.

Number underpass lighting units with the last letter of the feed point and with the luminaire number.

Label branch circuit breakers on the interior of the lighting service cabinets with the color of the circuit conductor and the luminaire number.

Verify that the light standards and lighting units to be reinstalled are correctly numbered. If the light standards and lighting units to be reinstalled are not correctly numbered, number the light standards and lighting units in accordance with this specification.

**Q Luminaire Installation**

Install and level luminaires in accordance with the manufacturer's recommendations and as approved by the Engineer.

Place a level on the area provided on the top of the luminaire, and level the luminaire in side-to-side and front-to-back directions.

**R Bonding and Grounding**

Provide bonding, grounding, ground rod electrodes, ground electrode conductors, and ground connections in accordance with 2565.3, "Traffic Control Signals, Construction Requirements," the NEC, and the following:

Provide mechanically and electrically secure metal poles, conduit, service cabinets, service equipment, and other non-current-carrying metal surfaces to form a continuous, bonded, grounded system and to provide a low impedance path from exposed metal surface to the system ground at the service cabinet or service equipment.

Bond the following together as specified on the plans and use as the equipment ground:

(1) Equipment grounding conductor in the direct buried lighting cable,
(2) Copper tape shield of the direct buried lighting cable,
(3) Equipment grounding conductor in conduit,
(4) Rigid steel conduit,
(5) Grounding lug of the light standard or sign post, and
(6) ACSR equipment ground messenger of overhead light cable

Provide at least No. 6 copper conductor bonding and grounding jumpers. Only ground the neutral conductor at the feedpoint.

Use a bronze or copper lug type connector or bolt to connect the grounding and bonding jumper to the copper tape shield. Use cast clamps or grounding bushings with an integral lug to accommodate the jumper to attach other grounding and bonding jumper attachments.

Use an NRTL-listed, reusable screw-type, active clamping ground lug with a tang that connects to the $^{5}/_{16}$ in [8 mm] light standard pole base grounding stud to attach the grounding conductor to the metal light standard.

Provide supplemental ground rod electrodes with the following characteristics, if specified in the contract:

(1) NRTL listed,
(2) Meeting the requirements of UL 467,
(3) Copper clad,
(4) Diameter of at least $^{5}/_{8}$ in [16 mm], and
(5) 15 ft [4.75 m] long.

Install the supplemental ground rod electrodes in the locations specified in the contract.

Provide ground rod electrodes at every other light base and at the light bases located at both ends of a run, unless otherwise specified in the contract.

Provide a direct grounding connection to a ground rod for all main switch cabinets, control cabinets, or service cabinets. For bridges or buildings, bond each cabinet or metal structure to the bridge or building grounding system. Make grounding conductor runs as short as possible.

Apply oxide inhibitor on all ground connections after final assembly.

**S Service Equipment Installation ..... 2565.3**

**T Existing Materials and Electrical Equipment**

Remove, salvage, reinstall, or stockpile existing materials and electrical equipment as specified in the contract or as directed by the Engineer in accordance with 2565.3"Traffic Control Signals, Construction Requirements."

**U Wood Pole Installation ..... 2565.3**

**V Lighting Units**

Install components of lighting units and include hardware required for a complete lighting unit installation.

**W Anti-Seize Lubricant**

Brush an anti-seize lubricant onto the threaded portions of light pole access cover bolt and nut before installation.

## 2545.4 METHOD OF MEASUREMENT

**A Complete Systems**

The Engineer will measure separate items listed in the contract for various types of complete electrical systems. The Engineer will measure the separate systems in accordance with the following:

**A.1 Electric Lighting System**

The Engineer will measure each separate *Electric Lighting System* as a single unit, complete in place.

**A.2 Electric Power System**

The Engineer will measure each separate *Electric Power System* as a single unit, complete in place.

**A.3 Sign Lighting System - ___ Luminaires**

The Engineer will measure each separate *Sign Lighting System - ___ Luminaries* as an integral unit, complete in place.

**A.4 Sign Lighting System Bridge Mounted - ___Luminaires**

The Engineer will measure each separate *Sign Lighting System Bridge Mounted - ___ Luminaries* as an integral unit, complete in place.

**A.5 Conduit System**

The Engineer will measure each separate *Conduit System* as an integral unit, complete in place.

**B Electrical System Components**

The Engineer will measure separate items listed in the contract for the various component parts of an electrical system in accordance with the following:

**B.1 Lighting Units**

The Engineer will separately measure lighting units of each type of mounting and luminaire design by the number of units of each type, complete in place.

**B.2 Luminaires**

The Engineer will separately measure luminaires of each type and wattage by the number of luminaires complete in place.

**B.3 Light Bases**

The Engineer will separately measure concrete bases of each design for lighting units as integral units, complete in place.

**B.4 Conduit**

The Engineer will separately measure conduit of each kind and diameter by the length between end terminals along the centerline of the conduit as installed.

**B.5 Underground Wire**

The Engineer will separately measure underground wire of each kind and size by the length between end terminals along the centerline of the wire as installed.

**B.6 Direct Buried Lighting Cable**

The Engineer will separately measure direct buried lighting cable of each kind and size by the length between end terminals along the centerline of the cable as installed.

**B.7 Overhead Light Cable**

The Engineer will separately measure overhead light cable of each kind and size by the length between end terminals along the centerline of the wire as installed.

**B.8 Service Cabinets**

The Engineer will separately measure service cabinets of each type by the number of cabinets, complete in place.

**B.9 Equipment Pads**

The Engineer will separately measure equipment pads of each type by the number of equipment pads complete in place.

**B.10 Junction Boxes**

The Engineer will measure junction boxes by the number of junction boxes complete in place.

**B.11 Handholes**

The Engineer will separately measure handholes of each design by the number of handholes complete in place.

**B.12 Underpass Luminaires**

The Engineer will separately measure underpass luminaries of each design by the number of underpass lighting units complete in place.

**B.13 Wood Poles**

The Engineer will measure wood poles by the number of wood poles complete in place.

**B.14 Service Equipment**

The Engineer will separately measure service equipment by the number of service equipment complete and in place and fully operational.

**B.15 Underground Cable Splice**

The Engineer will measure underground cable splices by the number of splices complete and in place.

**2545.5 BASIS OF PAYMENT**

The contract unit price for lighting systems, power systems, sign lighting systems, modify sign lighting systems, and conduit systems is full compensation for the cost of furnishing and installing the complete system as required by the contract.

The contract unit price for *Lighting Unit* includes the cost of lamps, luminaire, ballast, pole base, pole and bracket, inline fuse, wiring between pole base and luminaire, luminaire wire holder, splice to power circuit, numbering of the light standard, and other miscellaneous items required for a complete installation of the lighting unit.

The contract unit price for *Luminaire* includes the cost of the housing, reflector, glassware, lamp, ballast, mounting, mounting hardware, wiring, connections, numbering of the luminaire if not installed on a light standard, and other miscellaneous items required for a complete installation of the luminaire.

The contract unit price for *Light Base* includes the cost of excavation, concrete, reinforcement, anchor rods, ground rod, ground lead, grounding connections, conduit elbows and bushings, and other miscellaneous items required for a complete installation of the light base.

The contract unit price for *Conduit Systems* includes the cost of conduit, trenching, jacking, augering, conduit sleeves, couplings, weatherheads, elbows, bushings, sealing around the conduit where it enters a pull box, sealing conduit ends in concrete foundations and in pull boxes, grounding and bonding of conduit, backfilling and restoring sod, sidewalks, pavements, and other miscellaneous items required for a complete installation of the conduit.

The contract unit price for *Underground Wire* includes the cost of wire, pulling, splicing, terminals, making required connections, testing, and other miscellaneous items required for complete installation of underground wire.

The contract unit price for *Direct Buried Lighting Cable* includes the cost of cable, trenching, shield bonding, connections, fittings, fastenings, hangers, backfilling and surface restoration, testing, and other miscellaneous items required for a complete installation of the direct buried lighting cable.

The contract unit price for *Overhead Light Cable* includes the cost of cable, grounding of the messenger wire, connections, fastenings, hangars, testing, and all other miscellaneous items required for a complete installation of overhead light cable.

The contract unit price for *Service Cabinet* includes the cost of panelboard enclosure, circuit breakers, switches, relays, photoelectric control, internal wiring, service entrance circuit, service entrance conduit and weatherhead for wood pole mounted cabinets, mounting hardware, grounding, painting, sealing around cabinet base, numbering of the service cabinet, and miscellaneous items required for a complete installation of the lighting service cabinet.

The contract unit price for *Equipment Pad* includes the cost of excavation, concrete, reinforcement, anchoring hardware within the pad, conduits within the pad, ground rods, grounding connections, mounting brackets, mounting hardware, surface restoration, and miscellaneous items required for the complete equipment pad installation.

The contract unit price for *Junction Box* includes the cost of junction boxes, bushings, covers, gaskets, and miscellaneous items required for the complete installation of junction boxes.

The contract unit price for *Handhole* includes the cost of the handhole, metal frame and cover, excavation, aggregate drain bed, backfilling, sealing conduit entrances, surface restoration, and miscellaneous items required for the complete installation of handholes.

The contract unit price for *Underpass Luminaries* includes the cost of the housing, reflector, glassware, lamp, ballast, mounting, mounting hardware, wiring, connections, numbering of the luminaries, and miscellaneous items required for the complete installation of underpass luminaires.

The contract unit price for *Wood Pole* includes the cost the class of wood pole, surface restoration, and other miscellaneous items required for the complete installation of wood poles.

The contract unit price for *Service Equipment* includes the cost of meter socket and mounting brackets, conduit and power conductors on wood pole, wiring connections, ground rod electrode, bonding and grounding materials and connections, and incidental items required to a complete meter socket installation.

The contract unit price for *Underground Cable Splice* includes the cost of splice kits and miscellaneous items required for a complete underground cable splice.

The Department will pay each pay item at the contract unit price per the specified pay unit as follows:

| Item No: | Item: | Unit: |
|---|---|---|
| 2545.501 | Electric Light System | lump sum |
| 2545.503 | Electric Power System | lump sum |
| 2545.505 | Sign Lighting System - ___ Luminaires | system |
| 2545.506 | Sign Lighting System Bridge Mounted - ___ luminaries | system |
| 2545.509 | Conduit System | lump sum |
| 2545.511 | Lighting Unit, Type ___ | each |
| 2545.513 | Luminaire | each |
| 2545.514 | Underpass Luminaires, Type ___ | each |
| 2545.515 | Light Base, Design ___ | each |
| 2545.521 | ___in [mm] Rigid Steel Conduit | linear foot [meter] |
| 2545.522 | ___in [mm] Intermediate Metal Conduit | linear foot [meter] |
| 2545.523 | ___in [mm] Non-metallic Conduit | linear foot [meter] |
| 2545.531 | Underground Wire, ___ Conductor No. | linear foot [meter] |
| 2545.533 | Direct buried lighting Cable, ___ Conductor No. ___ | linear foot [meter] |
| 2545.537 | Overhead Light Cable, ___ Conductor No. ___ | linear foot [meter] |
| 2545.541 | Service Cabinet, ___ Type ___ | each |
| 2545.542 | ___ft [m] Wood Pole, Class ___ | each |
| 2545.543 | Underground Cable Splice | each |
| 2545.544 | Service Equipment | each |
| 2545.545 | Equipment Pad | each |
| 2545.551 | Junction Box | each |
| 2545.553 | Handhole | each |