DIVISION II
CONSTRUCTION DETAILS

2021

Mobilization

2021.1 DESCRIPTION
This item shall consist of preparatory work and operations, including, but not limited to, those necessary for the movement of personnel, equipment, supplies and incidentals to the Project site; for the establishment of all Contractor's offices and buildings or other facilities necessary for work on the Project.

2021.5 BASIS OF PAYMENT
Based on the lump sum Contract price for mobilization, partial payments will be made as follows:
(a) On the first partial estimate that shows work performed on at least one major Contract item or after 5% of the original Contract amount has been completed, exclusive of the Mobilization item, 50 percent of the amount bid for mobilization will be paid, but not to exceed 3 percent of the original Contract amount; or
(b) When 15% of the original Contract amount has been completed, exclusive of the Mobilization item, 75 percent of the amount bid for Mobilization will be paid, but not to exceed 5 percent of the original Contract amount; or
(c) On the first partial estimate that shows work performed on each and every major Contract item, 100 percent of the amount bid for mobilization will be paid; or
(d) When any previous partial estimate shows that 25 percent or more of the original Contract amount has been earned, exclusive of mobilization payments, 100 percent of the amount bid for mobilization will be paid on the next partial estimate.

The original Contract amount shall be the total value of all Contract items, including the mobilization item. Major Contract items may be listed as such in the Special Provisions or Bid Schedule. In the absence of such listing, these items shall be any Contract item or items having an individual amount in excess of 5 percent of the original Contract amount.

When the amount bid for the mobilization item exceeds 5 percent of the total original Contract amount, the Department reserves the right to withhold (on any partial estimate) the portion in excess of 5 percent
until 95 percent or more of the original Contract amount is earned. The total sum of all payments shall not exceed the original Contract amount bid for the mobilization item, regardless of the fact that the Contractor may have, for any reason, shut down work on the Project or moved equipment away from the Project and then back again. Nothing herein shall be construed to limit or preclude partial payments otherwise provided by the Contract.

<table>
<thead>
<tr>
<th>Item No.</th>
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<th>Unit</th>
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<tr>
<td>2021.501</td>
<td>Mobilization</td>
<td>Lump Sum</td>
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</tbody>
</table>

### 2031 Field Office and Laboratory

#### 2031.1 DESCRIPTION

This Specification covers the furnishing, maintaining, and removing field office and laboratory facilities for the exclusive use of Department personnel in making field tests and reports, for storage of records and equipment, and as field headquarters for the Engineer.

#### 2031.2 GENERAL PROVISIONS

The Contractor shall furnish all field office and laboratory facilities in accordance with these provisions. The facilities shall remain the property of the Contractor. The Contractor shall furnish, maintain, and service the facilities with fuel, electrical power, sanitary services, access roads, and other required items. The Contractor shall provide telephone service to all field office and laboratory facilities. The phone service shall include a modular jack and a voice activated, beeperless, telephone recorder. The Contractor shall pay for the telephone installation, basic monthly phone service charges, and the removal of the telephone. The Contractor shall submit invoices for long distance telephone charges to the Engineer for payment.

The Contractor shall not place field offices, laboratories, equipment, or supplies within a distance of 8 m (26 feet) outside of the dripline of specimen trees or other vegetation designated to be preserved without approval of the Engineer. The Contractor shall also restrict traffic movement from this protected area. The Engineer may specify temporary fence and other protection measures according to 2572.

The Contractor shall locate, relocate, and maintain the facilities as approved by the Engineer unless the Contract specifies otherwise. The Contractor shall locate the field office and laboratory sites within the Right of Way whenever possible. If it is not possible within the Right of Way, the Contractor shall arrange for a site adjacent to the Right of way. If it is necessary to rent the site, the Contractor will receive compensation for rent costs as Extra Work. The Engineer will give the Contractor reasonable advance notice before any unit is to be delivered.
to the Project, readied for occupancy, and relocated or removed. The Contractor shall not relocate or remove any unit from the Project without the Engineer's consent. However, the Contractor shall remove the facilities from the Project when released by the Engineer.

The Engineer may utilize field office units for the full life of the Contract including periods of work suspension and until the Certificate of final acceptance has been executed.

The Engineer will release field laboratory units upon completion of all field inspection work and acceptance as provided for in 1516, unless otherwise specified in the Contract. The Engineer will not utilize the laboratory units during periods of authorized winter suspension without the Contractor's permission or unless such use is otherwise specified in the Contract.

The Engineer will decide all disputes concerning site selection, placement conditions, service needs, and other functional matters.

2031.3 REQUIREMENTS

A Basic Requirements

Each field office and laboratory shall be a separate mobile unit or building. The Engineer may approve other equivalent facilities. Separate quarters in stationary structures or combination trailer units will be accepted only if and when the location and mobility needs can be satisfied without appreciable inconvenience or loss of serviceability to the Department.

Each field office or laboratory unit shall be constructed and equipped to meet the following basic requirements:

1. Weatherproof thermal resistant construction with finished interior walls, ceiling, and floor, capable of being easily maintained and cleaned.

2. Exterior width of 2.4 m (8 feet) or more, and a floor to ceiling height of not less than 2.1 m (7 feet).

3. Two or more entrance doors with inside latches, at least one of which shall be an exterior door equipped with an outside lock and an opening of not less than 750 x 1930 mm (30 x 76 inches).

4. Commercial type windows of normal number and size, with a total window area not less than 20 percent of the unit floor area, and with inside latches on all vent windows.

5. Ceiling ventilator or exhaust fan, insect-proof screening on each exterior door and all vent windows, and Venetian blinds or effective awnings over all windows.

6. Artificial lighting system with fixtures providing adequate illumination over each desk and all work areas.

7. Portable or wall mounted plans rack.
2031.3

(8) One or more multipurpose fire extinguishers that comply with applicable Federal and State safety and health regulations.

(9) Electric heating system capable of maintaining a reasonably uniform temperature of 22°C (70°F) or more throughout the interior in all zones.

(10) Minimum floor area, based on exterior dimensions, of not less than 21 m² (230 square feet) for the field office or 14 m² (150 square feet) for the field laboratory.

The exterior doors shall provide convenient and safe egress from the ends of the unit. Dimensions of the main door shall be not less than 750 x 1930 mm (30 x 76 inches). A smaller auxiliary door may be allowed on laboratory units, at the discretion of the Engineer, provided it fulfills the basic needs for an emergency exit. The doors and passageways shall provide easy access to all areas of the unit.

B Specific Requirements

The interior layout of each unit shall be designed or arranged to make the furnishings easy to use, accommodate the use and storage of ordinary office machines and testing apparatus, and provide a reasonably modern and universally acceptable facility. Built-in furnishings and fixtures shall meet conventional standards. All desk, table, and work top surfaces shall be surfaced or finished with mar resistant materials.

All appliance installations, sanitary facilities, electrical circuitry, waste and water supply systems, venting, and safety features, shall meet Federal, State, and local regulations.

The field office or laboratory shall also be equipped to meet the following specific requirements:

B1 Field Office Furnishings

B1a Two or more pedestal type desks with supply drawers, and a top width of at least 750 mm (30 inches). The desks may be either the portable or built-in type, having a top length of at least 1500 mm (60 inches). If one or both ends of the desk are mounted flush with a wall, however, the top length shall be at least 1800 mm (72 inches). Vacant wall space shall be provided for placement of a Department-furnished stenographic desk if one is not furnished.

B1b Three or more letter or legal size file drawers, either of the built-in or portable cabinet type, located for convenient access.

B1c One drafting desk with plan sheet and pencil drawer and with top dimensions not less than 900 x 1800 mm (36 x 72 inches). It shall be a commercially built, tilt or slant top desk of the wall mounted, pedestal, or cabinet style, but neither end shall be mounted flush with a wall.
B1d  An enclosed storage cabinet or closet with adequate space for the usual outdoor garments, office supplies, and other materials not separately stored on open shelves or in desk drawers.

B1e  At least 6 m (20 linear feet) of open shelving not less than 300 mm (12 inches) wide above desks or at other convenient locations.

B1f  One drafting stool and sufficient desk chairs, preferably of a swivel type, for all desks and for at least two additional persons.

B2  Field Laboratory Furnishings

B2a  One sturdily built workbench situated along a side wall, with a work top not less than 3 m x 600 mm (10 feet x 24 inches), and with open space below for placement of a curing tank or other needed equipment.

B2b  One 300 mm (12 inches) deep service sink located near one end of the workbench and with a capacity of not less than 75 L (20 gallons). The sink shall be recessed into the workbench and have a water supply, faucet, and an outside drain.

B2c  An enclosed storage cabinet or closet with adequate space for the usual outdoor garments, standard supplies, and other miscellaneous equipment or apparatus that would ordinarily be stored for convenience or protection.

B2d  One desk or table with a suitable work top not less than 750 x 1500 mm (30 x 60 inches) located conveniently for clerical use and plans reviewing.

B2e  Two or more letter or legal size file drawers, either of the built-in or portable cabinet type, located for convenient access.

B2f  Two or more stools or chairs of suitable height to provide seating at both workbench and clerical desk.

B2g  At least 3600 mm (12 linear feet) of open shelving not less than 300 mm (12 inches) wide above the workbench or at other convenient locations.

B2h  One electric kitchen stove with four heating plates and electric oven. Separate heating plates may be substituted only with approval by the Engineer.

B2i  Blank

B2j  An electric exhaust fan or other approved mechanical means of achieving satisfactory air circulation and of exhausting air pollution.

C  Special Requirements

All units shall be leveled and supported at the site as necessary for satisfactory placement. Unless other means are provided for acceptable
weigh scale support, the field laboratory shall be rigidly supported to eliminate floor and workbench vibrations to an acceptable degree for accurate weighing on a bench-supported scale.

A curing tank shall be furnished by the Contractor for concrete test cylinder curing when the construction work involves casting of standard concrete test cylinders. The tank shall have adequate capacity and have dimensions that permit its installation below a laboratory workbench. The Engineer may authorize outside placement of the tank when it is to be used at the site of a field office.

The field office or laboratory shall also be equipped with the following special services, as indicated for the Type specified.

C1 Type A Service
Water supply of sufficient capacity to serve all needs for materials testing and test cylinder curing, as required for the work in progress. A storage tank with a capacity of 180 L (50 gallons) or more shall be furnished and installed at each field laboratory site where a pressurized water supply is not provided. The tank installation shall provide sufficient gravity pressure to maintain constant flow through the sink faucet.

C2 Type B Service
All Type A services, together with toilet and lavatory facilities, drinking water facilities, and trash disposal service. Detached portable toilets shall be conveniently located. A closed, faucet equipped, drinking water container or cooler with adequate supply of potable water shall be furnished when a potable pressure water system is not provided. Suitable trash containers shall be furnished and the accumulated trash shall be regularly removed from the premises. All of these facilities and services shall be provided to the satisfaction of the Engineer.

C3 Type C Service
All Type B services, together with electrical power supply and fixtures, including duplex outlet receptacles capable of providing adequate amperage for electric lighting and other appliance needs. An electrically powered mechanical sieving apparatus shall also be furnished for determining particle size distribution of fine aggregate (minus 4.75 mm (#4) sieve). The apparatus shall accommodate six full height 200 mm (4 inch) round sieves with pan and cover (which will be furnished by the Department). The apparatus shall be equipped with an automatic timing device of at least 15 minutes duration. The complete apparatus must be approved by the Materials Engineer, by verification of sieving sufficiency in accordance with AASHTO T-27, before its acceptance.
C4  Type D Service

All Type C services, together with a thermostatically controlled heating and cooling system capable of maintaining a uniform temperature between 22 and 29°C (72 and 85°F) in all zones. Separate systems may be provided.

C5  Type X Service

Type X Service shall apply only to field laboratory units, and then only in combination with one of the above described Types. When Type AX, BX, CX, or DX Service is specified, the Engineer shall have the right to utilize the prescribed laboratory unit as a combination office-laboratory facility for the full life of the Contract, including periods of work suspension and until the Certificate of Final Contract Acceptance has been executed according to 1516. Otherwise, the service requirements shall be as indicated for the first “letter” of the type designation.

2031.4 METHOD OF MEASUREMENT

The accepted field office and field laboratory units will be measured separately by the number and type furnished and utilized in accordance with the provisions of the Contract, regardless of the duration of its use at any one or different locations.

2031.5 BASIS OF PAYMENT

Payment for field office or field laboratory units of each type at the Contract bid price, or at any adjusted price provided for in the Contract, shall include full compensation for all costs of furnishing, placing, relocating, maintaining, and servicing the complete facility as required, including any removal and relocation costs incurred, but not including any costs incurred for public utility connections made necessary as the result of relocating the unit at the Engineer's direction, after its initial placement. Once the initial public utility connections have been made at the original site, any charges for utility connections will be at the Department's expense, unless the move is made by request of the Contractor. No extra compensation will be made for ordinary relocation expenses not involving public utility changes.

No payment will be made for field office or field laboratory units if the facility is not for the exclusive use of Department personnel for the contracted Project.

Payment for field office and laboratory facilities will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2031.501</td>
<td>Field Office, Type _________________</td>
<td>Each</td>
</tr>
<tr>
<td>2031.503</td>
<td>Field Laboratory, Type ______________</td>
<td>Each</td>
</tr>
</tbody>
</table>
2051

Maintenance and Restoration of Haul Roads

2051.1 DESCRIPTION

This work shall consist of the maintenance, repair, and restoration of designated haul roads over which materials of the kinds and for the purposes named are hauled for the work covered by the Contract.

2051.2 DEFINITIONS

For the purpose of this Specification, the term "designated haul road" means any public road or street officially designated as a "haul road" (except a Minnesota trunk highway or road which has been officially designated by the Commissioner as a detour around a construction Project), over which materials from any source, of the kinds and for the purposes listed below are hauled. The hauling may be to points within the geographic limits of the Project or to points outside those limits if use of the material outside such limits is required.

(a) Soil or other material for embankment construction.
(b) Sand, gravel, or other material for backfill.
(c) Sand, gravel, or crushed rock for base or surfacing courses.
(d) Aggregates for bituminous surfacing, including the hauling of bituminous mixtures from the mixing plant.
(e) Aggregates for concrete base or pavement, including the hauling of concrete batches from batch plants.
(f) Bituminous materials and Portland cement for paving mixtures.

2051.3 DESIGNATION AND USE OF HAUL ROADS

Where Maintenance and Restoration of Haul Roads is a bid item under the Contract, material of the kinds and for the purposes described above shall not be hauled from any source until the haul road from that source has been officially designated as a haul road. Thereafter, all materials hauled from that source shall be hauled over that road.

All vehicle trips, either loaded or unloaded, between material source(s) and the Project for the purpose of hauling materials described above shall be made only on a designated haul road.

If the Contract is with the Minnesota Department of Transportation for State Trunk Highway Projects, the Contractor shall select a haul road (or roads) to haul the materials previously described, and notify the Engineer as to the road (or roads) so selected. Within 15 calendar days after being notified of the haul road selection, the Commissioner will determine if the selected road (or roads) is an acceptable route. If the route is acceptable, the Commissioner will designate that road as a temporary trunk highway haul road.

If the Contract is with or for a governmental agency other than the Minnesota Department of Transportation, the Contractor shall select a haul road (or roads) to haul the materials, as previously described, and
notify the Engineer representing that governmental agency as to the road (or roads) so selected. Within 15 calendar days after being notified of the haul road selection, the Engineer will determine if the selected road (or roads) is an acceptable route. If the route is acceptable, the Engineer will approve that road as a designated haul road.

After a haul road has been officially designated, the Contractor may select a different road for official designation under the same conditions as previously stated. However, any changes made in haul road designation shall not relieve the Contractor of the obligation to restore the previously designated haul road if any of the above described materials were hauled over that road.

The Contractor will be required to reimburse the local government agency(s) for its haul road use on certain bituminous roadways as set forth below.

The Contractor shall verify spring load capacities of proposed haul roads with the local government agency(s). Reimbursement to local government agency(s) for concrete surfaced roadways is not required.

When a designated haul road has a bituminous surface and a spring load capacity of less than nine (9) tons, reimbursement to the local government agency(s) for haul road use shall be made at the rates as follows: $0.007/metric ton of material per kilometer ($0.01/ton of material hauled per mile).

The contractor shall make full payment to the local government agency(s) upon receiving notice of payment due and computations from the Engineer. The contractor shall provide the Engineer with confirmation of payment to the local agency(s). Should the amount due an individual local government agency be less than $500.00, no payment will be required.

2051.4 MAINTENANCE AND RESTORATION

While hauling operations are in progress, the Contractor shall maintain the haul road in a condition satisfactory to the Engineer. This work shall include application of water, bituminous material, or calcium chloride to the road surface as may be necessary to alleviate dust nuisance and eliminate traffic hazards.

When hauling operations over any haul road are completed, the Contractor shall either:
(a) Restore that haul road to a condition at least equal to that which existed at the time the hauling operations were started, or
(b) Compensate the local road authority in an amount satisfactory to that road authority and concurred in by the Engineer for the restoration of that haul road by the local authority.

The fact that other traffic has used the haul road concurrently with the hauling of the above described materials shall not relieve the Contractor of the obligation to maintain and restore the haul road as above provided, except that, if any other contractor (or contractors) engaged in highway construction under a contract with the same governmental agency also has materials of the kinds and for the purposes described above hauled over that road concurrently with the hauling of materials for the Contract work, the Engineer will determine the amount of maintenance and restoration obligation to be shared by each.

The Engineer's determination as to the kind and amount of maintenance and restoration work required to restore the haul road to a condition equal to that which existed at the time the hauling operations were started shall be final, binding, and conclusive.

When hauling over any designated haul road has been completed and the Contractor has restored that road or has compensated for that restoration as required, the Engineer will accept such restoration or concur in such financial settlement for the restoration of the haul road in writing, and such acceptance will relieve the Contractor of any additional obligation in connection with the restoration of that road.

2051.5 BASIS OF PAYMENT

Payment for the Item, Maintenance and Restoration of Haul Roads, at the Contract lump sum shall be considered compensation in full for all costs of maintenance, restoration and the reimbursement to local government agency(s) as specified for use of haul roads officially designated and used in conjunction with the Contract work.

No payment will be made under the these provisions unless one or more haul roads have been both officially designated and used for hauling materials of the kinds and for the purposes described. When these two conditions are met, payment will be made at the lump sum Contract price regardless of the amount of maintenance and restoration work required, provided work has been completed acceptably or receipt of payment for such restoration has been certified by the local road authority.
If the Contractor fails or refuses to perform haul road restoration or to make satisfactory financial settlement for such restoration as required within the period specified in a written notice by the Engineer, the Department will cause the restoration work to be done and deduct the costs from any moneys that are or may become due the Contractor or require reimbursement from the Contractor's Surety.

Payment for maintenance and restoration of haul roads will be made on the basis of the following schedule:

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<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>2051.501</td>
<td>Maintenance and Restoration of Haul Roads</td>
<td>Lump Sum</td>
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</tbody>
</table>
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2101.3

2101
Clearing and Grubbing

2101.1 DESCRIPTION
This work consists of removing and disposing of the trees, brush, stumps, roots, and other plant life, including dead and decayed matter, that exist within the construction area and that are not specifically designated to remain.

2101.2 BLANK

2101.3 CONSTRUCTION REQUIREMENTS
The Engineer will establish the Right of Way lines and construction limits within which the clearing and grubbing operations are to be confined. The Engineer will designate those trees, brush, and other vegetation that are to be preserved and those that are to be removed. The Contractor shall remove and dispose of the trees, brush, stumps, and roots from the limits designated for clearing and grubbing.

The Contractor shall salvage topsoil to the extent feasible in accordance with 2105.

The Contractor shall protect the items designated to remain in accordance with 1712 and 2572, place temporary fence, and conduct all clearing and grubbing operations in a manner that will not damage or jeopardize the surrounding plant life and property.

The Contractor shall prune low hanging, unsound, or unsightly branches from the trees and brush designated to remain. Pruning shall be performed in accordance with 2571.3.

A Clearing and Grubbing Operations
The Contractor shall cut off, remove, and dispose of the trees, brush, stumps, and roots from designated areas within the construction limits as a clearing and grubbing operation, for clearing operations, and for grubbing operations. The Contractor shall perform clearing and grubbing as required on the Project to construct the proposed improvements as planned, including the clearing and grubbing of designated areas outside those construction limits, either as indicated in the Plans or as designated by the Engineer in consideration of the following:

(1) Within the Right of Way, the Engineer will designate and require the removal of trees, brush, stumps, and aesthetically undesirable items that can be viewed from the traveled way.

(2) Within 5 m (15 feet) of the construction limits outside of structures, the Engineer will designate and require the removal of trees, stumps, roots, brush, and branches as necessary to protect and maintain the completed improvements.

B Clearing Operations
The Contractor shall cut off, remove, and dispose of trees and brush in the areas designated as a clearing operation. When grubbing is not
required, the point of cut off shall be within 150 mm (6 inches) of the ground.

C  Grubbing Operations

The Contractor shall remove and dispose of the brush, stumps, roots, and other remains in the designated areas as a grubbing operation. Stumps shall be removed completely unless permitted to remain. If stumps are permitted to remain, they shall be cut off not more than 150 mm (6 inches) above ground, and flush with or below ground surface if so directed.

The Contractor shall fill all depressions resulting from the grubbing operations with suitable material and compact the material to the satisfaction of the Engineer, except in those areas to be excavated as part of the Contract work.

D  Disposal Limitations

The Contractor shall dispose of trees, brush, stumps, roots, and other debris or byproducts by chipping, marketing, burning, or burying. The Contractor:

1. May chip the wood through a chipping machine and use or dispose of the chips to the satisfaction of the Engineer.
2. Shall use unchipped marketable trees or make them available to wood-using industries and individuals.
3. Shall comply with the disposal requirements for pine, elm, and oak wilt infected red oak trees.
4. Shall conduct burning according to 2104.3, Minnesota Rules Chapter 7009 and any applicable local ordinances. At no time shall waste tires, rubber or plastics or similar materials be used to ignite these wastes.
5. Shall conduct burying operations according to 2104.3, Minnesota Rules Chapter 7035 and any applicable local ordinances. The Contractor must first receive approval from the Engineer to bury vegetation material.

D1  Marketable Trees

The Contractor shall make marketable trees, which are designated for removal, available to wood-using industries or individuals. Marketable trees are all trees, except elm and oak wilt infected red oak trees, that have a diameter of 150 mm (6 inches) or more measured at a point 600 mm (24 inches) above the ground surface. The Contractor:

a. Shall not burn or waste marketable trees without having written proof from three potential wood-using industries or individuals that the wood is not wanted. This requirement only applies when the volume of marketable trees on the Project exceeds 75 m³ (100 cubic yards).

b. Shall not dispose of marketable material remaining after harvesting by wood-using industries or individuals, without having written
proof of first offered them to the public for use as firewood in accordance with the intent of Minnesota Statute 116F.30.
(c) Is not required to make non-marketable trees available to wood-using industries or individuals.
(d) Is not required to cut trees in lengths of less than 2.5 m (6 feet).
D2  Elm and Oak Wilt Infected Red Oak Trees
D2a  Elm Trees
   The Contractor shall dispose of all elm trees, brush, stumps, roots, and debris, together with the bark and byproducts with adhering bark of elm tree origin according to Minnesota Rules 1505.0230, 1505.0240, and 1505.0250 and local ordinances.
D2b  Oak Wilt Infected Red Oak Trees
   The Contractor shall dispose of all stumps, roots and debris from all oak wilt infected oak trees of the red oak and white oak families consistent with Minnesota Rules 1505.0320 and 1505.0340 and local ordinances.
D2c  Disposal Deadlines and Locations
   The Contractor shall dispose of elm and oak wilt infected red oak trees:
   (1) Within 20 calendar days of notification or of clearing and grubbing, whichever comes first, when the cutting operations are performed between April 1 and September 15.
   (2) By April 1 when cutting operations are performed between September 15 and March 31.
   (3) Within the Right of Way by burning, burying, or chipping, when allowed.
   (4) Off the Right of Way provided the trees, with intact bark, are processed within the time limitations.
D3  Pine
   The Contractor shall dispose of all non-marketable pine trees, brush, stumps, roots, and debris by chipping, debarking, burning, burying, or covering with an air tight tarp within 20 calendar days of being cleared during the growing season.
D4  Blank
D5  Burning.............................................................. 2104.3
D6  Burying............................................................. 2104.3
   The Contractor must obtain the Engineer's approval before burying vegetation material.
E    Temporary Fencing................................. 2572
2101.4 METHOD OF MEASUREMENT

The Department will measure clearing and grubbing by area, lump sum, or individual unit basis as indicated in the Contract. Diameter will be determined by dividing the measured circumference by 3.14.

A Qualifying Trees and Stumps

The Engineer will only measure trees for payment that have a diameter of more than 100 mm (4 inches) at a point 600 mm (24 inches) above the ground surface.

The Engineer will only measure stumps for payment that have a diameter of more than 100 mm (4 inches) at:

(a) A point 600 mm (2 feet) above the ground surface when the tree was cleared under the same Contract, or

(b) The point of cutoff when the tree was not cleared under the same Contract.

No measurement will be made for the removal and disposal of brush nor of stumps having a diameter of 100 mm (4 inches) or less at the point of cutoff.

B Area Basis

When the hectare is the unit, quantities will be determined by measuring (to the nearest 0.02 ha (0.05 acre)) all areas cleared and all areas grubbed, within the limits shown in the Plans or staked by the Engineer. All measurements will be made horizontally to points 3 m (10 feet) outside the trunks of qualifying trees or stumps on the perimeter of the area being measured. Separate areas smaller than 0.02 ha (0.05 acre) will be considered to be 0.02 ha (0.05 acre).

Whenever isolated trees or stumps are to be removed outside the areas designated to be cleared or grubbed by the hectare, and no unit price is provided in the Contract for clearing and grubbing individual trees or stumps, payment will be made on the following basis:

(1) Each isolated qualifying tree measuring less than 1 m (40 inches) in diameter at a point 600 mm (2 feet) above the ground surface, and each isolated qualifying stump measuring less than 1 m at the point of cutoff, will be considered as being 0.04 ha (0.1 acre).

(2) Each isolated tree or stump measuring 1 m (40 inches) or more in diameter, at the points described above, will be considered as being 0.08 ha (0.2 acre).

C Individual Unit Basis

When the tree is the unit, quantities will be determined by counting the number of qualifying trees cleared and the number of qualifying stumps grubbed.

D Lump Sum Basis

No measurement will be made of an individual area, tree, or stump when clearing and grubbing is a lump sum item.
2101.5 BASIS OF PAYMENT

Payment for the accepted quantities of clearing and grubbing at the Contract prices per unit of measure will be full compensation for all removal and disposal costs, including the costs of securing outside disposal sites as needed and of carrying out the specified treatment in disposing of elmwood, oak wilt infected red oaks, pine, and marketable trees.

Payment of the lump sum item for clearing and grubbing, regardless of the size of the trees and stumps, will be compensation in full for all costs of clearing and grubbing required.

The Contractor shall remove and dispose of brush and stumps having a diameter of 100 mm \textbf{(4 inches)} or less at the point of cutoff as an incidental item to the Contract.

The Contractor will not receive compensation for pruning except as allowed in 2572.5.

When the Proposal does not contain a pay item for clearing and grubbing, the Contractor will receive compensation as Extra Work for clearing and grubbing of qualifying trees and stumps, as described in 2101.4, required for construction of the Project. The Department will not make payment for clearing and grubbing non-qualifying trees and stumps.

Payment will be as follows:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
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<td>2101.501</td>
<td>Clearing</td>
<td>hectare (acre)</td>
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<tr>
<td>2101.502</td>
<td>Clearing</td>
<td>tree</td>
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<tr>
<td>2101.506</td>
<td>Grubbing</td>
<td>hectare (acre)</td>
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<tr>
<td>2101.507</td>
<td>Grubbing</td>
<td>tree</td>
</tr>
<tr>
<td>2101.511</td>
<td>Clearing and Grubbing</td>
<td>lump sum</td>
</tr>
</tbody>
</table>

2102 Pavement Marking Removal

2102.1 DESCRIPTION

This work shall consist of the removal of pavement markings that conflict with revised traffic patterns. The markings will usually be in the form of 100 mm \textbf{(4 inches)} wide widths, in solid line or skip line lengths, but may include other patterns or widths and the type will be as (one) of the following:

A) Pavement Marking Removal: this work shall consist of the removal of non-durable pavement markings such as paint type markings.
2102.1

B) **Pavement Marking Removal - Temporary**: this work shall consist of the removal of Temporary Reflectorized Pavement Marking Tape or Removable Preformed Plastic Pavement Markings.

C) **Pavement Marking Removal - Permanent**: this work shall consist of the removal of durable pavement markings.

2102.2 BLANK

2102.3 **REMOVAL REQUIREMENTS**

Before effecting a change in traffic pattern, the Contractor shall remove all conflicting pavement markings approved by the Engineer, using methods and equipment that will not significantly damage the pavement structure or surface texture. Should the removal operations result in significant damage, as determined by the Engineer, the Contractor shall repair the damaged areas as the Engineer directs at no expense to the Department.

Whatever methods of removal are employed, the Contractor shall control or restrict operations to avoid exposing traffic to hazardous or detrimental conditions. Any expended materials or agents used in the removal process shall not be allowed to accumulate on the pavement surface but shall be promptly removed by suction or other approved methods as the work progresses.

Linear paint markings shall be removed so as not to leave a distinguishing pattern of removal. Where unsatisfactory results are achieved, the Contractor shall obliterate any deceptive lines remaining by applying a color-matched paint or asphalt sealer that will blend with the surface texture satisfactorily.

2102.4 **METHOD OF MEASUREMENT**

Pavement marking removal will be measured by either area or length of the original markings as acceptably removed. Unless otherwise provided, markings of all types will be included for payment under a single Contract item.

Removal areas will be computed on the basis of nominal widths and actual lengths as originally applied and still evidenced at the time of removal. Other irregular shaped markings will be measured as enclosed within rectangular boundaries of least dimension as determined by the Engineer.

Removal length will be computed by the actual length of each pavement marking removed and will not include the gap between the broken lines.

2102.5 **BASIS OF PAYMENT**

Payment for pavement marking removal at the Contract price per unit of measure will be compensation in full for all costs of obliterating the markings as specified and for all costs of restoring the original pavement texture as needed.
2103.3

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2102.501</td>
<td>Pavement Marking Removal</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2102.501</td>
<td>Pavement Marking Removal – Temporary</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2102.501</td>
<td>Pavement Marking Removal – Permanent</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2102.502</td>
<td>Pavement Marking Removal</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2102.502</td>
<td>Pavement Marking Removal – Temporary</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2102.502</td>
<td>Pavement Marking Removal – Permanent</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>

2103

Building Removal

2103.1 DESCRIPTION
This work consists of removing from the Right of Way those buildings that have been vacated and are not considered to have salvage value as buildings.

This work includes sewer and water service disconnections.

This work does not include the removal of sidewalks, driveways, or miscellaneous structures unless so indicated in the Contract.

2103.2 BLANK

2103.3 REMOVAL REQUIREMENTS

A General

The Contractor shall do all work in accordance with the applicable laws and ordinances.

The Contract will list the buildings to be removed, show the approximate location of each building by the street address or by reference to a survey station, and give a general description of the building. Building removal shall also include the listed miscellaneous removals from the locations indicated in the Contract.

In doing building removal work, the Contractor may remove any buildings (including all fixtures except those owned by public or private utilities) by demolition before removal from the Right of Way or remove any buildings from the Right of Way without demolition.

If the Contractor elects to move any building to another location, the Contractor shall obtain all necessary permits including those required by the Department.
2103.3

The Department assumes no responsibility for the condition of any buildings at any time, and no guarantee is made or implied that any building will remain in the condition the bidder finds it at the time of examination before preparing the Proposal.

B  Removal

The Contractor shall entirely remove all buildings and structures, including steps, basement walls, floor slabs, and footings from the Right of Way. Where the building rests on a concrete surface slab, the Contractor shall remove the entire slab and related footings.

C  Utilities ........................................................................ 1507

C1  Disconnection of Sewer and Water Services

The Contractor shall locate, expose, cut off, and plug all sewer and water service connections at the sewer and water mains. The Contractor shall, at no additional compensation, plug all sewers leading from the building using watertight plugs.

The Contractor shall abandon wells in accordance with 2104.

C2  Other Utilities

The utility owners are responsible for disconnecting telephone, electric power, and other wire services, and gas service pipes outside the buildings, and removing fixtures belonging to such utility companies; however, the Contractor's attention is directed to 1507.

D  Disposal of Materials and Debris

All materials removed, other than utility owned fixtures, and all debris resulting from the removal operations, shall become the property of the Contractor and the Contractor shall dispose of them in accordance with 2104.3C.

E  Filling Basements

If the building was removed under a separate Contract, the Contractor shall fill all basements and other excavations made, as specified in the Contract. The Contractor shall fill the excavation to the level of the existing ground surface using sand, gravel, clay, loam, or other inorganic soil. The Contractor shall furnish the fill material from sources outside the Right of Way, subject to 1405. The Engineer will not require mechanical compaction of the fill material.

If the building removal is included in the same Contract as the grading, the Contractor shall remove the foundations according to 2103.3B and fill basements according to 2105.3G.

2103.4 METHOD OF MEASUREMENT

A  Building Removal

The Department will measure all buildings listed for removal as a single lump sum.
B  Basement Fill
When the Contractor is required to furnish the material for filling basements, and only then, the Engineer will measure basement fill as the volume of the air space within the basements, below the ground surface.

C  Disconnection of Sewer and Water Services
The Department will measure each sewer and water service connection cut off and plugged at the main.

2103.5  BASIS OF PAYMENT
The Department will pay for the building removal item at the Contract lump sum as compensation for all costs of the work described above, except filling basements when the Contractor is required to furnish the fill material and for sewer and water disconnections.

The Department will pay for disconnect of sewer and water services at the main at the Contract unit price for each disconnection. This payment will be compensation in full for all costs involved, including restoration of street and property surfaces.

The Department will pay for building removal by the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2103.501</td>
<td>Building Removal</td>
<td>lump sum</td>
</tr>
<tr>
<td>2103.505</td>
<td>Disconnect Sewer Service</td>
<td>each</td>
</tr>
<tr>
<td>2103.507</td>
<td>Disconnect Water Service</td>
<td>each</td>
</tr>
<tr>
<td>2103.511</td>
<td>Basement Fill</td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>

2104  Removing Pavement and Miscellaneous Structures

2104.1  DESCRIPTION
This work shall consist of the removal, in part or wholly, and satisfactory disposal of pavement, sewers, culverts, guardrails, abandoned structures, and other obstructions existing on the Right of Way, but not including bridges, covered under 2442, and buildings. The work shall include salvaging designated materials and backfilling the resulting trenches, holes, and depressions.

2104.2  BLANK

2104.3  CONSTRUCTION REQUIREMENTS

A  General
Those structures and facilities that are to remain in place will be indicated in the Contract or designated by the Engineer.

The Engineer may determine that the existence of a structure or an obstruction does not interfere with, endanger, or detract from the new construction in any way, and therefore, may remain in place.

The Contractor shall remove and dispose of all structures and obstructions specifically included for payment in the Contract, except
those that are specified to be removed by others or that are permitted to remain by the Engineer.

In an excavation area, excavation includes removal of all obstructions unless the obstruction is specifically identified for removal in the Contract as a separate pay item. If obstructions are encountered in the excavation operations that require removal, and that require equipment and handling substantially different from that employed in the excavation operation, the Engineer may pay for the removal as Extra Work.

**B Removal Operations**

All removal operations that may endanger new construction shall be completed prior to construction of the affected work. All materials that have been designated for salvage shall be removed in a manner that will not result in unwarranted damage. The salvaged material shall be dismantled into section or assembly units as required to facilitate removing in undamaged condition and permit convenient handling. Pipe materials shall be completely emptied of infiltrated material prior to being stockpiled.

**B1 Remaining Portion of Structure**

Where a portion of an existing structure is to be retained for use, that portion shall not be damaged during the removal operations. Where a portion of a reinforced concrete structure is to be removed and the structure extended, existing reinforcement bars shall be left in place for a distance of not less than 40 diameters from the face of the cut, to provide bond between the old and new concrete. Where a concrete box culvert is to be extended, the old structure shall be removed to the extent shown in the Plans.

**B2 Pavements and Sidewalks**

In removing pavements, sidewalks, and similar structures, where the cut will be exposed in the finished work, the structure shall be sawed along the removal line(s) with a concrete saw, unless the removal is made to an existing joint. The use of wedges driven into the saw cut to break off the portion to be removed will not be permitted. Elsewhere, the structure shall be cut and chipped to true lines and vertical faces.

The Contractor shall saw the existing concrete or bituminous pavement at the location(s) shown in the Plans and as staked by the Engineer for the purpose of establishing a neat line from which to extend the new work.

**B2a Sawing Concrete Pavement**

The Contractor shall saw concrete pavement along the removal line(s) to the depth indicated in the Plans, the pertinent Specification, or, in the absence thereof, to a depth 30 percent of the thickness of the concrete prior to breaking off the pavement.
B2b  Sawing Bituminous Pavement

When sawing is specified, the Contractor shall saw bituminous pavement along the removal line(s) to a minimum depth of 75 mm (3 inches) prior to breaking off the pavement. When sawing is not specified, the Contractor may use other methods of removal that will produce a neat line acceptable to the Engineer.

B3  Integrant Curb

The Contractor shall remove integrant curb by controlled blasting, utilizing detonating cord of sufficient core load and so placed that the explosive force will effectively remove the curb to within 15 mm (0.5 inches) of the designated break line conforming to the normal pavement surface. Any projections extending more than 15 mm (0.5 inches) above the designated break line after blasting shall be removed by chipping with pneumatic hammers or by other approved methods. Overbreakage shall be held to a practical minimum by careful control of the blasting force. If any unacceptable overbreakage occurs, repairs shall be made as directed by the Engineer, using suitable patching mixture properly placed to restore the surface acceptably. Unless otherwise approved, the patching material shall be a suitable Portland cement concrete or mortar mix. All loose material shall be removed from the areas to be patched and an approved bonding agent shall be applied to the depression surfaces prior to placing the patching mixture.

After each blasting operation, the Contractor shall clean the traveled portions of the roadway of all debris before allowing resumption of traffic. All shoulder depressions resulting from the Contractor's operations shall be backfilled to the Engineer's satisfaction, prior to suspension of each day's operations.

All concrete removal debris shall be disposed of outside the Right of Way in accordance with this Specification.

B4  Blank

B5  Concrete and Masonry Structures

Within municipalities the Contractor shall entirely remove concrete and masonry structures located within the roadbed. Elsewhere, concrete and masonry structures located within the roadbed shall, unless they are specified to be removed entirely, be removed to an elevation at least 1200 mm (4 feet) below the surface of the subgrade. Concrete and masonry structures located outside the roadbed shall be removed to an elevation not less than 600 mm (2 feet) below the final ground surface.

The Contractor shall remove septic tanks, cisterns, and cesspools to the extent required above and in accordance with Minnesota Department of Health regulations.

The Contractor shall rebuild and reconnect live sewers when related manholes, catch basins, and drop inlets are removed. The Contractor
shall provide a by-pass and maintain the service during the operations, to the satisfaction of the Engineer.

The upgrade ends of all drainage or sewer pipes leading from abandoned basements, manholes, or similar structures shall be plugged with concrete or masonry.

Before filling abandoned basements, manholes, cesspools, septic tanks, cisterns, and similar structures that are not completely removed, the Contractor shall make holes in the bottom to prevent the entrapment of water.

B6 Timber Structures and Underground Tanks
The Contractor shall completely remove all timber structures and all underground tanks in accordance with applicable regulations.

B6a Underground Petroleum Tank
Contractors removing underground petroleum tanks and all related liquids and sludge residues must have MPCA certification.

The Contractor shall:
1. Give written notification to the Engineer at least 15 days prior to removal of the underground tank,
2. Obtain any required permits,
3. Have a MPCA Certified Supervisor on site during tank removal,
4. Drain all connecting pipes,
5. Close all connections except vents,
6. Remove all fluids, sludge residue, and explosive vapors from the tank,
7. Dispose of tanks in accordance with applicable Motor Carrier Safety and Hazardous Materials Transport requirements. During transport, all tanks shall be secured so that no material leaks from the tank onto the vehicle or onto the road, and
8. Give written certification to the Engineer within 30 days after removal of the tank that the tank, liquids, and residue have received proper disposal.

B7 Wells and Holes
All wells, well shafts, elevator shafts, environmental bore holes, and the like that are to be abandoned shall be filled and sealed by a Contractor licensed by the Minnesota Department of Health in accordance with the "Water Well Construction Code," Chapter 4725. Until permanently abandoned in accordance with the Code, wells, shafts, etc., shall be sealed or otherwise protected as necessary during the work to prevent any surface drainage from entering the opening. After abandonment and sealing has been completed, wells, shafts, etc., shall be removed to the elevations specified on the Plans or as designated by the Engineer. A copy of the completed Well Sealing Certificate shall be filed with the Department's Central Office Property Management Supervisor.
B8 Miscellaneous Items

When removing railroad tracks, the Contractor shall remove all rails, ties, paving, crossings, track encasements, and other appurtenances.

When removing guardrail and fences that are to be salvaged, the Contractor shall neatly coil the wire and cable, pull posts from the ground, and remove nails and staples from posts and boards.

C Disposal of Materials and Debris

The Contractor shall provide the Engineer with information and documentation substantiating proper disposal arrangements and operations. The Contractor's attention is directed to burying regulations, including Minnesota Rules 7035.2825. If waste materials or debris have been or are being disposed of improperly, the Engineer may order the Contractor to take corrective action. The Engineer may withhold payments until compliance is ensured.

The Contractor shall dispose of trees, brush, stumps, roots, and related vegetation according to 2101.3 and these requirements.

C1 Disposal of Salvageable Materials

The Contractor shall stockpile materials designated for salvage by the Department on the Right of Way at locations approved by the Engineer upon being removed, dismantled, and cleaned as required.

The Contractor shall dispose of materials not designated for salvage by the Department and all debris resulting from the removal and demolition operations as provided for in these requirements and in specific regulations imposed by laws, ordinances, orders, and decrees.

Materials of marketable value that are removed in accordance with these provisions, but that are not to be possessed by the Department, shall become the property of the Contractor and shall be removed from the Right of Way.

C2 Disposal Within Right of Way

The Contractor may dispose of noncombustible materials and debris other than metallic substances in the roadway embankments in accordance with 2105 for rock placement or by burying them under a minimum covering of 600 mm (2 feet) of earth material at locations approved by the Engineer.

The Contractor may burn combustible materials and debris within the Right of Way, provided the required burning permits are obtained. The Contractor shall conduct burning operations under the constant care of a competent caretaker and in accordance with all applicable regulations.

The Contractor may bury metallic materials and combustible materials or remains within the Right of Way at locations approved by the Engineer outside the roadbed, but not within the limits of a
2104.3

municipality. Before burying, the bulk must be reduced to a practicable minimum prior to being covered with earth.

C3 Disposal Outside Right of Way

The Contractor shall dispose of all materials and debris outside the Right of Way when so designated in the Contract. The Contractor shall also dispose of all materials and debris, resulting from removal or demolition operations, which have no specific disposal provisions, at locations outside the Right of Way. The Contractor shall dispose of the materials and debris in a manner that will not create a public nuisance nor result in unsightly conditions within view of a public road, recreational area, residential district, or other place of public concern.

The Contractor shall arrange for and secure suitable disposal sites for materials and debris to be removed from the Project for disposal outside the Right of Way. The Contractor shall assume full responsibility for acceptable disposition of the material as well as for damages resulting from the disposal operations.

The Engineer will not give final acceptance of the work:
(a) Unless disposal is made at a publicly controlled dumping site or some other established facility where the Engineer is satisfied that the material will be properly disposed of by and at no additional expense to the Department.
(b) Until the disposal areas are in acceptable condition with respect to the Contractor's obligations.

D Backfilling Depressions

If the remains of partially removed structures prevent natural filtration of water, the Contractor shall make perforations in the structure bottoms prior to placing the backfill to prevent entrapment of water.

All depressions and air spaces within partially removed structures shall be backfilled with suitable material in accordance with 2105.

2104.4 METHOD OF MEASUREMENT

No measurement will be made of any removals that are not required nor of any removals that are specifically designated as being covered by other Contract items.

Removal and salvage items will be measured separately by type of structure as identified in the item name. Measurements will be separated by size and kind of material only to the extent stated in the item Name.

A Area

Pavements, sidewalks, surfacing, and other uniform thickness items will be measured by area, without specifying thickness.

Pavement removal will be classified by kind of paving material whenever the material is comprised entirely of Portland cement concrete (remove concrete pavement) or entirely of bituminous-aggregate
mixtures (remove bituminous pavement). Otherwise, when the pavement is comprised of a combination of different paving materials such as a concrete base or pavement overlaid with bituminous surfacing, removal of the entire structure will be accomplished under the unclassified item of "remove pavement." Regardless of classification, pavement removal shall include the removal of any integrant curb removed in conjunction therewith.

Removal of pavement in connection with the excavation of trenches for installation of drainage structures or utility items will be measured separately from other pavement removals, under the item of remove trench pavement, which shall include the removal of all paving courses including unclassified materials.

Removal of surfacing will be limited to the stripping of a wearing course overlaid on a concrete base preparatory to placement of a new wearing course thereon. This item will be classified by kind of material, such as: remove bituminous surfacing, remove brick surfacing, etc. Removal shall include any granular cushion course existing on top of the concrete base, if so required.

B Length

Length measurements will be made along the longitudinal centerline of the structure, parallel to the base or foundation upon which the structure is placed, and from end to end of the structure as removed. Pipe measurements will be made from center to center of junction fittings, catch basins, or manholes, and will include the length of any aprons required to be removed in conjunction therewith.

Sawing of concrete and bituminous pavements will be measured by length along the saw cut line(s) as staked by the Engineer when these pay items appear in the Proposal.

C Volume

In the case of concrete or masonry structures, volume will be determined from measurements taken on the in place structure as it is being uncovered and removed except where the structure dimensions or volumes are otherwise established.

D Number (Complete Unit)

All items designated for payment on a per each basis will be measured separately by the number of individual units removed, salvaged, or abandoned, including all appurtenances.

2104.5 BASIS OF PAYMENT

Payment for the accepted quantities of remove, salvage, or abandon items at the Contract price per unit of measure will be compensation in full for all costs of removing the material or specified portions thereof, for disposing of the materials removed and the salvaging of parts thereof as may be specified, for the backfilling of depressions and other restoration work required, and for well abandonment procedures and the
performance of all other work of a special nature that may be specified or imposed by laws, ordinances, and regulations.

Payment for sawing will only be made for acceptable sawing of concrete and bituminous pavements when these pay items appear in the Proposal. All other sawing will be considered as incidental work to the Contract item.

Unless the Proposal includes an item for fence removal, the removal of abandoned fences shall be done at no expense to the Department, without any direct compensation being made therefor.

No direct compensation will be made for removing bituminous curbing, bituminous pavements less than 150 mm (6 inches) in thickness, and other minor encumbrances encountered within the limits of the roadway excavation that are not to be salvaged and that can be excavated and disposed of in the embankment or elsewhere without separate handling or the use of special equipment.

No direct compensation will be made for removing open metal flumes, metal curbs and gutters, and other similar metal items unless such materials are required to be salvaged.

In the case of salvage items, only those item units that are removed in acceptable condition will be measured for payment under the salvage items. Where removal is necessary, unacceptable units that are either damaged or deteriorated will be measured for payment under appropriate removal items or as Extra Work items in absence thereof. Otherwise, materials having insufficient salvage value shall be left in place where possible, without incurring removal expense.

If any materials designated for salvage are damaged due to negligence by the Contractor, the Department will deduct from any moneys due or becoming due the Contractor an amount equal to 60 percent of the current delivered price of new material of the same type and size as that damaged and equal to the quantity of material so damaged. The damaged material shall then become the property of the Contractor.

Removing the ends of old box culverts preparatory to extending the structure will be paid for by the cubic meter (cubic yard) of removal or by each unit.

Backfilling depressions resulting from the removal of structures will be considered to be embankment construction, and no extra compensation will be made.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2104.501</td>
<td>Remove (1).......................... meter (linear foot)</td>
<td></td>
</tr>
<tr>
<td>2104.503</td>
<td>Remove (1).......................... square meter (square foot)</td>
<td></td>
</tr>
<tr>
<td>2104.505</td>
<td>Remove (1).......................... (square yard)</td>
<td></td>
</tr>
</tbody>
</table>
2105.2

2104.507 Remove (1) ........................................... cubic meter (cubic yard)
2104.509 Remove (1) .......................................................... each
2104.511 Sawing Concrete Pavement ....................... meter (linear foot)
2104.513 Sawing Bituminous Pavement................. meter (linear foot)
2104.521 Salvage (1) ........................................... meter (linear foot)
2104.523 Salvage (1) .................................................. each
2104.525 Abandon (1) ............................................................ each

NOTE: (1) Specify item name, such as: culvert pipe, sewer pipe, drain pipe, curb and gutter, curb, sidewalk, fence, concrete or masonry structures, railway track, manholes or catch basins, integrant curb, concrete pavement, bituminous pavement, pavement, trench pavement, guardrail, water well, etc.

2105 Excavation and Embankment

2105.1 DESCRIPTION
This work shall consist of constructing roadway excavations and embankments within the Right of Way and easements, including any grading that may be specified on roadside areas.

2105.2 MATERIALS

A Excavation Material
Classification of excavated materials on each section of the Project will be made by the Engineer as the work progresses. The excavations will be classified for payment in accordance with the following provisions:
A1 Common Excavation
Common excavation shall consist of all excavation materials not classified herein as rock excavation, muck excavation, common channel excavation, or rock channel excavation, and shall include the excavations classified as subgrade excavation when a separate item therefor is not included in the Proposal.
A2 Rock Excavation
Rock excavation shall consist of all materials that cannot, in the Engineer's opinion, be excavated without drilling and blasting or without the use of rippers, together with all boulders and other detached rock each having a volume of 1 m (1 cubic yard) or more, but exclusive of those quantities that are to be paid for separately under the item of rock channel excavation.
A3 Muck Excavation
Muck excavation shall consist of all saturated and unsaturated mixtures of soil and organic matter not suitable for foundation material regardless of moisture content, that is removed from below the natural ground level of marshes, swamps, and bogs over which embankments are to be constructed, where the excavation is required:
(a) To provide a stable foundation for embankments, or
(b) To accelerate the subsidence of unstable material under embankment load.

A4 Subgrade Excavation
Subgrade excavation shall consist of all excavations made below the top of the final graded surface of the road and between the shoulder slopes that are not made for the purpose of obtaining topsoil and where the excavation materials are not classified for payment as rock excavation or muck excavation.

A5 Common Channel Excavation
Common channel excavation shall consist of the excavation of channel changes outside the limits of the normal roadway excavation and embankment, together with the excavation of waterways leading to and from culverts but outside the roadway section, and includes the excavation of all materials encountered except for that which is to be classified for payment as rock channel excavation.

A6 Rock Channel Excavation
Rock channel excavation shall consist of the same material as previously described for rock excavation, but includes only the material that is excavated in areas outside the normal roadway grading section as defined for common channel excavation.

A7 Unclassified Excavation
Unclassified excavation does not include excavation that would be classified as muck excavation, common channel excavation, or rock channel excavation, but includes all other excavations, regardless of character or classification of material, that are not included for payment under separate items.

B Borrow Material
Borrow material is material required for embankment construction or other specified purposes that is not available or is not to be obtained from the roadway excavations defined in 2105.2A. Unless otherwise provided in the Contract, borrow material shall be furnished by the Contractor from sources selected by the Contractor outside the Right of Way, subject to 1405 and 1602.

Borrow material will be classified in accordance with the material requirements given below. All borrow material furnished from sources selected by the Contractor must be approved by the Engineer prior to being delivered to the Project. The Contractor shall give the Engineer sufficient notice to permit any testing of the material that may be required for approval.

When measurement of borrow material is to be made at the source by cross-section methods, the Contractor shall allow sufficient time, and arrange the operations, so as to leave the excavated areas in a condition
that will permit the taking of original and final cross-sections as necessary for accurate determination of quantities.

Borrow material shall be furnished and placed only to the extent that the required materials are not obtainable from the excavations within the Right of Way.

If the Contractor places more borrow material than is required or ordered by the Engineer, and thereby causes materials excavated from within the Right of Way to be wasted, the quantity wasted will be deducted from the borrow material measurements.

If materials are encountered within the planned roadway excavation limits which are excess materials and which meet all specified requirements for a Plan designated borrow item, the Contractor may, at his/her option, utilize those materials in that portion of the roadway where said borrow item was designated. This does not apply to topsoil items.

If the Contractor elects to use such excess material as a borrow item, payment will be made at the respective Contract unit prices for both the excavation of the material and the item for which the excavated material is used. If the particular borrow item is not established in the Plan as a (P) Plan Quantity measurement, the Contractor shall perform its operations in cooperation with and as directed by the Engineer to provide for measurement of the material by the Department.

Whether the Contractor chooses to provide borrow from outside the excavation limits or as outlined above, any resultant excess material shall be disposed of outside the Right of Way at no additional cost to the State.

B1 Granular Borrow ........................................................... 3149

Material meeting the requirements for select granular borrow shall be furnished if so specified.

B2 Common Borrow

Common borrow shall consist of materials approved by the Engineer for use in the embankment construction or other specified purposes as the Engineer considers suitable.

B3 Topsoil Borrow ............................................................ 3877

Material meeting the requirements for select topsoil borrow shall be furnished if so specified.

C Salvage Material

Salvage material shall consist of material available on the Project, such as native topsoil or aggregates in existing pavement and base courses, which is to be reserved for a specific use, either in the work under Contract or in future construction. Salvage of these materials will be required only when the Proposal contains separate and specific items therefor.
The material to be salvaged shall be stockpiled for future use or utilized in the new construction as indicated in the Plans. All salvage material used in the new construction shall be placed in accordance with the Specification requirements for the class of work in which it is used. Salvage operations shall be in accordance with the following provisions.

C1 Salvaged Aggregate
Salvaged aggregate shall include all existing sand, gravel, or crushed rock materials that can be salvaged and utilized without pulverization.

C2 Salvaged Topsoil
Salvaged topsoil for general use as a growth medium shall be obtained from the soil horizons normally designated as "A" or "B", or shall be obtained from alluvial deposits.

As part of the salvaging operations, all debris and any stones exceeding 75 mm (3 inches) in greatest dimension shall be removed prior to stockpiling.

D Stabilizing Aggregate ................................................. 3149

2105.3 CONSTRUCTION REQUIREMENTS

A General
The Contractor shall complete all clearing and grubbing operations in an area according to 2101 prior to excavation and embankment operations. During winter construction, the Contractor shall remove all ice and snow from an area just prior to excavation or embankment construction operations.

The Contractor shall not begin excavation operations on any area until the necessary cross-sections have been taken and the necessary construction stakes and grades have been established to the satisfaction of the Engineer. No excavating shall be performed beyond the elevations, slopes, and limits established, without approval of the Engineer.

The Contractor shall schedule and conduct erosion control operations according to 1717.2.

The Contractor shall maintain all excavations and embankments in a well drained condition at all times. The Contractor shall install planned drainage facilities concurrently with the embankment construction, temporarily crown grades to minimize infiltration, and install temporary drainage facilities as directed by the Engineer. No material shall be stockpiled in a manner that will restrict surface drainage.

If the Contractor interrupts existing surface drainage, sewers, or subsurface drainage, the Contractor shall, at no expense to the Department, provide and maintain temporary drainage facilities as approved by the Engineer until permanent facilities are completed and operative.
B  Preparation of Embankment Foundation

Before placing embankment on an existing slope steeper than 1 vertical to 4 horizontal, the Contractor shall either:
(a) Flatten the existing slope to the extent that it will not be steeper than 1 vertical to 4 horizontal; or
(b) Construct steps in the slope, with the back surface being as nearly vertical as practicable and with the horizontal cuts being made as close together as the slope permits, but with no step being less than 300 mm (12 inches) in width. All work required by these provisions is incidental work for which no direct compensation will be made.

Before placing any embankment 1 m (3 feet) or less in height, all soil that the Engineer considers unsuitable for use in the upper 1 m (3 feet) of the roadbed shall be removed from the area between the shoulder lines and disposed of as hereinafter provided.

Where embankment is to be constructed over swamp or marsh areas or at other locations where the foundation material is unstable, the foundation shall be excavated to remove unstable material as indicated in the Plans or as directed by the Engineer. Where non-granular soils are to be used for excavation backfill and embankments, the foundation area shall be free of standing water. No direct compensation will be made for removing such water from the excavation.

Wherever practicable, the foundations for all embankments shall be compacted between the shoulder lines by a tamping roller. Four passes shall be made on each strip the width of the roller. Other rollers may be used with permission of the Engineer. No direct compensation will be made for compacting the embankment foundations.

Before placing embankment over an old road, the Contractor shall remove any surfacing that is specified to be salvaged and excavate the old road core to an elevation 300 mm (12 inches) below subgrade, unless a greater depth is required by the Plans.

Before backfilling depressions within the roadway caused by the removal of foundations, basements, and other structures, the Contractor shall enlarge the depressions as directed.

C  Excavating Operations

All excavations shall be made in conformity with the lines, grades, and slopes staked by the Engineer and as the Engineer may otherwise direct, based on the typical section and elevation controls shown in the Contract. Any excavating performed beyond the limits described by the stakes that was not authorized or ordered by the Engineer will be considered to be unauthorized work.

Excavations below final grade, for the purpose of removing unstable foundation materials or removing materials that are considered unsuitable for use in the upper portion of the roadbed, shall be
conducted with the understanding that the excavation limits staked will be subject to change as the actual subsurface conditions are disclosed. Where granular backfill is used, seepage trenches shall be excavated for drainage as directed by the Engineer.

Excavations in rock shall be made to secure uniformity of grade and cross-section. All rock outcroppings shall be removed from within the slope lines staked and above the elevations shown in the Plans. All loosened material shall be removed from the backslopes. Roadbed excavating shall be conducted to provide drainage to the shoulder slopes and not to leave depressions that cannot be drained. Unless otherwise specified, presplitting will be required for all rock backslopes steeper than 1:1 in hard rock types such as igneous, metamorphic, and carbonates.

Blasting operations shall be controlled to produce a shattering effect on the rock that will not throw the material out of the excavation areas. The "coyote" method of blasting will not be permitted. Any rock blasted away from the excavation and embankment areas shall be recovered as directed. If seismic methods are used to monitor blasting, a record shall be furnished to the Engineer.

D Disposition of Excavated Material

Excavated materials shall be utilized, to the fullest extent practicable and so far as the material is suitable, for construction of the embankments or as otherwise indicated in the Plans. Each layer of the roadbed shall be constructed of uniform material. When excavation operations disclose the presence of different types of soil, the Contractor shall select the different materials and place them in the embankments or elsewhere as directed. In general, when granular materials are uncovered, they shall be placed in the uppermost portion of the embankment. Granular material shall not be removed from the Project without the written approval of the Engineer.

When the soils are so varied that selection and placement of uniform soils is not practical, the Contractor shall use disks, plows, graders or other equipment to blend and mix suitable soils to produce a uniform soil texture, moisture content, and density; except that, all soils that contain 20 percent or more particles passing the 75 µm (#200) sieve shall be blended, mixed, and dried with a disk meeting 2123 within the entire upper 2 meters (6 feet) of embankment. A disk is also to be used below the upper 2 meters (6 feet) of the embankment fill area if, in the opinion of the Engineer, the contractor is not producing a uniform soil texture. No capping of granular materials with nongranular materials will be permitted at or within 300 mm (12 inches) of the subgrade surface. In the event that the Engineer orders the Contractor to select materials to an extent greater than could be normally expected with the
loading method employed by the Contractor, any additional costs incurred by the Contractor will be compensated for as Extra Work.

The Engineer will designate those soils that are considered unsuitable or unstable with respect to the requirements of the Plans and the provisions hereof.

The Contractor shall remove the topsoil, store it in locations selected by the Contractor, and use it for topsoil covering at locations and to the minimum depths shown in the Plans. The Plans will indicate the quantity of topsoil considered necessary. If, at the time the Plans are prepared, it is known that there will not be sufficient topsoil available in the areas indicated above, the Proposal will contain a bid item for topsoil borrow, in which case the Contractor shall furnish the topsoil in excess of the quantity available within the Right of Way.

Peat, muskeg, and other unstable materials that are not to be used in the roadbed embankments shall be deposited in the areas indicated in the Plans or elsewhere as approved by the Engineer. All other material, including bituminous and concrete waste, that is considered unsuitable for use in the upper portion of the roadbed shall be placed in embankments at least 1 m (3 feet) below the top of the subgrade or outside of a 1:1 slope down and outward from the shoulder lines on fills under 10 m (30 feet) in height or outside of a 1 vertical to 1.5 horizontal slope down and outward from shoulder lines on fills over 10 m (30 feet) in height, or used to flatten the embankment slopes, or disposed of elsewhere as approved by the Engineer.

If no other disposition is specified, the excavated materials in channels outside of the roadway construction limits shall be used to fill abandoned portions of the channels and any remaining material shall be deposited in spoil banks or elsewhere as approved by the Engineer. Spoil banks shall be properly shaped and shall be provided with sufficient openings to permit natural drainage from adjoining property. Any topsoil excavated shall be used to cover the other fill material.

Snow, ice and frozen lumps exceeding 150 mm (6 inches) in greatest dimension will not be permitted in the roadbed embankments. Sod and frozen lumps less than 150 mm (6 inches) in greatest dimension may be placed only in that portion of the embankment which is outside of a 1:1 slope down and outward from the shoulder lines, but not over or adjacent to structures.

No stone, broken concrete or bituminous fragments exceeding 75 mm (3 inches) in greatest dimension will be permitted in the upper 150 mm (6 inches) of the roadbed embankment nor within 500 mm (20 inches) of a structure. No stones exceeding 150 mm (6 inches) in greatest dimension will be permitted in the upper 300 mm (12 inches) of the roadbed embankment. Stones or broken concrete exceeding 150 mm (6 inches) in greatest dimension, and other solid materials shall
not be placed in embankment areas where piling is to be installed. Concrete and bituminous pavement or other such slabs of solid materials shall be processed or pulverized to the extent that the maximum size particles shall not exceed 150 mm (6 inches) in greatest dimension when used in the upper 1 m (3 feet) of embankment or backfill.

All combustible debris materials (stumps, roots, logs, brush, etc.), together with all noncombustible materials other than soils (oversized rock, broken concrete, metals, etc.) that cannot be placed satisfactorily in the embankments, shall be disposed of in accordance with 2104.3C.

All surplus excavated soils and rock that are not wasted, stockpiled, or otherwise disposed of as specifically allowed or required by the Contract shall become the property of the Contractor and shall be disposed of by the Contractor outside of the Project limits in accordance with a satisfactory Disposal Plan. This disposal plan shall constitute the Contractor's proposal for acceptable disposition of surplus materials outside of the Project limits in compliance with applicable environmental regulations, permit requirements, and any requirements or limitations imposed by the Contract. A satisfactory Disposal Plan shall be submitted to the Engineer prior to starting the disposal operations.

In the absence of Contract provisions requiring off-project disposal, such disposition of material will only be ordered as Extra Work, in which case an acceptable disposal plan will be required as a basis for agreement.

Whenever disposal sites are indicated in the Contract, whether on or off the Project, they are to be considered as being possible sites with the Contractor having the option of choosing other sites after award of the Contract under the disposal plan provisions, except in cases where mandatory disposition is intended.

E Placing Embankments

Roadbed embankments shall not be constructed during periods when the embankment material freezes while being placed and compacted, nor shall any embankment material be placed on soil that is frozen to a depth greater than 100 mm (4 inches). Where the foundation soil is frozen to a depth exceeding 100 mm (4 inches), at a time when weather conditions are such that embankment construction could be continued without the material freezing as it is being placed and compacted, the Contractor may be permitted to excavate the frozen foundation soil and proceed with the embankment construction for so long as the weather will permit, but only if and to the extent approved by the Engineer, and with the understanding that the additional costs involved shall be borne by the Contractor. The frozen soil shall be
wasted and replaced with other suitable soil as may be necessary to construct the embankments as specified.

Excavations below subgrade, together with any seepage trenches excavated to provide drainage, shall be backfilled in accordance with the requirements for embankment construction and with the material specified in the Contract, or with suitable materials obtained from the excavations if no other material is specified.

Before backfilling roadbed subcuts that are 750 mm (30 inches) or less in depth, the upper 150 mm (6 inches) of soil below the bottom of the excavation shall be compacted to 95 percent of maximum density.

Embankment material shall be deposited and spread in relatively uniform layers approximately parallel to the profile grade, and extending over the full width of the embankment. Earth moving equipment shall be routed evenly over the entire width of the roadway being constructed. Embankment widening construction shall proceed from the toe of the proposed slope inward toward the existing fill slope. Layers in the upper 1 m (3 feet) of the roadbed shall not be more than 200 mm (8 inches) in thickness (loose measurement) and those below the upper 1 m (3 feet) shall be not more than 300 mm (12 inches) in thickness (loose measurement), except under the following conditions:

(1) Where the foundation for the embankment (or backfill) is under water or is so unstable that it will not support the hauling equipment without appreciable displacement of the underlying soils, the embankment thereon may be constructed as one layer up to the lowest elevation at which the hauling equipment can operate over it without causing intrusion of the underlying soils into the upper 200 mm (8 inches) of the embankment so placed, but in no case shall the top of that layer be less than 1 m (3 feet) below the subgrade. The top of that layer shall be compacted to the satisfaction of the Engineer before any additional material is placed thereon.

(2) When the embankment material is of a granular nature, not more than 20 percent of which will pass a 75 µm (#200) sieve, the thickness of the layers in the upper 1 m (3 feet) of the roadbed may be increased to not more than 300 mm (12 inches) provided compaction is obtained by an approved compactor.

(3) When the embankment material consists predominantly of stone, broken concrete, or rock fragments of such sizes that the material cannot be compacted, that material may be placed in the embankment up to an elevation 1200 mm (4 feet) below the top of the subgrade, in layers not to exceed 600 mm (24 inches) in thickness, and with the exception that larger stones may be placed outside of the shoulder lines but not within the median area of a roadway.
(4) Except as otherwise permitted in (2) above, embankment materials placed adjacent to structures within the roadbed shall be placed in layers not more than 200 mm (8 inches) in loose thickness, for a distance of at least 15 m (50 feet) on each side of pipes 1200 mm (4 feet) or less in diameter and 30 m (100 feet) on each side of other structures, and for the full height from the embankment foundation to the top elevation of the structure.

(5) Except as may be necessary to obtain satisfactory compaction, layer construction will not be required in constructing such items as ditch blocks and entrances where the use of conventional equipment is impractical, nor in constructing such items as channel fills, spoil banks, and berms that do not provide foundation support for structural items.

(6) Granular Materials (3149.2B) which are excavated below the water surface or table shall not be placed on embankment soils if the water content of the excavated material, in the Engineer’s opinion, is causing saturation of the previously placed embankment soils and resulting in the loss of stability and density of these soils.

Each layer consisting predominantly of rock or broken concrete shall be leveled prior to placing the next layer thereon, using suitable equipment operated in a manner that will provide even distribution of the larger rock or broken concrete and fill the voids with finer material to form a compact mass.

If sufficient suitable material has not been made available to construct the embankments as specified, additional suitable material shall be obtained from sources designated by the Engineer. If additional material is obtained from sources outside the Right of Way, the furnishing of that material will be paid for as Extra Work.

If, at any time prior to or during construction, the Engineer determines that it is necessary to resort to a surcharge, the Contractor shall construct the embankment as directed by the Engineer. The surcharge shall continue until the Engineer considers that satisfactory subsidence has been obtained. If, at any time during the construction, the Engineer considers it necessary, the Contractor shall excavate relief trenches as directed by the Engineer adjacent to the toes of the embankment, and backfill them as required.

The Department reserves the right to install settlement plates within the approach embankments at any bridge site as well as in other embankment areas, together with measurement control points outside the embankments, all in such locations and numbers as the Engineer deems necessary to determine the stability of the embankments. The Contractor's operations shall not disturb such installations. Any settlement plates damaged or destroyed by the Contractor's operations shall be replaced at no expense to the Department. No compensation in
addition to Contract prices will be made to the Contractor for any inconvenience or expense incurred as a result of these settlement plate installations.

At a time designated by the Engineer, the Contractor shall complete the embankment by adding more material or removing any excess. After satisfactory settlement of the embankment has been obtained and the slopes have been roughly finished, the excavated material temporarily deposited outside the embankment slopes shall be disposed of as shown in the Plans or as approved by the Engineer.

If embankment surcharge is ordered to achieve subsidence, in the absence of Contract provisions requiring the same, any equipment movement required thereby that would not otherwise be necessary will be compensated for as Extra Work. Unless otherwise specified, removal of excess materials deposited by order of the Engineer will be paid for as Extra Work to the extent the removal is ordered by the Engineer.

Before any embankment is placed behind abutments that support steel superstructures, the Contractor shall place temporary hardwood wedges, as directed by the Engineer, between the superstructure and abutment parapets. These wedges shall be removed when, in the opinion of the Engineer, satisfactory settlement of the embankment has been secured.

When the design of a structure is such that the strength of the substructure is dependent upon the restraining effect of the superstructure, the abutting embankment shall not be constructed until the superstructure has been completed to the extent necessary to provide the required restraint.

**Compacting Embankments**

The rate of depositing material on the embankment shall not exceed the capacity of the leveling and compaction equipment. Compaction of this material should not be delayed after being placed.

Rollers shall be used to compact the embankment materials in totality (area, layers, etc.). The type of roller(s) used for compaction shall be sufficient to meet the density requirements, as specified. The minimum size, gross weight, and applied pressure exerted by the roller(s) shall be in accordance with the equipment requirements specified under 2123.

The use of equipment to haul material (trucks, carryalls, scrapers, etc.) shall not be considered in lieu of the specified compaction equipment. Construction traffic from such hauling equipment shall be distributed uniformly over the entire embankment to the maximum extent possible.
All roadbed embankment material shall be compacted as required herein for the Specified Density Method, except as otherwise provided for specific materials or portions of embankments.

Materials placed outside of a 1 vertical to 1.5 horizontal slope down and outward from the grading shoulder PI (point of intersection) on fills over 10 m (30 feet) in height, or outside of a 1:1 slope down and outward from the grading shoulder PI on fills of 10 m (30 feet) or less in height, will not be subject to the specified density requirements but shall be compacted to the satisfaction of the Engineer.

Mechanical compaction will not be required on those portions of the embankment that are constructed with material consisting predominantly of stone or rock fragments, nor in conjunction with placement of topsoil covering or roadside grading involving the filling of channels and depressions where acceptable consolidation is obtained with the grading equipment.

Density control shall not apply to waste materials (peat, muskeg, etc.) nor to any other non-rock material utilized for incidental drainage or landscape filling outside the roadbed embankment. However, such materials shall be consolidated to the satisfaction of the Engineer.

The Engineer shall have full authority to suspend hauling operations and the placement of additional embankment materials at any time, until the preceding layer has been blended and compacted, and its surface has been properly leveled.

F1 Specified Density Method
Where this method is specified, the Engineer will sample and test the soils that are to be used, to determine the maximum density and Optimum Moisture, and will make density and moisture tests on the compacted embankment, using methods described in the Mn/DOT Grading and Base Manual.

The upper 1 m (3 feet) of the embankment, together with those portions of the embankment that are below the upper 1 m (3 feet) but that are adjacent to structures and are subject to the same maximum layer thickness as the upper 1 m (3 feet), shall be compacted to a density of not less than 100 percent of maximum density. Those portions of the embankment that are below the upper 1 m (3 feet) and that are not adjacent to structures shall be compacted to a density of not less than 95 percent of maximum density.

At the time of compaction, the moisture content of the embankment material shall be not less than 65 percent nor more than 115 percent of Optimum Moisture where 95 percent of maximum density is required and shall be not less than 65 percent nor more than 102 percent of Optimum Moisture where 100 percent of maximum density is required.
F2 Quality Compaction (Visual Inspection) Method
When this method is specified, the equipment used in constructing the embankment shall meet 2123 and each layer of embankment material shall be compacted until there is no evidence of further consolidation. Embankment construction shall not continue when, in the opinion of the Engineer, the existing soil moisture content does not allow proper compaction.

The Engineer may elect to perform moisture and density tests as shown in the Mn/DOT Grading and Base Manual, as needed to assist Visual Inspection. The actual density or moisture obtained by testing the road embankment must meet or exceed the requirements shown in 2105.3F1 Specified Density of the Standard Specifications in order to be acceptable.

Compaction shall be obtained with a tamping roller or an approved type of vibratory compactor, except as otherwise provided for specific materials and portions of the embankments.

In plastic soils, pneumatic-tired, steel-wheeled, or grid rollers may be used for compacting embankment layers 75 mm (3 inches) or less in loose thickness or for compacting the upper 75 mm (3 inches) of thicker layers where a tamping roller will not produce an increase in density. In nonplastic soils, pneumatic-tired, steel-wheeled, or grid rollers may be used for compacting layers of 200 mm (8 inches) or less in loose thickness.

Compaction shall be obtained with special compacting equipment or by hand tamping methods where the use of conventional rollers is not feasible.

G Finishing Operations
All excavation, embankment and roadside areas involved in or disturbed by the construction shall be finished in reasonably close conformity with the established lines and grades, including any tolerances specified. The subgrade shall be finished and maintained as required by the applicable provisions of 2112.3. When compaction was obtained by the quality compaction method, the final shaping of the roadbed shall be done when, in the opinion of the Engineer, the moisture content of the upper portion of the roadbed is suitable for that work. If necessary, in conjunction with the final shaping, the Contractor shall, at no expense to the Department, scarify the roadbed to a depth of 150 mm (6 inches) and recompact it.

In conjunction with the final subgrade finishing operations, the upper portion of a granular subgrade shall be stabilized by incorporation of stabilizing aggregate if necessary to achieve satisfactory surface stability as determined by the Engineer. The aggregate shall be spread to the depth and width shown in the Plans or as needed and shall be mixed (if required) with the subgrade to the extent that stability is best
achieved. After incorporation of the aggregate, the subgrade shall be recompacted and shaped to produce a stable surface meeting the specified surface tolerances. When the material needing stabilization was furnished by the Contractor as a borrow material item, the furnishing and placing of stabilizing aggregate shall be at no expense to the Department. Otherwise, this work will be compensated for under the item "stabilizing aggregate", or as Extra Work in the absence of a Contract item therefor.

Earthwork finishing and topsoil covering operations shall be conducted concurrently with the grading operations so as to permit prosecution and completion of erosion control items at the earliest practicable time. Topsoil covering operations shall be carried out as soon as possible after the subsoil has been finished to grade on any significant area. At the time the topsoil covering is placed, the subsoil shall be in a loose, friable condition for a uniform depth of at least 75 mm (3 inches), and there shall be no erosion rills or washouts in the subsoil surface exceeding 75 mm (3 inches) in depth. To achieve this condition scarification of the subsoil will be required as directed by the Engineer, wherever the subsoil has been compacted by equipment operation or has become dried out and crusted, and where necessary to obliterate erosion rills.

Subsoiling shall be required to reduce soil compaction in all areas where turf establishment is shown on the Plan. Subsoiling shall be performed by the prime or excavating contractor and shall occur after topsoil placement.

The contractor shall schedule a 15 meter (50 foot), two directional test and demonstrate competence to the Engineer prior to continuing operations. The Engineer shall identify the test area. Subsoiled areas shall be loosened to less than 1400 kPa (200 psi) to a depth of 500 mm (20 inches) of the inplace and top soil. When directed by the Engineer, the Contractor shall verify that the subsoiling work conforms to the specified depth. To test for conformance, the Contractor shall use a cone penetrometer that meets standard ASAE Soil Testing Specifications of a 20 mm (13/16 inch) insertion rate per second.

After obtaining approval by the Engineer that the equipment and methods are sufficient to perform the work, the Contractor may proceed and complete the subsoiling operation. Work done without the Engineers approval will be considered as unauthorized work.

Subsoiling shall form a two-directional (90°) grid. Channels shall be created by a commercially available, multi-shanked, parallelogram implement attached to track-type equipment. The equipment shall be capable of exerting a penetration force necessary for the site. No disc cultivators, chisel plows, or spring-loaded equipment will be allowed. The grid channels shall be spaced a minimum of 300 mm
(12 inches) to a maximum of 910 mm (36 inches) apart, depending on equipment, site conditions, and the Plan. The channel depth shall be a minimum of 500 mm (20 inches) or as specified in the Plan. If soils are saturated, the Contractor shall delay operations until the soil dries to field capacity or less.

Only one pass shall be performed on erodible slopes greater than 1 vertical to 3 horizontal. Work shall be at right angles to the direction of surface drainage, whenever practical. Exceptions to subsoiling include areas within the dripline of any existing trees, over utility installations within 750 mm (30 inches) of the surface, where trenching/drainage lines are installed, where compaction is by design (abutments, footings, or inslopes), and inaccessible slopes, as approved by the Engineer. In cases where exceptions occur, the Contractor shall observe a minimum setback, as directed by the Engineer.

Those portions of an old road that are abandoned, which are outside the grading areas as staked, shall be graded and finished to an acceptable contour that blends with the adjoining terrain. On all areas where an old roadbed or temporary haul road have been located, and are to receive turf, the existing soils and granular material shall be removed and replaced and/or subsoiled to provide not less than 500 mm (20 inches) of loose, friable soil below the finished surface. All structural material including granular, shall be removed. Any temporary haul removal costs will be incidental to the Project. Removed material may be disposed of off the Project site or recycled on the Project if approved by the Engineer.

All depressions resulting from structure removals, debris burying, grubbing operations, and other causes, shall be backfilled with suitable material to the designated contour and so as to conform with any pertinent requirements. All debris and any stones exceeding 75 mm (3 inches) in diameter on the soil surface at the time of performing the final blading operations shall be removed from the Project site. They shall be disposed of in accordance with 2104.3C (Disposal of Materials and Debris). If pre-existing to the Project, debris and stone removal will be paid for as Extra Work.

All work involved in the finishing operations, as specified herein and as otherwise required by the Contract, shall be compensated for as part of the payment for Contract items covering excavation, removals, or the furnishing of material.

**2105.4 METHOD OF MEASUREMENT**

The Department will determine quantities for excavation and embankment according to 1901 as modified by these provisions.

**A Excavation Material**

The Department will determine the quantities by excavated volume (EV) of the excavation material in its original position. Volumes will be
computed by the average end area method determined from original and final cross-sections.

In excavations classified as rock, the measurement will include a volume allowance for overbreakage if the plane of the bottom of the excavation falls within a layer or stratum of rock. Unless other limits are shown on the typical grading sections, measurements will include a 150 mm (6 inches) overbreak allowance outside the grading section as staked, with the exception that 500 mm (20 inches) (measured horizontally) will be allowed outside of backslopes in hard rock types where pre-splitting is not required. No overbreak allowance will be made for pre-split backslopes.

The Engineer will determine the actual limits between different material classifications by field measurements during construction as true elevations are disclosed. If any changes are made in the Plan grading sections or grades that affect the excavation limits as indicated in the Contract, measurements will be taken as necessary to establish the actual limits of excavation. Where topsoil covering is required, measurements will be taken on the finished surface after placement of the topsoil, and a quantity allowance will be made equal to the thickness of topsoil placed. In excavations made below finished grade, the limits of excavation measurement will be as defined by the grades and slope lines staked, unless actual field measurements are taken.

The Contractor may dispute the Engineer's determination of excavation quantities after completing the excavations within a specific balance (as planned) when the Contractor has a reasonable cause for dispute. The Contractor must submit a written dispute within 7 days after completing the excavations within a balance except for final finishing. The Contractor shall have waived the right to dispute the pay quantity determinations in that balance if these conditions are not met. However, at any time prior to completion of all roadway excavations on the Project, the Engineer will honor any request for investigation of quantity irregularities that may be submitted in writing by the Contractor, and if findings so warrant, quantity adjustments will be made on the basis of any measurements taken at the Engineer's discretion.

The limits for determination of quantities will be defined by the cross-sections. The limits for quantity determinations will not extend beyond the authorized grading sections as staked, except for the allowances specified. Quantity deductions will be determined by actual or fixed dimensions to exclude materials encompassed by the excavation measurements that are to be removed or salvaged under other Contract items. Excavation quantities, will be recomputed or otherwise adjusted on the basis of actual limits as measured or
otherwise fixed, and payment for excavation items will be made as altered thereby.

**B  Borrow Material**

The Engineer will measure borrow material by volume according to 1901 and as specified in the Contract as one of the following:

1. Excavated volume (EV),
2. Loose volume (LV),
3. Compacted volume (CV), or
4. Stockpile volume (SV).

Only those materials accepted for use on the Project will be measured for payment under the borrow material items.

**C  Salvage Material**

The Engineer will measure salvage material by loose volume unless a different basis of measure is indicated in the item name, in which case the designation symbols will be the same as given for borrow materials in 2105.4B. The Engineer will select either:

1. Loose volume (LV), or
2. Stockpile volume (SV).

Salvaging, processing, stockpiling (if necessary), and placing operations will all be considered a single operation (one complete unit of measure), unless the item name is expanded to include the words "in Stockpiles" or "from Stockpiles." Also see 1901.

The operations of salvaging material from the existing roadway, processing the material as specified, and placing the processed material in stockpiles will be one operation constituting a complete unit of measure. The operations of removing material from stockpiles and placing it in the work as specified will be one operation constituting a complete unit of measure.

**D  Stabilizing Aggregate**

The Engineer will measure stabilizing aggregate according to 1901 by mass or loose volume (LV) as furnished and incorporated into the subgrade.

**E  Subsoiling**

The Engineer will measure subsoiling according to 1901 by area field measurement.

**2105.5 BASIS OF PAYMENT**

If it should be ordered by the Engineer, but not otherwise required by the Contract, that excavated material or salvage material be stockpiled and later loaded and hauled to a different location, rehandling the material will be paid for at the same Contract prices as that paid for the initial excavation or salvage work.

Payment for salvage material under items of salvaged aggregate or salvaged topsoil at the Contract prices per unit of measure will be compensation in full for all costs of excavating, processing, loading,
haling, and placing the material in the new construction as specified. Salvage material "in Stockpiles" will cover all costs incurred in production of the stockpiled material, and salvage material "from Stockpiles" will cover all costs of placing stockpiled material in the new construction as specified.

Payment for the accepted quantities of borrow material or stabilizing aggregate at the Contract prices per unit of measure will be compensation in full for furnishing and placing the material as specified, including final finishing operations.

No separate compensation will be made for any incidental pit stripping, waste excavation, clearing and grubbing, topsoil replacement, pit shaping, seeding, or other expenses incurred in supplying borrow material from Contractor selected sources, whether indicated as a possible source or not. However, when the Contractor is required to obtain borrow material from a source specifically stipulated in the Contract, any required incidental pit excavation (stripping, waste, etc.) will be compensated for separately, or as Extra Work in the absence of such payment provisions.

Payment for the accepted quantities of roadway excavation items at the Contract prices per unit of measure of excavation, subject to the price adjustment and Extra Work compensation specified herein, will be compensation in full for all costs of scalping and preparing the excavation and embankment construction areas; of excavating, loading, hauling and placing, or disposing of the materials as specified; of compacting the embankments and finishing the construction areas as specified; and of all other operations incidental to the work. No direct compensation will be made for water used in conjunction with the mixing, placing, and compacting operations.

Extra Work compensation will be provided for the removal and disposal of any debris encountered in the excavations to the extent that its existence was not known to the Contractor at the time of bidding, and then only when its satisfactory removal and disposition requires separate handling or the use of special equipment.

Compensation for roadway excavation items will include any increased haul costs not qualifying for Extra Work compensation or bid price adjustment in consideration of 1.402.

When the Proposal contains an item for common excavation but does not provide an item for common channel excavation, any excavation ordered and performed that would otherwise be classified as common channel excavation will be paid for separately at the Contract price for common excavation plus $1.30 additional per cubic meter ($1.00 per cubic yard).

If the Proposal fails to include a bid item for rock excavation or rock channel excavation, and material is uncovered that is so classified,
excavation of the rock will be paid for separately at the Contract price for common excavation or common channel excavation, plus an additional $16.00 per cubic meter ($12.00 per cubic yard). If no bid item is provided for common channel excavation, excavation of materials classified as rock channel excavation will be paid for at the Contract price for common excavation plus an additional $18.00 per cubic meter ($13.50 per cubic yard). Such stipulated prices for rock excavation will apply up to a maximum of 200 m³ (260 cubic yards) of excavation per item or to such quantity as may be performed by mutual consent prior to execution of an Extra Work agreement.

When payment for muck excavation on the basis of equipment rental is specified, all operations of excavating and disposing of the materials so classified will be paid for at the Contract prices for the equipment used, in accordance with 2123. In the absence of Contract prices covering removal of material classified as muck excavation, payment will be made for its removal as Extra Work.

If any muck excavation in addition to that indicated in the Plans is required by the Engineer, when payment is made on the basis of excavation volumes, the increased quantity will not be considered as a basis of claim for increased compensation, except as provided by the following:

(a) That portion of the additional excavation that is removed from below a plane parallel to and 5 m (15 feet) below the natural ground surface will be measured in 2 m (5 foot) depth zone increments and paid for separately at adjusted unit prices. The adjusted unit price will be equal to the Contract bid price for muck excavation plus $0.20 per cubic meter ($0.15 per cubic yard) for the additional excavation within the 5-7 m (15-20 foot) depth zone and an additional $0.05 per cubic meter ($0.05 per cubic yard) for each additional 2 m (5 foot) increment of depth beyond 7 m (20 feet).

(b) If any portion of the additional excavated material should be required to be placed in a disposal area other than shown or described for the planned excavation, any additional costs incurred will be compensated for as Extra Work.

The adjusted unit prices specified above for muck excavation will be compensation in full for all additional costs incurred in excavating to depths greater than planned, in finishing the additional disposal quantities and areas, and in rehandling any materials deposited within the extended excavation limits. Payment at the Contract price will include full compensation for all pumping and dewatering specifically required, for all rehandling and hauling of the excavated material that is necessary for its disposal as planned, and for all finishing of the planned disposal areas.
Partial payments will be subject to withholding of a portion of the Contract amount to cover the reasonable value of any uncompleted operations that are designated as a part of the complete unit. The amounts so withheld will be based upon the estimated surface area exposed to probable erosion without the required surface finishing and turf establishment operations being completed.

All areas within the grading construction limits, exclusive of roadbed areas, on which the natural vegetation has been rendered ineffective by the grading or grubbing operations, will be considered as being exposed to probable erosion until such time that the final surface finishing and turf establishment operations have been completed.

The amounts to be withheld on each partial estimate will be the product of $7413.00 per hectare ($3000.00 per acre), unless otherwise stated in the Contract, and the estimated number of unfinished hectares (acres) exposed to probable erosion at the time the estimate is prepared. This withholding will apply to the entire Project or to any area, as determined by the Engineer.

For application and release purposes, the Project may be divided into separate control areas based on earthwork balance points, drainage area boundaries, or roadway segments as indicated in the Contract or as otherwise deemed appropriate by the Engineer.

Upon completion of the rough grading operations and placement of topsoil in each control area, the amount withheld for that area will be reduced by 50 percent. Once mulch has been placed, the amount will be reduced by an additional 30 percent. Full release of the amount withheld will be made when the seeding has been accepted.

Whenever the possibility for erosion damage or water pollution exists, release of withheld amounts will not be made for a control area until adequate temporary or permanent erosion control measures have been provided.

Topsoil borrow will be accepted for payment in accordance with the provisions of Table 2105-1.
TABLE 2105-1
TOPSOIL BORROW ACCEPTANCE SCHEDULE

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>FULL PAYMENT RANGE</th>
<th>PRICE REDUCTION RANGE</th>
<th>CORRECTIVE ACTION REQUIRED WHEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent passing the 2.00 mm (#10)</td>
<td>85% or Greater</td>
<td>80.0 - 84.9</td>
<td>75.0 - 79.9</td>
</tr>
<tr>
<td>Clay Content</td>
<td>5% or Greater</td>
<td>3.0 - 4.9</td>
<td>2.0 - 2.9</td>
</tr>
<tr>
<td></td>
<td>30% or Less</td>
<td>30.1 - 35.0</td>
<td>35.1 - 40.0</td>
</tr>
<tr>
<td>Silt Content</td>
<td>10% or Greater</td>
<td>7.0 - 9.9</td>
<td>4.0 - 6.9</td>
</tr>
<tr>
<td></td>
<td>70% or Less</td>
<td>70.1 - 75.0</td>
<td>75.1 - 78.0</td>
</tr>
<tr>
<td>Sand and Gravel Content</td>
<td>10% or Greater</td>
<td>7.0 - 9.9</td>
<td>4.0 - 6.9</td>
</tr>
<tr>
<td></td>
<td>70% or Less</td>
<td>70.1 - 75.0</td>
<td>75.1 - 78.0</td>
</tr>
<tr>
<td>Organic</td>
<td>3% or Greater</td>
<td>2.0 - 2.9</td>
<td>1.5 - 1.9</td>
</tr>
<tr>
<td></td>
<td>20% or Less</td>
<td>20.1 - 22.0</td>
<td>22.1 - 25.0</td>
</tr>
<tr>
<td>pH</td>
<td>6.1 or Greater</td>
<td>(A)</td>
<td>(A)</td>
</tr>
<tr>
<td></td>
<td>7.8 or Less</td>
<td>7.9 - 8.0</td>
<td>8.1 - 8.2</td>
</tr>
</tbody>
</table>

NOTE: The price reductions for multiple failures are cumulative.

(A) May be corrected by the addition of agricultural lime at a rate determined by the Engineer.

Payment for excavation and embankment construction will be made on the basis of the following schedule:

Item No.  Item                              Unit
2105.501  Common Excavation .................. cubic meter (cubic yard)
2105.503  Rock Excavation .................... cubic meter (cubic yard)
2105.505  Muck Excavation .................... cubic meter (cubic yard)
2105.507  Subgrade Excavation ............... cubic meter (cubic yard)
2105.511  Common Channel Excavation .......... cubic meter (cubic yard)
2105.513  Rock Channel Excavation ........... cubic meter (cubic yard)
2105.515  Unclassified Excavation ........... cubic meter (cubic yard)
2105.521  Granular Borrow (1) .............. cubic meter (cubic yard)
2105.522  Select Granular Borrow (1) ........ cubic meter (cubic yard)
2105.523  Common Borrow (1) .................. cubic meter (cubic yard)
2105.525  Topsoil Borrow (1) ............... cubic meter (cubic yard)
2105.526  Select Topsoil Borrow (1) .......... cubic meter (cubic yard)
2105.533  Salvage Aggregate (1) ............. cubic meter (cubic yard)
2105.535  Salvaged Topsoil (1) ............. cubic meter (cubic yard)
2105.541  Stabilizing Aggregate ............. cubic meter (cubic yard)
2105.5

2105.543  Stabilizing Aggregate .............................. metric ton (ton)
2105.550  Subsoiling ........................................ hectare (acre)

NOTE:  (1) Specify basis of measure:  EV, LV, SV, or CV.  See 2105.4 and 1901.

See 2105.4C and insert the words "in Stockpile" or "from Stockpile" if appropriate.

2111  Test Rolling

2111.1 DESCRIPTION

This work shall consist of testing the bearing capacity of the roadbed by rolling with heavy rollers.

Test rolling will be required only when and where specifically provided in the Contract.

2111.2 EQUIPMENT

The roller shall be pneumatic-tired, towed by suitable tractive equipment and shall conform to the following requirements:

(a) The roller shall have 2 wheels spaced not less than 1.8 m (6 feet) apart (center to center transversely).

(b) The tire size shall be either 18 x 24 or 18 x 25.  Each tire shall be inflated to a pressure of 650 kPa (95 psi).

(c) The gross mass of the roller shall be not less than 13.5 metric tons (14.9 tons) and not more than 13.7 metric tons (15.1 tons) on each wheel.

2111.3 CONSTRUCTION REQUIREMENTS

Test rolling shall be performed on the roadbed as required at a time when the grading grade is completed within 100 mm (4 inches) of the grade staked by the Engineer, and shall cover the full top width of the proposed pavement structure as defined by the bottom width of the typical subcut sections shown in the Plans, unless other specific dimensions are given.  Test rolling shall not be performed until the Engineer and Contractor mutually agree that the subgrade has been properly prepared and is acceptable for test rolling.

The test rolling shall be performed by making one pass over each strip covered by the width of a tire.  Unrolled areas between tire paths shall not be wider than 300 mm (12 inches).  The roller shall be operated at a speed of not less than 4 km/h (2.5 mph) nor more than 8 km/h (5 mph) and in a pattern approved by the Engineer

The Contractor shall take precautions to protect culverts and other structures during the test rolling.  Where a culvert or other structure has, or will have, insufficient protective cover to withstand test rolling, the test rolling may be performed prior to installing the structure or performed on the surface of any additional cover that may be provided.
as protection for in place structures. Any structures damaged by the test rolling shall be replaced at no expense to the Department.

On those portions of a Project where the Plans require treatment of the upper portion of a granular subgrade by the addition of aggregate or binder soil, the test rolling may be performed either before or after the treatment work is performed.

The roadbed will be considered to be unstable if, under the operation of the roller, the surface shows yielding or rutting (at the time the roller passes over the grade) of more than 50 mm (2 inches) measured from the top of the constructed grade to the bottom of the rut, except that an additional 25 mm (1 inch) will be allowed when a granular subgrade is to be treated after test rolling. The Contractor will be required to furnish a device that will mark the surface of the roadbed where rutting or yielding occurs as approved by the Engineer.

Where test failure occurs on a roadbed not constructed by the Contractor under the same Contract, the unstable sections shall be repaired by the Contractor, as directed by the Engineer, at the Department's expense.

If, on a roadbed constructed by the Contractor under the same Contract, test rolling shows any sections of the roadbed to be unstable, the Contractor shall, at no expense to the Department, scarify the roadbed and aerate or add moisture to the material as necessary, and recompact the material to the extent that it will be stable when retested by rolling. However, where test failure occurs on an isolated section of roadbed less than 50 m (2 road stations) in length, retesting of that section by rolling will not be required if the Engineer is satisfied that the corrective measures taken have eliminated the cause of failure and have produced acceptable stability as evidenced by density tests or visual inspection.

**2111.5 METHOD OF MEASUREMENT**

If the roadbed tested was constructed under a previous Contract, and only then, test rolling (together with any retesting required by the Engineer after unstable sections have been repaired) will be measured by length where such work is performed. The work on each separate roadbed, in the case of divided highways, will be measured separately. If the Engineer orders testing on any portion of the roadbed to an extent less than the full width specified, the measurement will be in proportion to the width tested.

**2111.5 BASIS OF PAYMENT**

If the roadbed tested was constructed by the Contractor under the same Contract, the Contractor shall perform test rolling (including all repairs to unstable sections and retesting) as incidental work with no direct compensation.
2111.5

If the roadbed tested was constructed under a previous Contract, and only then, all repairs to unstable sections ordered by the Engineer will be paid for as Extra Work and the test rolling will be paid for on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2111.501</td>
<td>Test Rolling</td>
<td>meter (road station)</td>
</tr>
</tbody>
</table>

2112 Subgrade Preparation

2112.1 DESCRIPTION
This work shall consist of shaping and compacting the subgrade prior to placing a base or surface course thereon.

2112.3 CONSTRUCTION REQUIREMENTS
This work shall be performed after any unstable sections of the subgrade have been repaired and after any existing base or surface courses required to be removed have been removed.

The Contractor shall compact and shape the subgrade for its full width as may be necessary to produce, at the time the base or surface course is placed, the required density and stability in the top 150 mm (6 inches) of the subgrade and the required grade and cross-section. The Contractor shall scarify, dry the material, or apply water as may be necessary to obtain the required density and stability. Unless otherwise provided in the Contract, the density shall be 100 percent of maximum density as defined by the Specified Density Method.

The required stability shall be such that when any material for base or surface courses is deposited on the subgrade, no rutting or displacement of the roadbed will occur.

The required grade and cross-section shall consist of a smooth subgrade surface conforming to the prescribed elevations for the particular subgrade being prepared prior to constructing an additional course thereon. The prescribed elevation for any point on the subgrade surface where measurement is made shall be as determined from the grades staked by the Engineer and the typical sections shown in the Plans, within the following tolerances:
(a) When the subgrade is being prepared for placement of an aggregate wearing course or is being finished for acceptance of the grading construction, the elevation of the finished surface shall not vary by more than 30 mm (0.1 foot) from the prescribed elevation at any point where measurement is made.

(b) When the subgrade is being prepared for placement of an aggregate base course, the elevation of the finished surface at the time the next layer is placed, shall not vary by more than 15 mm (0.05 foot) above or 30 mm (0.1 foot) below the prescribed elevation at any point where measurement is made.

(c) When the subgrade is being prepared for placement of a surface course, the elevation of the finished surface at the time the next layer is placed, shall not vary by more than 15 mm (0.05 foot) from the prescribed elevation at any point where measurement is made.

In conjunction with the operations of subgrade preparation, the Contractor shall produce, load, and haul aggregate (of the same type as that used in the subgrade or in the course to be constructed) where and in such quantities as the Engineer directs, and incorporate such material into the subgrade. This work will be paid for at the appropriate Contract prices for the material in place or, in the absence of such prices, as Extra Work.

2112.4 METHOD OF MEASUREMENT

Subgrade preparation will be measured by length, along the centerline of the roadbed. The work on each separate roadbed, in the case of divided highways will be measured separately. Locations where grading or subgrade excavation (as described in 2105) is required will not be included in the measurements. On ramps and loops, the length will be measured between the ends of the exit and entrance noses, along the centerline of the ramp or loop roadbed.

2112.5 BASIS OF PAYMENT

If the roadbed or other course being prepared was constructed under the same Contract, the Contractor shall perform subgrade preparation as incidental work with no direct compensation. Payment for subgrade preparation, as a separate item, will be made only when the roadbed or other course being prepared was constructed under a previous contract.

Payment for subgrade preparation at the Contract price per unit of measure will be compensation in full for all costs of preparing the subgrade as specified, except that any expenses incurred in correcting unstable conditions below the top 150 mm (6 inches) will be compensated for separately as Extra Work, or at the Contract prices for the equipment used if so provided for in the Contract.
2112.5

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2112.501</td>
<td>Subgrade Preparation</td>
<td>meter (road station)</td>
</tr>
</tbody>
</table>

2118

Aggregate Surfacing

2118.1 DESCRIPTION
This work shall consist of constructing an aggregate wearing course on a prepared Subgrade.

2118.2 MATERIALS
A. Aggregate
The class of aggregate to be used will be as shown in the Contract.

2118.3 CONSTRUCTION REQUIREMENTS
The specified quantity of aggregate shall be deposited on the road and spread to the required cross-section only when the roadbed is so dry and compact that no rutting or displacement will occur, and only on sections of such length as will meet the Engineer's approval. Aggregate shall be deposited and spread on public road approaches and private entrances in the quantities directed by the Engineer.

Aggregate windrows shall be moved as necessary to permit drying and reshaping of the subgrade. The aggregate shall be mixed prior to spreading, as necessary to produce uniformity in the gradation of the material.

No compaction will be required of the aggregate surfacing unless the quantity of aggregate placed results in a surface thickness in excess of 50 mm (2 inches), in which case the aggregate surfacing shall be compacted in accordance with 2211.3, quality compaction method.

2118.4 METHOD OF MEASUREMENT
Aggregate surfacing will be measured, as indicated in the Proposal, by mass (weight) or by volume (vehicular measure) of aggregate deposited on the road.

2118.5 BASIS OF PAYMENT
Payment for the accepted quantity of aggregate surfacing at the Contract price per unit of measure will be compensation in full for all costs of furnishing and placing the aggregate surfacing as specified.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2118.501</td>
<td>Aggregate Surfacing, Class</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>
2123.1 DESCRIPTION

This work shall consist of furnishing laborers and of furnishing and operating equipment, in cases where the Contract provides that the work is to be performed as directed by the Engineer and at the Department's expense.

2123.2 GENERAL REQUIREMENTS

All equipment shall be in a mechanical condition such that it will operate in a manner satisfactory to the Engineer.

All equipment that operates on bituminous or concrete surfaces shall be equipped with rubber tires or smooth street plates.

Tractive equipment used to draw any other equipment shall be of a type that will not damage the work being performed and that has sufficient power to effectively operate the drawn equipment.

2123.3 SPECIFIC REQUIREMENTS

Equipment rented under this Specification shall meet the following specific requirements regarding type, size, capacity, power, or dimensions.

A Motor Grader

The motor grader shall be of the self-propelled type with pneumatic-tired wheels and power-operated controls and shall have a mass of not less than 8600 kg (19,000 pounds). It shall have a moldboard at least 3.6 m (12 feet) long with a suitable cutting edge and shall be equipped with a suitable scarifier.

B Dozer

The dozer may be of either the angle-dozer or bull-dozer type attached to a crawler-type tractor having at least 56 kw (75 horsepower) at the draw-bar and power operated controls. The dozer blade shall be not less than 2.3 m (90 inches) wide. Angle-dozers shall be adjustable to an angle of 90 degrees with the direction of travel of the tractor. The dozer and tractor will be considered as a single unit.

C Scraper

The scraper may be the carryall type mounted on pneumatic-tired wheels or the rotary type drawn by a tractor of suitable size. It shall have not less than the volumetric capacity indicated in the Proposal, which shall be construed to be the manufacturer's rated heaped capacity.

D Dragline

The dragline shall be of the full-revolving type, equipped with a bucket of at least the size specified in the Proposal, but in no case larger than that for which the machine is designed.

The 0.75 m³ (1 cubic yard) dragline shall have at least a 13.7 m (45 foot) boom and a working radius of at least 10.6 m (35 feet).
The 1.9 m³ (2.5 cubic yard) dragline shall have at least a 24.3 m (80 foot) boom and a working radius of at least 18.2 m (60 feet). Any other size of dragline shall have the boom length and working radius specified in the Contract.

For swamp work, one set of mats shall be furnished for each dragline. Each mat shall have a length of not less than twice the distance between the outside edges of the crawler treads. The combined width of all the mats shall equal at least twice the bearing length of the crawler treads.

E  Power Shovel
The power shovel shall be of the full-revolving crawler-type with a bucket of the size recommended by the manufacturer. The size of the shovel will be indicated in the Proposal by the capacity of the bucket.

F  Tractor
The tractor shall be of the crawler type and shall have the specified power at the draw-bar as indicated in the Proposal. The power shall be measured in kilowatts (horsepower).

G  Pneumatic-Tired Roller
The pneumatic-tired roller shall have a compacting width of 1.5 m (5 foot) or more and shall be so constructed that the gross mass can be varied, as directed by the Engineer, within the range of 1700-4400 kg/meter (100-250 pounds/inch) of rolling width. The arrangement of the tires shall be such that compaction will be obtained over the full compacting width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless the Proposal specifies a certain type. If more than one roller is propelled by a single tractive unit, the combination will be counted as a single roller unit.

H  Tamping Roller
For the purposes of this Specification, a tamping roller consists of two sections, each having a drum at least 1.2 m (48 inches) in diameter, a gross mass and number of pads as approved by the Engineer, and drawn by suitable tractive equipment.

I  Blank

J  Steel-Wheeled Roller
The steel-wheeled roller shall be self propelled and have a minimum total mass of 7.3 metric tons (8 tons), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN per meter (250 pounds/inch) of width. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rolls on both the front and back.

Unless otherwise specified in the Proposal, steel-wheeled rollers may be either the tandem type or the three wheeled type.
K  Truck
The truck shall have a minimum manufacturer's rated capacity of at least 1.3 metric tons (1.5 tons) and shall have a volumetric capacity of not less than 3.8 m$^3$ (5 cubic yards). It shall be equipped with a power-operated hoist and a metal dump box of the end dump type. The rear axle of the truck shall be equipped with dual wheels and tires not less than 200 mm (8 inches) in width (manufacturer's designated size).

L  Rotary Tiller
The rotary tiller shall be at least 1370 mm (54 inches) wide and adjustable for any depth up to 225 mm (9 inches), and shall be drawn by suitable tractive equipment.

M  Front End Loader
The front end loader shall consist of a crawler type or rubber-tired tractor, equipped with a power-operated loader having a bucket with at least the struck capacity specified in the Proposal. It shall be capable of excavating to a depth of at least 250 mm (10 inches) below the bottom of the treads (or tires) and loading the excavated material on the trucks used for hauling.

2123.4 METHOD OF MEASUREMENT
A  Equipment Hours
Rental of each unit of equipment will be measured by the number of hours of actual working time and necessary traveling time within the Project limits.

B  Common Laborer Hire
Common laborer hire will be measured by the hours of actual working time and necessary traveling time within the Project limits.

2123.5 BASIS OF PAYMENT
Payment for the use of any equipment at the Contract price per hour will be compensation in full for the use and operation of such equipment, including the operator or operators and any tractive equipment and other accessories required in connection with such use, subject only to these provisions for additional compensation in cases where the Contractor is obligated to pay overtime wages for work performed by order of the Engineer on Sundays, holidays, or during overtime periods.

Payment for laborers at the Contract price per hour will include compensation for the use of any hand tools used by such laborers, subject only to these provisions for additional compensation in cases where the Contractor is obligated to pay overtime wages for work performed by order of the Engineer on Sundays, holidays, or during overtime periods.

No compensation in addition to the Contract price per hour for equipment rental or common laborer hire will be made because of any overtime or work performed on Sundays or holidays except when such
work is ordered by the Engineer to be performed during those times. If the Engineer orders the use of equipment or common laborers during overtime periods or on Sundays or holidays, compensation will be made in addition to the Contract price per hour for equipment rental or common laborer hire only for the increased wages for which the Contractor is obligated under the terms of wage agreements. Such additional compensation will be made by increasing the Contract price per hour for the equipment or common laborers used by an amount equal to the difference between the normal hourly wage for straight time work and the overtime hourly wage actually paid the laborers employed in operating the equipment or performing the labor, as determined from the Contractor's payroll.

Payment as provided above will include such supervision by the Contractor as may be necessary to accomplish the work in the manner directed by the Engineer, except that, if the Engineer considers that a full time foreman is necessary and so orders, payment for furnishing such a foreman will be as Extra Work on a Force Account basis.

Payment for equipment rental and common labor hire will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2123.501</td>
<td>Common Laborers</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.503</td>
<td>Motor Grader</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.506</td>
<td>__ m$^3$ (cubic yard) Dragline</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.507</td>
<td>__ m$^3$ (cubic yard) Shovel</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.508</td>
<td>__ m$^3$ (cubic yard) Scraper</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.509</td>
<td>Dozer</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.510</td>
<td>__ m$^3$ (cubic yard) Truck</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.511</td>
<td>__ kW (hp) Tractor</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.512</td>
<td>Rotary Tiller</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.514</td>
<td>__ m$^3$ (cubic yard) Front End Loader</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.521</td>
<td>Pneumatic-Tired Roller</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.522</td>
<td>Pneumatic-Tired Roller (Tractor Drawn)</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.523</td>
<td>Pneumatic-Tired Roller (Self Propelled)</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.524</td>
<td>Tamping Roller</td>
<td>................................................................. hour</td>
</tr>
<tr>
<td>2123.525</td>
<td>__ metric ton (ton) Steel-Wheeled Roller</td>
<td>................................................................. hour</td>
</tr>
</tbody>
</table>
2130

Application of Water

2130.1 DESCRIPTION
This work shall consist of furnishing and applying water for dust control within the Project limits as directed by the Engineer or stipulated in the Contract.

2130.2 MATERIALS
The water shall be furnished by the Contractor and it shall be reasonably clean.

2130.3 CONSTRUCTION REQUIREMENTS
A  Equipment
Water supply tanks shall be equipped with distributing bars or other apparatus that will ensure uniform application of the water. Application of water on the road shall be with a self-propelled distributor of the pressure type, mounted on pneumatic-tired wheels. Pump capacity shall be sufficient to permit application of the whole load uniformly at any rate up to 940 L (250 gallons) per minute.

B  Application
The water supply and equipment used shall be sufficient to apply the quantity required within the time interval necessary to secure optimum results and avoid unwarranted loss of water through evaporation, absorption, or drainage. The water shall be applied at such times and in such quantities as the Engineer approves.

2130.4 METHOD OF MEASUREMENT
Water applied for dust control within the Project limits, by direct order of the Engineer or when application is specified at the Department's expense, will be measured for payment by volume.

Deductions may be made for any water wasted through failure of the Contractor to coordinate the application of water with other operations as may be directed.

2130.5 BASIS OF PAYMENT
Payment for the accepted quantities of water at the Contract price per unit of measure will be compensation in full for all costs of furnishing, transporting, and applying the water as directed.

These provisions apply to water used for dust control within the Project limits as directed by the Engineer. These provisions do not apply to any sprinkling or other uses for water required in conjunction with the construction of concrete pavements; to any water used in the production or curing of concrete; to any water used to maintain plant life; to any water used in conjunction with compacting soil and aggregate; or to any water used for dust control on any Contractor selected haul roads, detours, or work sites outside of the Project limits; all costs of which will be incidental to the Contract items involved.
2130.5

Water applied by order or approval of the Engineer for dust control will be paid for at a unit price of $3.00 per cubic meter ($11.00 per 1000 gallons) in the absence of the Contract bid item 2130.501.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2130.501</td>
<td>Water</td>
<td>cubic meter (1000 M Gal)</td>
</tr>
</tbody>
</table>

2131

Application of Calcium Chloride

2131.1 DESCRIPTION

This work shall consist of furnishing and applying calcium chloride, either as a surface treatment or as an admixture, in conjunction with grading or the construction of an aggregate base or surface course, or as a surface application on the road.

2131.2 MATERIALS

A  Calcium Chloride, type as specified or permitted .......................................................... 3911

B  Water

Water used for preparing solutions shall be reasonably clean and free of suspended matter.

2131.3 CONSTRUCTION REQUIREMENTS

A  Surface Application

Calcium chloride in dry form shall be applied on the road with a spreader capable of distributing the material uniformly at the rate directed. Calcium chloride solutions shall be applied on the road with a distributor meeting the requirements of 2321.3C1.

Unless otherwise specified, application rates shall be as directed by the Engineer.

B  Admixture Application

When used as an admixture, the calcium chloride may be mixed with the aggregate at the aggregate producing plant, applied on the road as a surface application and there mixed with the aggregate, or applied on the road in solution with the mixing water.

If the calcium chloride is added at the aggregate producing plant, it shall be introduced into the aggregate at a uniform rate and in the required proportions, by a separate conveyor or metering device approved by the Engineer.

2131.4 METHOD OF MEASUREMENT

In the case of bulk shipments of dry calcium chloride, the material of each type as delivered and used will be measured by the net railroad or truck mass. In the case of bag or drum shipments, the mass of the material as delivered and used will be computed from the bag or drum mass.
Calcium chloride solutions will be measured by volume as adjusted to 15°C (60°F). Tank volumes will be corrected for temperature by using the correction factors for asphalt emulsion as shown in the Mn/DOT Bituminous Manual. Conversion of shipping mass to volume will be on the basis of 1390 kg/m³ (11.6 pound/gallon) in the case of solutions of 38 percent concentration.

For application, measurement, and payment purposes, the percentage of anhydrous chloride in the various types of material as delivered will be assumed to be as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Anhydrous Chloride Percentage by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Chloride, Type 1</td>
<td>77%</td>
</tr>
<tr>
<td>Calcium Chloride, Type 2</td>
<td>94%</td>
</tr>
<tr>
<td>Calcium Chloride Solution</td>
<td>38%</td>
</tr>
</tbody>
</table>

If the material as delivered does not conform to the above specified percentages, the application rates and pay quantities will be adjusted by the Engineer so as to make payment for equivalent quantities based on conversion factors established by the Department in accordance with the assumed percentages for each type.

In the event of unseasonably cold weather, which might cause crystallization in the 38 percent calcium chloride solution, a solution containing 35 percent anhydrous chloride may be furnished with the Engineer's approval, in which case conversion of shipping mass to volume will be on the basis of 1360 kg/m³ (11.35 pounds/gallon). For payment, the net volume of 35 percent solution will be converted to equivalent volume of 38 percent solution by multiplying by 0.921.

**2131.5 BASIS OF PAYMENT**

Payment for calcium chloride at the Contract price per unit of measure will be compensation in full for furnishing and applying the material as specified.

Application of water in conjunction with the use of dry calcium chloride will be paid for in accordance with 2130, as a separate item, only to the extent that water is used by order of the Engineer.

Payment for application of calcium chloride will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2131.501</td>
<td>Calcium Chloride, Type</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2131.502</td>
<td>Calcium Chloride Solution</td>
<td>cubic meter (gallons)</td>
</tr>
</tbody>
</table>
2201

Concrete Base

2201.1 DESCRIPTION

This work shall consist of constructing a base course of Portland cement concrete, with or without reinforcement, on a prepared subgrade.

2201.2 MATERIALS

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

Mix designations shall be as given below for the method of placement to be used.

Manual Placement ......................................................... Mix No. 3B42
Standard Machine Placement ........................................ Mix No. 3B32
Vibratory Machine Placement ....................................... Mix No. 3B22

In the event Class C aggregate is used meeting the requirements for CA-15 as given in 3137, the cement content required will not exceed the values given in 2461.3C.

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

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

D  Steel Fabric ............................................................. 3303

E  Blank

F  Preformed Joint Filler ................................................. 3702

G  Emulsified Asphalt .................................................. 3151

H  Curing Paper ........................................................... 3752

I  Blank

J  Plastic Sheeting ....................................................... 3756

K  Membrane Curing Compound ...................................... 3754

2201.3 CONSTRUCTION REQUIREMENTS

Construction requirements shall be the same as those specified in 2301.3, Concrete Pavement, except as modified by the following:

A  Joint Construction

When emulsified asphalt is used for curing and the joints are sawed, the sawing operations shall be completed within 24 hours after concrete placement.

When a widening strip is constructed adjacent to an existing pavement, a transverse joint shall be constructed opposite each old joint and, where the old joints are more than 9 m (30 feet) apart, additional joints shall be constructed approximately half-way between the old joints.

B  Surface Finishing

When a concrete base is constructed to widen an existing concrete pavement and the Plans show the top of the base at the same elevation as the existing pavement surface, the surface of the base shall conform to the pavement surface.
After the surface has been screeded, no additional surface finishing will be required except for a final brooming to roughen the surface and such other finishing as may be necessary to produce a surface conforming to the requirements specified hereinafter.

C Integrant Curb

Concrete for integrant curb shall be Mix No. 3A22, 3A32, or 3A42, depending on the slump requirements for the equipment used.

D Concrete Curing

The concrete base shall be cured by the use of curing paper or plastic sheeting as provided for in 2301.3M, or by the use of emulsified asphalt applied by means of power spraying equipment at a total rate that will provide a moisture-proof film over the entire surface of the base.

Within 2 hours after application of asphalt emulsion, a coating of whitewash made of hydrated lime and water shall be applied. The proportions used in the whitewash and the rate of application shall be such that a uniform color, not darker than uncoated concrete after curing, will be produced on the surface of the base. After September 15th, the use of the whitewash application may be discontinued with the consent of the Engineer.

E Workmanship and Quality

The workmanship and quality requirements of 2301.3P shall apply to concrete base construction except that: (1) the surface smoothness requirements set forth hereinafter shall apply in lieu of 2301.3P; (2) the permissible deviations in average thickness of the base shall be 6 mm (¼ inch); and (3) the riding quality requirements of 2301.3P shall not apply.

After completion of the curing period, the Department will test the surface of the base for slope and grade uniformity. Except for any irregularities induced by grade requirements when the base is constructed adjacent to an existing concrete pavement or gutter, the surface of the base shall not vary more than from a 3 m (10 foot) straightedge.

Areas that are found to vary from the 3 m (10 feet) straightedge by more than 10 mm (3/8 inch) will not be excluded from the pay quantities, but in lieu of being removed and replaced acceptably, a deduction will be made from the moneys due the Contractor equal to the product of the defective area and: (1) $1.25/ m² ($1.00 per square yard) for those areas where the maximum deviation is more than 10 mm (3/8 inch), but not more than 15 mm (5/8 inch), and (2) $2.50/m² ($2.00 per square yard) for those areas where the maximum deviation exceeds 15 mm (5/8 inch).
2201.4 METHOD OF MEASUREMENT
The methods of measurement will be the same as specified in 2301.4 with the substitution of the term "base" for "pavement."

2201.5 BASIS OF PAYMENT
 Basis of payment will be the same as specified in 2301.5 except for substituting the term "base" for "pavement" and using the following schedule.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2201.501</td>
<td>Concrete Base</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2201.503</td>
<td>Concrete Base, Irregular Width</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2201.511</td>
<td>Structural Concrete</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2201.521</td>
<td>Base Reinforcement, Type___</td>
<td>square meter (cubic yard)</td>
</tr>
<tr>
<td>2201.529</td>
<td>Reinforcement Bars</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2201.531</td>
<td>Expansion Joints, Design___</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2201.541</td>
<td>Integrant Curb, Design___</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>

2211 Aggregate Base

2211.1 DESCRIPTION
This work shall consist of constructing one or more courses of Contractor certified aggregate base on a prepared subgrade. The aggregate base shall be produced and placed under the Contractor's quality control program in accordance with Section 5-692.705 of the Mn/DOT Grading and Base Manual.

2211.2 MATERIALS
A Aggregate .......................................................... 3138
The class of aggregate to be used in each course will be shown in the contract. Gradation acceptance for Classes 1, 2, 3, 4, 5, 6 and 7 aggregates will be by the random sampling method in accordance with 2211.3F.

2211.3 CONSTRUCTION REQUIREMENTS
A General
 Aggregate removed from below water shall be stockpiled and allowed to drain for at least 24 hours before being delivered on the road when its water content is such that, in the Engineer's opinion, it will cause saturation of the subgrade soils.

The base shall be constructed in layers not more than 75 mm (3 inches) in compacted thickness, except that each layer compacted with approved types of special compacting equipment may be increased
to a maximum of 150 mm (6 inches). Class 7 materials shall be constructed in layers not more than 75 mm (3 inches) in compacted thickness unless approved by the Engineer. Vibratory rollers will be allowed for use on a performance basis in accordance with 1805.

Where successive courses are to be constructed with different classes of aggregate, the Engineer may allow the Contractor to construct any course in accordance with the material requirements for the next above course. However, the Engineer will make payment for the combined work on the basis that each course was constructed according to the Plans.

B Placing and Mixing

When the base is constructed in a single layer, aggregate shall not be deposited on the roadbed more than 3 km (2 miles) in advance of the completed portion of the base. When the base is constructed in more than one layer, the aggregate for one layer shall not be deposited more than 5 km (3 miles) in advance of the completed portion of the succeeding layer, except that a single class of aggregate may be placed and compacted for the entire length of the Project before another class of aggregate is placed thereon. At the time of depositing the aggregate on the road, the roadbed shall be so dry and compact that no rutting or displacement will occur. Aggregate shall be placed on public road approaches and private entrances in the quantities designated by the Engineer.

If so required by the Contract, calcium chloride shall be furnished and mixed with the aggregate in accordance with 2131. Water may be added to the aggregate during mixing operations in the quantity necessary to produce proper compaction.

Aggregate windrows shall be moved, as directed by the Engineer, to permit satisfactory maintenance and drying of the subgrade. Any material that becomes contaminated after placement shall be removed and replaced, or corrected and retested.

When any surfacing is included in the same Contract as the aggregate base, the Contractor shall conduct operations in such a manner that, before suspending operations for the winter, all base aggregate deposited on the roadbed shall be covered with the initial surface course or otherwise protected in a manner approved by the Engineer. A bituminous penetration prime coat is not considered to be a surface course.

C Spreading and Compacting

At the time of spreading the base material for compaction, the aggregate shall be so uniformly mixed that it will meet specified gradation requirements, based on the results of gradation tests run on aggregate samples obtained after mixing and prior to compaction.
2211.3

The material for each layer shall be spread and compacted with adequate moisture content, to the required cross section and density before placing aggregate thereon for a succeeding layer. The surface of each layer shall be maintained, with uniform texture and firmly keyed particles, until the next layer required by the Contract is placed thereon or until the completed base is accepted if no other construction is required thereon.

Compaction shall be obtained by the:
(1) Specified Density Method,
(2) Quality Compaction Method, or
(3) Penetration Index Method
whichever method is prescribed for the particular course. Compaction by the Specified Density Method will be required on all base courses except those that are otherwise designated in the contract for compaction by either the quality compaction or penetration index method. If Class 7 is specified or substituted for another class of aggregate, then densification shall only be obtained by the Quality Compaction Method or the Penetration Index Method.

C1 Specified Density Method
The full thickness of each layer shall be compacted to not less than 100 percent of maximum density. For test purposes, a layer will be considered to be 75 mm (3 inches) in compacted thickness. At the time of compaction, the moisture content of the base material shall be not less than 65 percent of optimum moisture.

The Engineer will make tests to determine the actual field density of the compacted base. The field density, optimum moisture, and maximum density will be determined in the field by methods described in the Mn/DOT Grading and Base Manual.

C2 Quality Compaction Method
Each layer shall be compacted until there is no further evidence of consolidation using a steel-wheeled roller or pneumatic-tired roller meeting 2123 unless the use of vibratory or other special compaction equipment is approved by the Engineer.

Water shall be applied to the base material during the mixing and spreading operations so that at the time of compaction the moisture content is not less than 5 percent of the dry weight.

The Engineer may elect to perform density tests as shown in the Mn/DOT Grading and Base Manual, as needed to assist inspection. The actual density obtained by testing the aggregate base must meet or exceed the requirements shown in 2211.3C1 Specified Density in order to be acceptable.

C3 Penetration Index Method
The full thickness of each layer of Class 5, 6 or 7 shall be compacted to achieve a penetration index value less than or equal to
10 mm (0.4 inch) per blow, as determined by a Mn/DOT standard dynamic cone penetrometer (DCP) device. For test purposes, a layer will be considered to be 75 mm (3 inch) in compacted thickness but a testing layer can be increased in thickness to a maximum of 150 mm (6 inch) if compacted in one lift by a vibratory roller. Two DCP tests shall be conducted at selected sites within each 800 m³ (1000 cubic yard) (CV) of constructed base course. If either of the tests fails to meet the specified requirements, the material represented by the test shall require corrective action and be retested for penetration index compliance.

All aggregates prescribed to be tested under the Penetration Index Method 2211.3C3 must be tested and approved within 24 hours of placement and final compaction.

Water shall be applied to the base material during the mixing and spreading operations so that at the time of compaction the moisture content is not less than 5 percent of the dry weight.

D Workmanship and Quality

The Contractor shall construct each base course in conformity with the cross-sectional dimensions shown in the Plans and the staked grades. When the final layer of base has been completed, and at the time any additional construction is to be placed thereon, the finished surface of the base shall not vary more than 15 mm (0.05 foot) from the elevation prescribed for that point as determined from the staked grades and the typical sections shown in the Plans. When the base is placed adjacent to a pavement, the elevation of the finished surface of the base shall be referenced to the edge of the pavement.

When fine grading operations are required on the finished base prior to constructing pavement thereon, the surface elevation tolerance shall be met at the time of completing the fine grading. Any excess material deposited on the shoulders as a result of those operations, that is contaminated to the extent that it does not meet the Specification requirements for use in the aggregate shoulder, will be deducted from the pay quantities.

E Aggregate in Stockpiles

When the Proposal contains an item for stockpile aggregate, the Contractor shall, in addition to the aggregate required for the base construction, produce, deliver, and stockpile aggregate of the class specified at the designated sites as directed by the Engineer.

F Random Sampling Gradation Acceptance Method

The following provisions shall apply to the use of Class 1, 2, 3, 4, 5, 6 and 7 aggregates:

F1 Gradation Control

The Contractor and/or aggregate producer shall be responsible for maintaining a gradation control program in accordance with the random
s sampling acceptance method described in Section 5-692.705 of the Mn/DOT Grading and Base Manual. The Contractor will be permitted to proceed with and complete the base construction on the basis of the Contractor’s Certification (on Form 24346 furnished by the Engineer) that the material supplied and used conforms to the appropriate specification requirements. The Contractor shall assume full responsibility for the production and placement of uniform and acceptable materials. All payments for aggregate base materials shall be withheld until the Project Engineer receives and accepts the Contractor’s Certification and quality control testing results.

F2 Acceptance Testing

Aggregate gradation compliance will be determined in accordance with following table:

<table>
<thead>
<tr>
<th>TABLE 2211-A</th>
<th>ACCEPTANCE TESTING SCHEDULE(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantity</strong>&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td><strong>No. Lots</strong>&lt;sup&gt;(c)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Metric tons&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>less than 500</td>
<td>N/A</td>
</tr>
<tr>
<td>≥500 but less than 4,000</td>
<td>N/A</td>
</tr>
<tr>
<td>≥4,000 but less than 10,000</td>
<td>1&lt;sup&gt;(i)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

(a) In accordance with 1503, Conformity with Plans and Specifications, it is the intent of these specifications that materials and workmanship shall be uniform in character and shall conform to the prescribed target value or to the middle portion of the tolerance range. The purpose of the tolerance range is to accommodate occasional minor variations from the median zone. The production and processing of the materials and the performance of the work shall be so controlled that the material or workmanship will not be of borderline quality.

(b) Or equivalent in cubic meters loose volume or cubic meters compacted volume:

1 metric ton = 0.6 m³ (1 ton = 0.7 cubic yard) (LV) or 1 metric ton = 0.46 m³ (1 ton = 0.55 cubic yard) (CV).

(c) The use of any one kind or class of material from more than one source is prohibited without permission of the engineer according to 1601. If the contractor changes sources (with Mn/DOT’s approval), a new lot consisting of four sublots will be established provided that
the quantity equals or exceeds 4000 metric tons (tons). When a material source is changed prior to completing a lot, the remainder of the 4 samples will be taken from the previously placed materials, provided that the quantity equals or exceeds 4000 metric tons (tons). However, if the quantity placed is less than 4000 metric tons (tons), acceptance testing will be used on one test per thousand metric tons (tons).

(d) Samples for gradation testing will be taken randomly by the Engineer prior to compaction, in accordance with the random sampling method described in the Grading and Base Manual. All gradation tests will be reported to the nearest one-tenth of one percent for the specified sieves.

(e) Classes 1, 2 and 7, Shoulder Surfacing Aggregate, may be sampled from the stockpile for testing and acceptance, in accordance with 3138.3.

(f) Each lot will be divided into four sublots which are approximately equal in quantity.

(g) Each individual sample will be analyzed separately for payment.

(h) Each lot shall consist of a maximum of approximately 10000 metric tons (tons) of material, although lesser sized lots may occur due to construction constraints.

(i) Each lot will be analyzed separately for payment.

(j) One gradation sample will be taken from each subplot and tested. Payment will be based on the average results from the four subplot samples (to the nearest one-tenth of one percent) for each specified sieve.

(k) Quantities shown are the same for both metric and English units. The Engineer will have each sample tested in the field by a Mn/DOT Certified Tester or submit them to the laboratory approved by the Project Engineer for testing. A delay of at least 3 working days is anticipated before laboratory test results are available but a maximum of 8 working hours delay is anticipated for field gradations.

The individual test results or subplot averages, which are based on Table 2211-A, Acceptance Testing Schedule, shall be compared with tolerances shown in Tables 2211-B or 2211-C, Aggregate Base Payment Schedules. Acceptance for non-complying material shall be made in accordance with the respective tables. To qualify for full payment the Contractor may correct, at no cost to the Department, any lot of non-compliance material where acceptance is based on the lot criteria (greater than 4,000 metric tons (tons)) and/or the quantity of material represented by a failing test where acceptance is based on the individual sample criteria.

A 5.0% price reduction will be assessed to both individual or averaged test lots for each test result that fails to meet specified
gradations for sieve sizes not listed in Tables 2211-B and 2211-C by more than 2.0%. These price reductions are cumulative and shall be analyzed both separately and averaged by lot when applicable. When corrective action is required for acceptance of the work, in accordance with Tables 2211-B and 2211-C, the Contractor shall perform the corrective work at no cost to the Department. The Contractor shall remove the unacceptable material and replace it with acceptable material, or correct the unacceptable material on the road. In lieu of replacement or correction, the Engineer may allow (in the best interest of the Department) the Contractor to accept a price reduction instead of corrective action.

Upon completion of any corrective work required for full payment, whether it is by blending, mixing, adding and/or replacing material, the corrected material will be sampled and tested for acceptance. The entire lot shall be retested, in accordance with Table 2211-A, when the acceptance is based on the lot criteria; otherwise, retesting will be based on one sample per thousand metric tons (tons).

### TABLE 2211-B
AGGREGATE BASE PAYMENT SCHEDULE  
(4 Sublots/4 Samples)

<table>
<thead>
<tr>
<th>% Passing Outside Specified Limits*</th>
<th>4.75 mm (#4), 2.00 mm (#10), And 425 µm (#40) Sieves</th>
<th>75 µm (#200) Sieve</th>
<th>Acceptance Schedule (Price Reduction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>5.0%</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>0.2</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>0.3</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>0.4</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>0.5</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>&gt;2</td>
<td>&gt;0.6</td>
<td>Corrective Action</td>
<td></td>
</tr>
</tbody>
</table>

*Based on average of 4 tests

Price reductions for more than one failing sieve size shall be cumulative. The compensation due to the Contractor for the quantity of material represented by the failing test results shall be reduced by the sum of the respective percentages. The Contractor does not have the option of taking a price reduction in lieu of complying with the Specifications.
### TABLE 2211-C
**AGGREGATE BASE PAYMENT SCHEDULE**
*(Individual Test)*

<table>
<thead>
<tr>
<th>% Passing Outside Specified Limits*</th>
<th>4.75 mm (#4), 2.00 mm (#10), and 425 μm (#40) Sieves</th>
<th>75 μm (#200) Sieve</th>
<th>Acceptance Schedule (Price Reduction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1-0.5</td>
<td>0.6</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>0.7</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>0.8</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>0.9-1.0</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>1.1</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>1.2</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>1.3</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>1.4</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>1.5</td>
<td>9%</td>
</tr>
<tr>
<td>2</td>
<td>1.6-1.7</td>
<td>1.8</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>1.9</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>2.0</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>---------</td>
<td>2.1</td>
<td>14%</td>
</tr>
<tr>
<td>3</td>
<td>2.2-2.5</td>
<td>&gt;2.5</td>
<td>15%</td>
</tr>
<tr>
<td>&gt;3</td>
<td></td>
<td></td>
<td>Corrective Action</td>
</tr>
</tbody>
</table>

*Based on individual sample test results. Price reductions for more than one failing sieve size shall be cumulative. The compensation due to the Contractor for the quantity of material represented by the failing test results shall be reduced by the sum of the respective percentages; however, the reduction will not exceed 50 percent. The Contractor does not have the option of taking a price reduction in lieu of complying with the Specifications.
2211.3

TABLE 2211-D
BITUMEN CONTENT ACCEPTANCE SCHEDULE

<table>
<thead>
<tr>
<th>Bitumen Content (Composite Mixture)</th>
<th>Acceptance Schedule (Price Reduction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1% Substantial Compliance</td>
<td></td>
</tr>
<tr>
<td>3.2%</td>
<td>7%</td>
</tr>
<tr>
<td>3.3%</td>
<td>10%</td>
</tr>
<tr>
<td>3.4%</td>
<td>14%</td>
</tr>
<tr>
<td>3.5%</td>
<td>18%</td>
</tr>
<tr>
<td>3.6%</td>
<td>21%</td>
</tr>
<tr>
<td>3.7%</td>
<td>25%</td>
</tr>
<tr>
<td>3.8%</td>
<td>28%</td>
</tr>
<tr>
<td>3.9%</td>
<td>32%</td>
</tr>
<tr>
<td>4.0%</td>
<td>35%</td>
</tr>
<tr>
<td>4.1%</td>
<td>39%</td>
</tr>
<tr>
<td>4.2%</td>
<td>43%</td>
</tr>
<tr>
<td>4.3%</td>
<td>46%</td>
</tr>
<tr>
<td>4.4% to 4.5%</td>
<td>50%</td>
</tr>
<tr>
<td>&gt;4.5%</td>
<td>Corrective Action</td>
</tr>
</tbody>
</table>

2211.4  METHOD OF MEASUREMENT

The Engineer will measure aggregate base according to 1901 and as specified in the Contract, by mass or volume. No deductions will be made for the mass or volume of water and admixtures.

A  Aggregate Base

Aggregate base of each class will be measured as indicated by:
(1) Mass,
(2) Loose volume (LV),
(3) Compacted volume (CV), or
(4) Stockpile volume (SV).

Where variables or placement conditions make it impractical to determine the volume of placed material, the base material will be measured by mass or by loose volume (LV). The mass so measured will be converted to equivalent compacted volume on the basis of 2160 kg/m³ (135 pounds per cubic foot) of compacted base. Vehicular measure will be converted to compacted volume by methods determined by the Engineer.

B  Stockpile Aggregate

Aggregate of each class placed in stockpiles will be measured as indicated by:
(1) Mass,
(2) Loose volume (LV), or
2211.5 BASIS OF PAYMENT

Payment for the accepted quantities of aggregate base of each class at the Contract prices per unit of measure will be compensation in full for all costs of furnishing the materials and constructing the base as specified, except that separate payment will be made for any admixtures that may be specified.

No direct compensation will be made for water used in conjunction with the mixing, placing, and compacting operations.

Payment for the accepted quantities of stockpile aggregate of each class at the Contract prices per unit of measure will be compensation in full for all costs of furnishing and delivering the material as specified.

Payment will be made under items selected from the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2211.501</td>
<td>Aggregate Base, Class</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2211.502</td>
<td>Aggregate Base (LV), Class</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2211.503</td>
<td>Aggregate Base (CV), Class</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2211.505</td>
<td>Stockpile Aggregate, Class</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2211.506</td>
<td>Stockpile Aggregate (LV), Class</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2211.507</td>
<td>Stockpile Aggregate (SV), Class</td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>

NOTE: See 2105.4C and insert the words “in Stockpile” or “from Stockpile” if appropriate.

2221 Aggregate Shouldering

2221.1 DESCRIPTION

This work shall consist of constructing one or more courses of Contractor certified aggregate on shoulders adjacent to concrete or bituminous pavements. The aggregate shall be produced and placed under the Contractor’s quality control program in accordance with Section 5-692.705 of the Mn/DOT Grading and Base Manual.

2221.2 MATERIALS

A Aggregate

The class of aggregate to be used in each course will be shown in the contract.

Gradation acceptance for Classes 1, 2, 3, 4, 5, 6, and 7 will be by the random sampling method in accordance with 2211.3F. The Engineer may elect to sample Classes 1, 2 and 7 shoulder surfing aggregate from the stockpile. The stockpile sampling and testing will be
performed by Mn/DOT project personnel at the rate of one field gradation test per 1000 metric ton (ton). Acceptance will be in accordance with the provisions of 3138.3.

2221.3 CONSTRUCTION REQUIREMENTS

Construction requirements for the aggregate shouldering shall be the same as those specified in 2211.3 for aggregate base, except that surfacing aggregate may not be substituted for lower courses.

A Subgrade Preparation

The existing shoulders, or that part of the subgrade on which the shouldering is to be placed, shall be shaped and compacted to the required grades and cross sections as given for the bottom of the shouldering, provided, however, that removal of excess material will not be required if it meets the Specification requirements for the shouldering aggregate. Contaminated material shall be removed and disposed of as directed.

The Contractor may place excess aggregate from the roadbed base construction operations on the shoulder when:

1. The Engineer accepts the aggregate for use in shouldering.
2. The Contractor shapes and compacts the shoulder to a uniform grade and cross-section, permitting placement of the remaining shoulder aggregate at a relatively constant spread, so far as this can be accomplished without loading and hauling materials.

When placing aggregate shouldering on an existing shoulder, the preparation of the existing shoulder shall be as directed by the Engineer. Removal of vegetation and the shaping and compacting of the shoulder subgrade shall be incidental work for which no direct compensation will be made. Removal of excess materials from the existing shoulders will be paid for as Extra Work in the absence of specific Contract items therefore, but only to the extent that the Engineer orders the excess material to be loaded and hauled away from the immediate shoulder area.

B Placing and Mixing

The aggregate shall not be deposited or mixed on the adjoining concrete pavement or bituminous wearing course surface. Any material spilled on the pavement surface shall be removed by sweeping.

At the time of depositing the aggregate on the shoulders, the subgrade shall be so dry and compact that no rutting or displacement will occur.

In conjunction with the placement of shoulder aggregate, additional material shall be placed on private entrances and road approaches as the Engineer directs.

The Contractor may place and compact the shoulder aggregate the same day that the bituminous base or surfacing is placed, if the bituminous is not damaged by this operation.
### 2221.5

#### C  Spreading and Compacting
When Class 1, 2, or 7 aggregates are used for shouldering, compaction shall be obtained by the Quality Compaction Method.

#### D  Construction Under Traffic
The Contractor shall protect the traffic from drop-off conditions when traffic is carried during construction.
Drop-off conditions will be covered by the most current Mn/DOT Field Manual.
The final construction of the shoulder shall be in accordance with the typical section shown in the Plan.

#### 2221.4  METHOD OF MEASUREMENT
 Aggregate shouldering of each class specified will be measured by the same methods as prescribed in 2211.4.

#### 2221.5  BASIS OF PAYMENT
Payment for the accepted quantities of aggregate shouldering of each class at the Contract prices per unit of measure will be compensation in full for all costs of furnishing the materials and constructing the shouldering as specified, except that separate payment will be made for any admixtures that may be specified.
No direct compensation will be made for water used in conjunction with the mixing, placing, and compacting operations.
Except as otherwise provided for in the Contract, all costs incurred in preparing and maintaining the shoulder subgrade shall be compensated for as a part of work required in 2112 or 1514.
Payment will be as follows:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2221.501</td>
<td>Aggregate Shouldering, Class ____</td>
<td>metric ton</td>
</tr>
<tr>
<td>2221.502</td>
<td>Aggregate Shouldering (LV), Class ____</td>
<td>cubic meter</td>
</tr>
<tr>
<td>2221.503</td>
<td>Aggregate Shouldering (CV), Class ____</td>
<td>cubic meter</td>
</tr>
<tr>
<td>2221.505</td>
<td>Stockpile Aggregate, Class ____</td>
<td>metric ton</td>
</tr>
<tr>
<td>2221.506</td>
<td>Stockpile Aggregate (LV), Class ____</td>
<td>cubic meter</td>
</tr>
<tr>
<td>2221.507</td>
<td>Stockpile Aggregate (SV), Class ____</td>
<td>cubic meter</td>
</tr>
</tbody>
</table>

NOTE: See 2105.4C and insert the words "in Stockpile" or "from Stockpile" if appropriate.
Bituminous Surface Reconditioning

2231.1 DESCRIPTION
This work shall consist of reconditioning the existing bituminous surface prior to construction of bituminous overlay or surfacing courses. It shall include the reconditioning of old pavements and all types of base courses other than an untreated aggregate base.

This work does not include the removal and replacement of pavement structure items to full depth, which may be necessary to remove unstable foundation material or facilitate other subsurface construction.

2231.2 MATERIALS
A  Bituminous Patching Mixture
Bituminous patching mixture shall be the same material as will be used in the initial bituminous surfacing course that is to be constructed on the reconditioned base.

B  Mixture for Joints and Cracks
Mixture for joints and cracks shall consist of a prepared mix containing fine aggregate and bituminous material conforming to the following:

<table>
<thead>
<tr>
<th>Aggregate Gradation</th>
<th>Percent by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 12.5-mm (½ inch) sieve</td>
<td>100</td>
</tr>
<tr>
<td>Passing 2.00-mm (# 8) sieve</td>
<td>45 – 80</td>
</tr>
<tr>
<td>Passing 75-µm (# 200) sieve</td>
<td>2.0 – 7.0</td>
</tr>
</tbody>
</table>

Maximum spall content in the total aggregate sample shall not exceed 5.0 percent.

Bituminous Material Percent by Mass
Asphalt Cement 6.5-7.0

The Engineer will designate the kind and grade of bituminous material to be used. The bituminous material used shall meet 3151.

Mixing operations shall be conducted as approved by the Engineer.

C  Joint and Crack Filler (As specified in the Plans or Special Provisions)

2231.3 CONSTRUCTION REQUIREMENTS
A  General
Where so indicated in the Plans or ordered by the Engineer, the existing base or pavement shall be removed and replaced in accordance with other provisions of the Contract.
B  Surface Repair

Surface repairs shall be made as directed by the Engineer, so as to produce a satisfactory base on which to construct the pavement provided for in the Contract. All loose, unstable, or deteriorated portions of the existing base or pavement shall be removed to the extent that a stable surface will be achieved upon completion of the patching operations. All waste or surplus material shall be disposed of to the satisfaction of the Engineer.

All holes and depressions shall be filled with bituminous patching mixture in layers of a thickness approved by the Engineer. Compaction shall be obtained with mechanical tampers in areas not accessible to conventional rolling equipment. Specified density requirements will not apply.

C  Joint Repair

Existing joints and cracks in concrete pavement that are more than 6 mm (1/4 inch) shall be cleaned and refilled as specified herein, if and to the extent that the required material is provided for as a Contract item.

Joints and cracks more than 6 mm (1/4 inch) but not more than 20 mm (3/4 inch) in width shall be cleaned of old filler material and foreign matter to a depth of at least 20 mm (3/4 inch), after which they are to be filled with joint and crack filler material.

Joints and cracks more than 20 mm (3/4 inch) in width shall be cleaned of old filler material and foreign matter to a depth of at least 25 mm (1 inch), after which they are to be refilled with mixture for joints and cracks. The material shall be thoroughly tamped into place.

2231.4  METHOD OF MEASUREMENT

The accepted quantities of bituminous patching mixture, mixture for joints and cracks, and joint and crack filler, as furnished and placed, will each be measured separately by the mass or by the LV of material, as indicated in the Proposal.

2231.5  BASIS OF PAYMENT

Payment for the accepted quantities of bituminous patching mixture, mixture for joints and cracks, and joint and crack filler, at the appropriate Contract price per unit of material furnished and placed, will be compensation in full for all costs of removal and disposal of the existing deteriorated materials, and for all costs of furnishing and placing the patching or filler materials as specified.

Removal of a concrete base or pavement to full depth and width between existing joints, or by sawing, shall be accomplished as Extra Work in the absence of an item covering its removal under the provisions of 2104.
2231.5

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2231.501</td>
<td>Bituminous Patching Mixture</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2231.502</td>
<td>Bituminous Patching Mixture cubic meter (cubic yard)</td>
<td></td>
</tr>
<tr>
<td>2231.505</td>
<td>Mixture for Joints and Cracks</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2231.507</td>
<td>Joint and Crack Filler</td>
<td>kilogram (pound)</td>
</tr>
</tbody>
</table>

2232

Mill Pavement Surface

2232.1 DESCRIPTION

This work shall consist of improving the profile, cross slope, and surface texture of an existing pavement surface by machine (cold) milling preparatory to placement of another course thereon.

2232.2 BLANK

2232.3 CONSTRUCTION REQUIREMENTS

A  Equipment

Pavement milling shall be accomplished with a power operated, self-propelled cold milling machine capable of removing concrete and bituminous surface material as necessary to produce the required profile, cross slope, and surface texture uniformly across the pavement surface. The machine shall also be equipped with means to control dust and other particulate matter created by the cutting action.

The machine shall be equipped to accurately and automatically establish profile grades along each edge of the machine, within plus or minus 3 mm (1/8 inch), by referencing from the existing pavement by means of a ski or matching shoe, or from an independent grade control. The machine shall be controlled by an automatic system for controlling grade, elevation, and cross slope at a given rate.

B  Operations

The pavement surface shall be milled to the depth, width, grade, and cross slope as shown in the Plans or as otherwise directed by the Engineer. Machine speeds shall be varied to produce the desired surface texture grid pattern. Milling shall be performed without excessive tearing or gouging of the underlying material.

The pavement milling operations shall be referenced from an independent grade control in those areas where the Engineer considers such control is essential. The control shall be established and maintained by the Contractor in a manner and in such position as the Engineer approves.

Milling operations shall be conducted so that the entire pavement width is milled to a flush surface at the end of each work period, whenever the pavement is open to traffic. In case of uncompleted operations resulting in a vertical or near vertical longitudinal cutting
face, it shall be the Contractor's responsibility to minimize the hazardous effects to traffic by resloping the longitudinal face to provide a suitable taper, by constructing a temporary bituminous taper, or by otherwise providing the necessary protective measures, as approved by the Engineer. Transverse cutting faces shall be tapered at the end of each working period where traffic is permitted. To further provide for traffic, the Contractor shall also construct temporary bituminous tapers at intersecting streets, around utility appurtenances, and at all appropriate entrances during the milling operations, as ordered by the Engineer.

The Contractor shall construct the temporary milled tapers and furnish, place, and remove temporary bituminous tapers as incidental work for which no direct compensation will be made.

In areas inaccessible to the milling machine, the work shall be accomplished by other equipment or methods acceptable to the Engineer.

The surfacing removed in conjunction with the milling operations may be recycled for use on the Project in accordance with the applicable Specifications, or disposed of outside of the Right of Way as specified in 2104.3.

After the milling operations are completed to the planned depth, the milled area shall be cleaned by sweeping or vacuuming with equipment approved by the Engineer. Such cleaning shall be performed to the satisfaction of the Engineer.

Debris resulting from milling and cleaning operations shall be disposed of outside of the Right of Way as specified in 2104.3, except as otherwise authorized by the Engineer.

Milling at previously patched areas shall be performed to the required depth below the pavement surface existing prior to the previous patch being placed, and not from the surface of the patch.

The Contractor shall take care to avoid disturbing or damaging any existing drainage or utility structures on the Project. Any damage resulting from the Contractor's operations shall be repaired by the Contractor at no expense to the Department.

2232.4 METHOD OF MEASUREMENT

Pavement milling will be measured by the area of each type of surface removed. Measurements will be of those areas milled as specified, based on actual finished dimensions of the work.
2232.5

2232.5 BASIS OF PAYMENT

Payment for pavement milling at the appropriate Contract price per unit of measure will be compensation in full for all costs of performing the work as specified, including, but not limited to, traffic safety, cleanup, and disposal operations.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2232.501</td>
<td>Mill Bituminous Surface (___mm (inches))</td>
<td>............................ square meter (square yard)</td>
</tr>
<tr>
<td>2232.502</td>
<td>Mill Concrete Pavement Surface (___mm (inches))</td>
<td>............................. square meter (square yard)</td>
</tr>
</tbody>
</table>
Concrete Pavement

2301.2

2301
Concrete Pavement

2301.1 DESCRIPTION
This work shall consist of constructing Portland cement concrete pavement on a prepared base.

2301.2 MATERIALS

A Concrete

A1 Incentives/Disincentives
When the Contract includes concrete aggregate and water-cementitious incentive/disincentive provisions, they shall apply only to materials provided for or produced by the Contractor's primary concrete paving plant. The primary paving plant may be a batch plant or a ready mix plant. The use of any one kind or class of material from more than one source is prohibited without permission from the Engineer. Permission, if granted, will set forth the conditions under which the change of source is allowed.

The incentive/disincentive provisions shall not apply to materials provided for or produced by a secondary concrete plant providing mixture for minor work such as fill-ins or other work not provided by the Contractor's primary concrete plant.

A2 Blank

A3 Class R as the Coarse Aggregate
For 100 percent Class R coarse aggregate concrete mixes, the mix designations shall be as given below for the method of placement to be used.

Manual Placement....................................................... Mix No. 3A40R
Standard Machine Placement ...................................... Mix No. 3A30R
Vibratory Machine Placement ................................. Mix No. 3A20R

A4 Blank

A5 Concrete Paving Aggregate

A5a Required Preliminary Aggregate Testing
As soon as coarse and fine aggregate is available for testing, the Contractor shall contact Mn/DOT or designated representative to coordinate preliminary sampling of aggregate for concrete paving. Mn/DOT will sample and test the aggregate to update specific gravity and absorption data and perform other tests as determined by the Engineer.

A5b Blank

A5c Coarse Aggregate Quality Control/Quality Assurance (QC/QA) Incentive/Disincentive
Acceptance of the coarse aggregate for paving concrete shall be by statistical methods. This provision is in addition to all other requirements of 2301, 2461, and 3137. Sufficient aggregate must be produced 4 weeks prior to the commencement of paving operations to provide sufficient time for verification testing.

The QC/QA program for CLASS B and C Aggregates will comply with the following procedure:
(1) The aggregate producer will produce a 1000 metric ton (ton) stockpile of each fraction of aggregate that is to go into the work.
Then, production shall cease for 4 business days to check aggregate quality. The Engineer and the aggregate producer, in the presence of one another, shall take 3 split samples of each stockpile and each run the appropriate test, depending on the aggregate class, to examine aggregate quality. The aggregate producer can use this correlation to aid in the quality control of the aggregates. If the Mn/DOT test results indicate that the aggregate is acceptable, production can resume. If the test results are unacceptable, the stockpile will be rejected and the procedure will start again after the aggregate producer has corrected the operation.

(2) After acceptability is verified, the aggregate producer will continue to take quality control samples for testing at the rate of 1 sample per fraction per ½ day of production during the entire period of aggregate production. The appropriate test for the aggregate class will be run as soon as possible after sampling. For each fraction, the aggregate producer will plot the test results on a chart indicating the specification limits for the appropriate test. The aggregate producer shall make changes in the operation if the material approaches the specification limit.

(3) The Engineer will take acceptance samples at a location as close as possible to incorporation into the work (the belt leading to the weigh hopper is the suggested location). The acceptance sampling rate shall be as follows:

<table>
<thead>
<tr>
<th>Plan m³ (cubic yards) of concrete</th>
<th>Samples per fraction (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 – 10,000</td>
<td>5</td>
</tr>
<tr>
<td>10,000 – 40,000</td>
<td>10</td>
</tr>
<tr>
<td>40,000+</td>
<td>15</td>
</tr>
</tbody>
</table>

The acceptance samples will be randomly chosen. A lot representing the plan m³ (cubic yards) of concrete will be divided by the number of samples to form sublots. The number of m³ (cubic yards) in a sublot is multiplied by a random number (Attachment A) between 0.00 and 0.99 to obtain the position in the sublot for the sample. The samples will be split and half left for the aggregate producer. The Engineer's laboratory will test the samples and report the individual results. The Engineer will calculate a Quality Index (QI) for each fraction as follows:

\[
QI = X + k(s) \quad \text{where: } X = \frac{\sum X_i}{n} \\
X_i = \text{individual quality test results}
\]

<table>
<thead>
<tr>
<th>K</th>
<th>No. of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.23</td>
<td>5</td>
</tr>
<tr>
<td>1.26</td>
<td>10</td>
</tr>
<tr>
<td>1.27</td>
<td>15</td>
</tr>
</tbody>
</table>
s = standard deviation

\[ s = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n-1}} \]

For Class B aggregate the special quality requirement is absorption and:

<table>
<thead>
<tr>
<th>QI for Fraction %</th>
<th>Structural Concrete m³ (cubic yards)</th>
<th>Payment Change Per Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1.00</td>
<td></td>
<td>+ $1.30 ($1.00)</td>
</tr>
<tr>
<td>1.01 - 1.45</td>
<td></td>
<td>+ $0.65 ($0.50)</td>
</tr>
<tr>
<td>1.46 - 1.76</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1.77 - 1.85</td>
<td></td>
<td>- $1.30 ($1.00)</td>
</tr>
<tr>
<td>≥ 1.86</td>
<td></td>
<td>Recommendation of State Concrete Engineer</td>
</tr>
</tbody>
</table>

For Class C aggregate the special quality requirement is % carbonate, and:

<table>
<thead>
<tr>
<th>QI for Fraction %</th>
<th>Structural Concrete m³ (cubic yards)</th>
<th>Payment Change Per Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 15.0</td>
<td></td>
<td>+ $1.30 ($1.00)</td>
</tr>
<tr>
<td>15.1 - 24.0</td>
<td></td>
<td>+ $0.65 ($0.50)</td>
</tr>
<tr>
<td>24.1 - 31.0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>31.1 - 35.0</td>
<td></td>
<td>- $1.30 ($1.00)</td>
</tr>
<tr>
<td>≥ 35.1</td>
<td></td>
<td>Recommendation of State Concrete Engineer</td>
</tr>
</tbody>
</table>

Class A aggregates (including quartzite and gneiss), if meeting all other Mn/DOT requirements, qualify for $1.30 per m³ ($1.00 per cubic yard) per fraction incentive.

Class R aggregates are not considered in this incentive/disincentive program.

If the concrete mixture contains 3 or more fractions of coarse aggregate (such as 19 mm+, 19 mm-, 9.5 mm- (\(\frac{3}{8}\) inch+, \(\frac{3}{8}\) inch-, \(\frac{3}{8}\) inch-), only the 2 containing the highest percentage by weight are eligible for incentive. Two or more sub-fractions may be combined (such as 19 mm- (\(\frac{3}{8}\) inch-) and 9.5 mm- (\(\frac{3}{8}\) inch-) sub-fractions combined to produce the 19 mm- (\(\frac{3}{8}\) inch-) fraction) to form either the coarse or fine fraction of the coarse aggregate. The sub-fractions shall be blended by weight. Therefore, the maximum incentive for aggregate quality is $2.60 per m³ ($2.00 per cubic yard) of structural concrete.
A5d  Optional Incentive for Well-Graded Aggregate

An optional incentive of $2.60 per m³ ($2.00 per cubic yard) of concrete is available to the Contractor provided a concrete mixture is designed and produced with a combined aggregate gradation that meets the following requirements:

<table>
<thead>
<tr>
<th>Sieve Sizes</th>
<th>% Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm (2 inch)</td>
<td>0%</td>
</tr>
<tr>
<td>37.5 mm (1 ½ inch)</td>
<td>≤ 8%</td>
</tr>
<tr>
<td>25 mm (1 inch)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>19 mm (3/4 inch)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>12.5 mm (1/2 inch)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>9.5 mm (3/8 inch)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>4.75 mm (# 4)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>2.36 mm (# 8)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>1.18 mm (# 16)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>600 µm (# 30)</td>
<td>8% to 18%</td>
</tr>
<tr>
<td>300 µm (# 50)</td>
<td>≤ 18%</td>
</tr>
<tr>
<td>150 µm (# 100)</td>
<td>≤ 8%</td>
</tr>
<tr>
<td>75 µm (# 200)</td>
<td>≤ 1.6%</td>
</tr>
</tbody>
</table>

If the previous gradation is not met an optional incentive of $0.65/m³ ($0.50 per cubic yard) of concrete is available to the Contractor provided a concrete mixture is designed and produced with a combined aggregate gradation that meets the following requirements:

<table>
<thead>
<tr>
<th>Sieve Sizes</th>
<th>% Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm (2 inch)</td>
<td>0%</td>
</tr>
<tr>
<td>37.5 mm (1 ½ inch)</td>
<td>≤ 7%</td>
</tr>
<tr>
<td>25 mm (1 inch)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>19 mm (3/4 inch)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>12.5 mm (1/2 inch)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>9.5 mm (3/8 inch)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>4.75 mm (# 4)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>2.36 mm (# 8)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>1.18 mm (# 16)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>600 µm (# 30)</td>
<td>7% to 18%</td>
</tr>
<tr>
<td>300 µm (# 50)</td>
<td>≤ 18%</td>
</tr>
<tr>
<td>150 µm (# 100)</td>
<td>≤ 7%</td>
</tr>
<tr>
<td>75 µm (# 200)</td>
<td>≤ 1.6%</td>
</tr>
</tbody>
</table>

Compliance is determined based on the Contractor's composite aggregate gradation test results as verified by Agency testing.

The Agency's statistical analysis of samples for well-graded aggregate...
A6 Cementitious Materials – General

The minimum cementitious material requirements shall be (315 kg/m³ (530 pounds per cubic yard). Of the cementitious fraction, the minimum portland cement content shall be 237 kg/m³ (400 pounds per cubic yard) whether using fly ash or ground granulated blast furnace slag as a portland cement replacement (See below for Special Requirements for Quartzite and Gneiss). Any additional cementitious material necessary to meet any requirement described herein shall be the responsibility of the Contractor with no additional compensation from the Agency. Total cementitious shall not exceed 356 kg/m³ (600 pounds per cubic yard) except for high-early mixes.

Mn/DOT 2461.3D is modified to allow up to 30 percent replacement with fly ash. Portland cement may be replaced with up to 35 percent ground granulated blast furnace slag (GGBFS), however, ternary mixes (Portland cement, GGBFS, fly ash or other cementitious materials) are not allowed.

Specification 3101 is hereby modified such that the total alkalis in the portland cement (Na₂O + 0.658 K₂O) shall not exceed 0.60 percent. The total alkalis in the cementitious material shall not exceed 3.0 kg/m³ (5.0 pounds per cubic yard).

A6a Special Cementitious Requirements for Quartzite and Gneiss

If the Contractor selects to use coarse aggregate from sources identified by Mn/DOT as quartzite or gneiss and the aggregate does not comply with the 0.04 percent expansion limits of ASTM C-1293, the other cementitious material shall be:

(1) 30% of an approved fly ash meeting the following requirements:

Mn/DOT 3115 is modified such that fly ash used as cementitious material in the concrete mixture shall have a minimum SiO₂ + Fe₂O₃ +Al₂O₃ of 66.0% on a dry weight basis. In addition, it shall have a minimum SiO₂ content of 38.0%.

-or-

(2) 35% of an approved ground granulated blast furnace slag.

A7 Concrete Mix Design

The Contractor shall review the Special Provisions of the Contract to determine which of the following specifications apply. If nothing is specified then 2301.A7a shall apply. If the concrete paving is < 385 m³ (500 cubic yards) then 2461.4D7a shall apply.

A7a Small Concrete Paving Projects > 385 m³ (500 cubic yards) and ≤ 3825 m³ (5000 cubic yards)

Unless modified in the Special Provisions of the Contract, the following
shall apply:

A7a(1) Mix Design
Grade A paving concrete shall be designed and placed at a water cementitious ratio not greater than 0.40. The Mn/DOT Concrete Engineering Unit shall provide the mix design. In lieu of a mix design provided by the Mn/DOT Concrete Engineering Unit, the Contractor has the option to supply the mix design.

A7a(2) Optional Contractor Mix Design
The Contractor shall design the concrete paving mixture based on a volume of 1.000 m³ (cubic yard) according to industry standard practice.

The concrete pavement placement may commence 15 days after preliminary approval of the Contractor’s concrete pavement mix design by the Concrete Engineer. Final approval of the mixture is based on satisfactory field placement.

A7a(3) Coarse Aggregate Gradation
All coarse aggregate for concrete pavement that does not contain 100% recycled concrete shall meet the following gradation:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm (2 inch)</td>
<td>100</td>
</tr>
<tr>
<td>37.5 mm (1 1/2 inch)</td>
<td>95-100</td>
</tr>
<tr>
<td>19 mm (3/4 inch)</td>
<td>35-70</td>
</tr>
<tr>
<td>9.5 mm (3/8 inch)</td>
<td>10-30</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>0-7</td>
</tr>
</tbody>
</table>

A7a(4) Admixtures (Other than Mineral Admixtures)
An approved Type A water reducing admixture shall be used. (Approved list on file at the Departments’ Concrete Engineering Unit Website) The use of any admixtures other than air entraining agents and Type A water reducers require the approval of the Concrete Engineer.

A7b Large Concrete Paving Projects > 3825 m³ (5000 cubic yards)
 Unless modified in the Special Provisions of the Contract, the following shall apply:

A7b(1) General
The concrete pavement placement may commence 15 days after preliminary approval of the Contractor’s concrete pavement mix design and job mix formula (JMF) by the Concrete Engineer. Final approval of the mixture is based on satisfactory field placement.

A7b(2) Contractor Concrete Mix Design
The Contractor shall design the concrete paving mixture based on a volume of 1.000 m³ (cubic yard) according to industry standard practice.

Grade A paving concrete shall be designed and placed at a water cementitious ratio not greater than 0.40.

High early mixes may have up to 100% portland cement. High-early mixes are not eligible for incentive payments for water/cementitious ratio.
For the minor work such as fill-ins or other work not provided by the Contractor's primary concrete plant, the Contractor may choose to use a 3A41HE mix designed by Mn/DOT in lieu of the Contractor mix design requirement.

A7b(3) Job Mix Formula

A Formula (JMF) containing proportions of materials and individual gradations of each material plus a composite gradation. All admixtures shall also be included. The JMF shall be based on the combination of coarse and fine aggregate for the following sieves:

- 50 mm (2 inch)
- 37.5 mm (1-1/2 inch)
- 25 mm (1 inch)
- 19 mm (3/4 inch)
- 12.5 mm (1/2 inch)
- 9.5 mm (3/8 inch)
- 4.75 mm (# 4)
- 2.36 mm (# 8)
- 1.18 mm (# 16)
- 600 µm (# 30)
- 300 µm (# 50)
- 150 µm (# 100)
- 75 µm (# 200)

During the testing process, additional fill-in sieves may need to be added to prevent overloading. Table 3137-1 and Table 3137-2 and the gradation requirements of Mn/DOT 3126 are hereby deleted. The percent passing the 50 mm (2 inch) sieve shall be 100 percent; the percent passing the 75 µm (# 200) sieve shall not exceed 1.6 percent.*

*(Note: See Mn/DOT 3137.2D1i for additional requirements for coarse aggregate cleanliness.)

The JMF submittal shall include working ranges based on the composite gradation of the above sieves.

The working range limits of the composite gradation are based on a moving average of 4-tests (N=4). The working ranges are:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Working Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75 mm (# 4) sieve or greater</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2.36 mm (# 8) to 600 µm (# 30) sieve</td>
<td>+/- 4%</td>
</tr>
<tr>
<td>300 µm (# 50) sieve</td>
<td>+/- 3%</td>
</tr>
<tr>
<td>150 µm (# 100) sieve</td>
<td>+/- 2%</td>
</tr>
</tbody>
</table>

A new concrete mix design and JMF shall be submitted if the moving average falls outside of the JMF working range or any proportions of the mix design are adjusted.

A7b(4) Admixtures (Other than Mineral Admixtures)

An approved Type A water reducing admixture may be used at the discretion of the Contractor. (Approved list on file at the Departments' Concrete Engineering Unit Website). The use of any admixtures other than air entraining agents and Type A water reducers require the approval of the Concrete Engineer.

A7b(5) Water/Cementitious Ratio

The water/cementitious ratio shall conform to the requirements of Table WC-1. Statistical analysis may indicate a percentage of the production is
above or below the specified requirement. Concrete represented by water/cementitious ratios above the limits listed in the Table may be removed and replaced by the Contractor. If the Contractor elects not to remove the material and the level of payment is not defined in the table, the material will be evaluated by the Concrete Engineer as to the adequacy for the use intended. All concrete evaluated as unsatisfactory by the Concrete Engineer for the intended use shall be removed and replaced by the Contractor at no expense to the Agency.

The Agency’s determination of the water/cementitious ratio will be based on the following procedures:

1) Water Content

(a) For a concrete paving batch plant, the water added to the mix (including temper water) shall be recorded by an electronic meter approved by the Engineer that records and prints the amount of total water including temper water as part of each batch ticket.

For a ready mix plant, the water added to the mix (including temper water added and other trim water added prior to placement) shall be recorded on the computerized Certificate of Compliance. The water content for calculating w/c shall be based on the average water computed from 10 batch tickets/Certificates of Compliance surrounding the randomly selected batch ticket sample (4 previous tickets, ticket representing the random sample, 5 following tickets).

(b) For a batch plant, the water content in the mix determined in "a" shall be verified with samples taken from the plastic concrete at the plant site.

For a ready-mix plant, the water content shall be verified in the field or at the plant site at the discretion of the Engineer. Samples transported to the plant site for testing must be packaged in a manner that will prevent moisture loss.

The water content in the plastic concrete mixture is determined by test procedure AASHTO Designation: TP23-93 "Standard Test Method for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying". The test must commence within 45 minutes after the water has contacted the cementitious material.

The Contractor shall supply the microwave oven and the ancillary equipment necessary to perform the above test.

The water content in the concrete mix used for the determination of the water-cementitious ratio consists of the free water (water in excess to absorbed water) carried by the aggregate plus the water added to the mixer. The moisture contents of the aggregates (all fractions) are determined by the Agency according to the Agency Quality Assurance Testing Rate. Close coordination is required to assure that the aggregate samples taken for moisture determination represent the same material as the plastic concrete mix sample taken for microwave water content determination.

2) Cementitious Content

The cementitious content is the target value (mix design weights) printed
on the batch ticket/Certificate of Compliance as verified by cement cutoffs. Adjustments for mix going to commercial or other agency work may be necessary.

The Agency’s statistical analysis of acceptance samples for water/cementitious ratio will be based on a lot basis representing one day’s paving. Paving includes integrant curb and gutter and curb and gutter placed adjacent to the concrete mainline with the same mixture as used in the paving. A new mix design shall dictate a new lot. On the last day of paving or on the last day of using a specific mix design, the concrete involved shall constitute separate lot/sublot unless the above applies regarding less than 3 sublots.

The Agency’s acceptance samples shall be randomly chosen. The location of the sample shall be determined using a random number chart and multiplying the random number by the sublot size. (Example: Random number (0.65) x 750 m$^3$ (1000 cubic yards) results in taking a sample from the load representing the 488th cubic meter (650th cubic yard)).

The samples will be tested by Agency personnel and the individual results recorded.

The Engineer will calculate a Quality Index (QI) for each lot as follows:

\[
QI = \frac{\sum X}{n} \quad \text{where:} \quad X = \text{Individual water/cementitious tests} \quad \text{and} \quad n = \text{Number of tests}
\]

Concrete mix not meeting the 0.40 water/cementitious requirement shall not knowingly be placed in the work. Should any non-conforming material be inadvertently placed in the work, it will be accepted for payment according to Table WC-1.

<table>
<thead>
<tr>
<th>QI Value</th>
<th>Payment incentive/disincentive per m$^3$ (cubic yard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.35 or less</td>
<td>+$5.20 ($4.00)</td>
</tr>
<tr>
<td>0.36</td>
<td>+$3.90 ($3.00)</td>
</tr>
<tr>
<td>0.37</td>
<td>+$2.60 ($2.00)</td>
</tr>
<tr>
<td>0.38</td>
<td>+$1.62 ($1.25)</td>
</tr>
<tr>
<td>0.39</td>
<td>+$0.65 ($0.50)</td>
</tr>
<tr>
<td>0.40</td>
<td>0.00</td>
</tr>
<tr>
<td>0.41</td>
<td>-$0.65 ($0.50)</td>
</tr>
<tr>
<td>0.42</td>
<td>-$1.62 ($1.25)</td>
</tr>
<tr>
<td>0.43</td>
<td>-$2.60 ($2.00)</td>
</tr>
<tr>
<td>0.44</td>
<td>-$3.90 ($3.00)</td>
</tr>
<tr>
<td>0.45+</td>
<td>Determined by the Concrete Engineer</td>
</tr>
</tbody>
</table>
Price adjustments based on the Table WC-1 shall apply to Item 2301.511 (Structural Concrete) only.

A7b(6) Contractor Testing

As part of the Contract, the Contractor shall provide qualified personnel and sufficient equipment meeting the requirements listed in the Mn/DOT Concrete Manual to conduct quality control testing.

The Contractor shall calibrate and correlate the testing equipment with prescribed procedures and conduct tests in conformance with specified testing procedures as listed in the Mn/DOT Concrete and Laboratory Manuals. Gradations for both coarse and fine aggregate shall be mechanically sieved.

The Contractor shall maintain and keep current control charts. The charts shall be an easily readable size and be displayed on the testing facility wall or stored in a 3-ring binder. Test data from such characteristics as moisture content of aggregates and total water in mix, w/c ratio, composite gradation, air content and flexural strength shall be plotted on control charts. The charts shall contain the following characteristics: date, time, lot and sublot, applicable specifications and other data necessary to facilitate control of the process. Batch weight adjustments shall be noted on the control charts under a remarks column. The Engineer will approve all charting procedures.

Reports, records, and diaries developed during the progress of construction activities shall be filed at the direction of the Engineer and will become the property of the Agency. Reports shall include:

1. Copies of all test results and control charts at the completion of concrete paving operations
2. Copies of all failing test results sent by facsimile on a daily basis to the Project Engineer and the District Materials Engineer. Failure to provide daily test results shall be grounds for suspension of plant operations.

A8 Testing Rates

Testing rates shall comply with the Schedule of Materials Control unless modified in the Special Provisions of the Contract.

B Reinforcement Bars ......................................................... 3301
C Dowel Bars ........................................................................ 3302
D Steel Fabric ....................................................................... 3303
E Blank
F Concrete Joint Sealers,
   F1 Hot-Poured, Crumb Rubber Type ......................... 3719
   F2 Hot-poured, Low Modulus Type ......................... 3720
   F3 Preformed Type ...................................................... 3721
   F4 Hot-poured, Elastic Type ................................. 3723
   F5 Hot-poured, Elastic Type ............................................ 3725
   F6 Silicone Type........................................................ 3722
G Preformed Joint Filler .................................................... 3702
H Curing Materials
   H1 Waterproof Curing Paper.............................. 3752
   H2 Plastic Curing Blankets.............................. 3756
2301.3 CONSTRUCTION REQUIREMENTS

Unless otherwise stated in the Special Provisions, the "Slip Form" method of construction is the standard construction method. In this case references to the use of fixed side forms or to the use of equipment designed to ride on fixed forms shall not apply.

A  General

A1  Operation and Supervision

Construction operations shall not be started until the Engineer has determined that all equipment, tools, inspection facilities, preliminary testing, and accessories necessary for the phases of work being undertaken at the time are on the work site and meet the Specification requirements as to design, capacity, and mechanical condition.

The Contractor shall submit to the Engineer an organizational chart listing names and phone numbers of individuals and alternates responsible for mix design, process control administration, and inspection. The organizational chart shall be posted in the Contractor's on site facility.

The Contractor's quality control organization or private testing firm shall have Mn/DOT Certified Technicians. All testing and plant operations shall be overseen by a Quality Control Supervisor who is a Concrete Plant Level II Technician certified by Mn/DOT. The Quality Control Supervisor must be on site at all times or have a cellular phone in their possession and must be able to be at the plant site in a reasonable time frame when called. Individuals performing mix design calculations or mix design adjustments must be certified as a Concrete Plant Level II Technician. Individuals performing process control testing must be certified as a Concrete Plant Level I Technician.

The Agency and Contractor shall complete and sign a Paving Contact Report to verify all requirements are met.

The Contractor shall have in the Project organization a separate foreman, sub-foreman, or designated worker in charge of each phase of the work requiring direct supervision, who is authorized to receive instructions and orders in the absence of the general foreman or superintendent. Major phases of the work requiring this direct supervision shall be as follows:

(a) Aggregate producing plant, if operated as a part of the Contract.
(b) Concrete batching and mixing plant.
(c) Subgrade preparation and fine grading.
(d) Form setting (if required)
(e) Concrete placing.
(f) Finishing and curing.
(g) Joint sealing and cleanup.
2301.3

The Contractor should also have available a manufacturer's manual that explains the operation and adjustments of the major pieces of power operated equipment to be used.

A2 Combination Plant Lab – Office Requirements

The following special requirements apply for concrete paving projects which meet the requirements of 2301.2A7b.

A separate combination Plant Lab-Office shall be furnished for use during the concrete paving operation. This combination Plant Lab – Office shall be shared equally by the Concrete Paving Contractor QC technicians and the Agency QA technicians. This combination Plant Lab – Office supplied by the Concrete Paving Contractor shall be considered incidental and shall meet the requirements of Mn/DOT 1604.

The Contractor's testing facility shall be located at the plant site and be approved by the Engineer prior to the commencement of concrete production. Any other location must be approved by both the Engineer and the Concrete Engineer. The Contractor shall provide suitable space and specified testing equipment for their quality control personnel to perform the required tests.

The combination Plant Lab – Office will be constructed and equipped to all provisions of Mn/DOT 2031.3A except as modified below:

a. Minimum total floor area, based on exterior dimensions, will not be less than 21 m² (224 square feet).

b. Minimum Plant Lab floor area, based on exterior dimensions, will not be less than 13.5 m² (144 square feet).

c. Minimum Plant Office floor area, based on exterior dimensions, will not be less than 7.5 m² (80 square feet).

d. Plant Lab and Plant Office areas will be separated by a wall to effectively isolate the Plant Lab from the Plant Office.

In addition to the requirements set forth above, each combination Plant Lab – Office will be equipped to meet all the provisions of Mn/DOT 2031.3B1 (Field Office Furnishings) and Mn/DOT 2031.3B2 (Field Laboratory Furnishings) except as modified below:

(a) Plant Office Furnishings

1. Two (2) desks with minimum total exterior dimensions of ¾ m by 1.50 meters (30 x 60 inches). One each for the Agency and Contractor.

2. Sufficient desk chairs to utilize all desks and provide seating for at least two additional persons.

3. Two (2) file cabinets with two or more file drawers. One each for the Agency and Contractor.

4. To facilitate communication between the Contractor and the Engineer regarding quality control, the Contractor shall provide a working telephone, working copy machine and working fax machine. The Contractor shall provide local and long distance telephone service in the Plant office only for the duration of concrete paving operations. The Contractor shall pay for the telephone installation, the basic monthly phone service charges and the
eventual removal of the telephone. Payment for local telephone service will be considered incidental for which no direct payment will be made. The Contractor shall bill Mn/DOT for long distance phone charges by sending an invoice and a copy of the long distance charges, provided said charges were not incurred by the Contractor, his employees, his subcontractors, or suppliers.

(b) Plant Laboratory Furnishings
1. One sturdily built workbench or countertop with minimum dimensions of 0.75 x 3.65 m (30 x 144 inches) to be shared equally between the contractor and agency.
2. Shelf space above workbench or countertop or at other convenient locations, totaling a minimum of 2.5 m (8 linear feet) length by (0.20 m (8 inches) minimum width).
3. Electronic balances/scales for all materials testing.

In addition to the requirements set forth above, the combination Plant Lab – Office will meet requirements of Mn/DOT 2031.3C. Type D service will be provided with the exception that toilet and lavatory facilities are not required.

Concrete paving operations will not be permitted to begin until the combination Plant Lab – Plant Office meets all requirements herein.

A3 Equipment Restrictions

Equipment, other than sawing equipment, shall not operate on the new pavement slab until the joints have been sealed. Equipment operated on a slab shall be designed, equipped, and operated so as not to cause damage. Should any damage result, the operations shall be suspended until corrective action has been taken. In no case shall the equipment wheels or tracks be operated within 100 mm (4 inches) of the slab edge.

The Contractor shall not operate paving or other heavy equipment on a new pavement slab until the concrete has attained an age of 7 days or until it has a minimum flexural strength meeting the minimum requirements of 2301.3A7 and then only when authorized by the Engineer. The concrete test specimens shall be cast, cured, and tested as prescribed in the Mn/DOT Concrete Manual. When such paving operations are authorized, the following conditions shall be complied with:

(a) Before moving on and off the pavement, a ramp of compacted earth or other suitable material of sufficient strength and elevation shall be constructed to prevent undue stress in the pavement slab.

(b) The paving equipment shall operate on protective mats consisting of wood strips, belting, or other suitable material to prevent damage to the pavement surface and joints. The pavement surface shall be swept free of debris prior to placing the protective mats.

A4 Integrant Curb

Integrant curb is a curb that is constructed monolithically with the pavement.
2301.3

A5  Permanent Terminal Headers

This work shall consist of constructing concrete pavement terminal headers at the locations shown in the Plans and as directed by the Engineer in accordance with Mn/DOT 2301, the details shown on Standard Plate No. 1150.

A6  High Early Strength Sections

Where so indicated in the Plans or directed by the Engineer, a section of pavement shall be constructed of high early strength concrete at important road crossings, intersections, driveway entrances, or other locations where early use of the pavement may be required to accommodate traffic.

Because of the accelerated rate of hardening of high early strength concrete, the Contractor shall take such extra precautions as necessary to ensure satisfactory finishing of these sections.

High-early concrete is defined as a concrete mixture having a cementitious content greater than 356 kg/m³ (600 pounds per cubic yard).

High Early mixes shall be designed to provide a maximum water/cementitious ratio of 0.40 and a minimum flexural strength of 3450 kPa (500 psi) or a minimum compressive strength of 20.7 Mpa (3000 psi) in 48 hours. High early mixes may have up to 100% portland cement. High-early mixes are not eligible for incentive payments for water/cementitious ratio.

For the minor work such as fill-ins or other work not provided by the Contractor's primary concrete plant, the Contractor may choose to use a 3A41HE mix designed by Mn/DOT in lieu of the Contractor mix design requirement.

A7  Closed Period for New Pavement

New pavement shall not be opened to use by any traffic until the joints have been sealed.

Newly constructed pavement may be opened to use by light vehicles (axle loads of 2700 kg (6000 pounds) or less) 72 hours after the concrete has been placed.

New pavement shall be closed to use by construction and general public traffic for 7 days or according to the values listed in the Table 2301-A whichever is the shorter. When the opening of new pavement to traffic is to be determined by flexural strength, the test specimens shall be cast and tested as prescribed in 2461.4A5. The test specimens shall be cured in the same manner and under the same conditions as the pavement represented.
Table 2301-A
Minimum Strength Requirements for Opening Pavements to Construction and General Public Traffic

<table>
<thead>
<tr>
<th>Slab Thickness (mm in.)</th>
<th>Flexural Strength (Mpa psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 (6.0)</td>
<td>3.4 (500)</td>
</tr>
<tr>
<td>165 (6.5)</td>
<td>3.4 (500)</td>
</tr>
<tr>
<td>175 (7.0)</td>
<td>3.4 (500)</td>
</tr>
<tr>
<td>190 (7.5)</td>
<td>3.3 (480)</td>
</tr>
<tr>
<td>200 (8.0)</td>
<td>3.2 (460)</td>
</tr>
<tr>
<td>215 (8.5)</td>
<td>3.0 (440)</td>
</tr>
<tr>
<td>225 (9.0)</td>
<td>2.7 (390)</td>
</tr>
<tr>
<td>240 (9.5)</td>
<td>2.4 (350)</td>
</tr>
<tr>
<td>255 (10.0)</td>
<td>2.4 (350)</td>
</tr>
<tr>
<td>≥265 (≥10.5)</td>
<td>2.4 (350)</td>
</tr>
</tbody>
</table>

B Subgrade Preparations

The aggregate base construction and subgrade preparations, as provided for in 2211 and 2112 respectively, shall be completed in sufficient time to permit all tests and measurements to be completed prior to the fine grading operation. The subgrade shall then be fine graded to the required shape and grade to ensure construction of pavement meeting the specified thickness and cross section. Fine grading shall be accomplished with a template planer or other suitable machine capable of producing the necessary finish. Fine grading operations shall be completed at least 3 hours in advance of concrete placement, except on crossovers and other such small areas as the Engineer exempts.

If the slipform method of construction is used, the base course from out to out of the paver treads shall be accurately fine graded to the required elevation by an approved fine grading machine mounted on crawler treads. Base construction shall be completed and the required subgrade density obtained to a width at least 1 m (3 feet) beyond the outside edges of the pavement treads before the fine grading is performed. The aggregate base shall have sufficient stability and firmness to support the fine grading equipment and slipform paver without any serious distortion of the alignment or grade line.

Following the fine grading operations, the subgrade shall be recompacted as necessary to produce a firm smooth subgrade. Water shall be added as necessary during the recompacting operations, and the subgrade shall be maintained in a moist condition until placement of the concrete. The subgrade shall be rechecked with a suitable device prior to placing the concrete, if paving equipment or hauling equipment has been operating thereon. The Engineer may recheck the density of the base after completion.
of fine grading operations. Any disturbed material shall be recompacted.

The Contractor shall shape the shoulders in such a manner and to such an extent that surface water will drain away from the pavement and off the shoulders. The Contractor shall maintain the shoulders in that condition.

C Form Placement and Removal

C1 Form Sections

Regardless of type or design, forms shall have a height at least equal to the edge thickness of the pavement and shall have a strength and rigidity such that, when they are set in place and braced, they will withstand the mass (weight) and action of passing equipment without springing, settlement, or lateral displacement. Individual form sections shall be connected by methods that will secure the effect of a continuous form.

Form sections shall be not less than 3 m (10 feet) long except that wood forms may be 2.4 m (8 feet) or more in length. Approved flexible or curved forms of proper radius shall be used on curves having a radius of 45 m (150 feet) or less, except that, on curves having a radius greater than 30 m (100 feet), straight forms not over 3 m (10 feet) in length may be used when power operated strike-off and finishing equipment is used. The finished face of all curbing shall be constructed and finished to a line closely conforming to the Plan curvature and location. Straight forms longer than 3 m (10 feet) shall not be used on any curved line unless specifically authorized by the Engineer.

The top surfaces of all forms shall be smooth and free of localized indentations and deformities, and shall show no deviations greater than 3 mm (1/8 inch) from a straight edge having a length equal to the form section. The faces of straight forms shall show no deviations greater than 13 mm (½ inch) from a 3 m (10 foot) straight edge.

Integrant curb forms shall conform to the applicable requirements for paving forms and shall be equipped with clamps or other satisfactory means to ensure their support and alignment.

C2 Form Setting

The Contractor shall set the forms to the proper alignment and grade for a distance equal to at least 3 hours of paving time ahead of the paver, except when less than that quantity of paving remains to be done.

The foundation upon which the forms will be set shall be compacted in accordance with 2301.3B. The forms shall have a firm and uniform bearing over their whole base area; shall be tightly joined and securely staked; and shall be clean and free of accumulations of hardened concrete. The contact faces of the forms shall be coated with a chemical release agent conforming to 3902 prior to placing the concrete against them.

In the event of rain, the forms shall be removed and reset as necessary to permit drainage and comply with the above requirements.

C3 Keyway Forms

Keyway forms that are attached to the side forms may be cut off not more than 75 mm (3 inches) from each end of the form section length. All keyway forms for fixed form paving shall be manufactured to the Plan dimensions.
C4  Removal of Forms

Side forms for pavement and back forms on integrant curb shall not be removed earlier than 12 hours after the concrete has been placed, except that the Engineer may authorize earlier removal based on the procedure to be used.

Forms shall be removed in a manner that exerts no apparent shock or strain on the pavement or curb and under satisfactory conditions of visibility (such as natural daylight), as determined by the Engineer.

D  Batch Hauling

Concrete shall be hauled in trucks that are mortar tight and capable of complete discharge of the concrete. The trucks shall be equipped with vibrators to aid in such discharge. Dump type trucks shall not dump concrete directly on the grade unless approved by the Engineer, and such approval will only be granted when the dimensions of the work make other methods impractical.

Any truck operations on the base will be subject to 2301.3B.

E  Placing Metal Reinforcement

All metal reinforcement shall be clean when used. The forms shall be of the type, style, and dimensions shown in the Plans, unless otherwise approved.

Metal reinforcement shall be placed at the locations shown in the Plans and in accordance with the following:

E1  Blank
E2  Bar Reinforcement

All bar reinforcement except dowel bars will be classified as Reinforcement Bars. Reinforcement bars include, but are not limited to, joint ties and construction headers.

All reinforcement bars shall be epoxy coated in accordance with 3301.

Bar reinforcement of greater section area than that specified in the Plans may be used at the Contractor's option, but the spacing between the individual members shall not exceed the spacing shown in the Plans for the type of reinforcement and bar size specified.

Unless otherwise shown in the Plans, splices in reinforcement bars shall not be less than 40 diameters and the overlapped ends shall be securely tied with wire. All reinforcement bars shall be placed on chairs or by appropriate equipment for depressing the bars to the specified location.

The tie bar steel required for L1T joints shall be placed by an approved mechanical device attached to the spreader or paver. Such device shall space and depress the tie bar steel to the desired depth and location.

E3  Dowel Bars

The Contractor shall:

(a) Furnish dowel bar assemblies that are fabricated in single units for the appropriate lanes. Use not more than two assembled sections in any one joint for ramps, loops, and tapered sections.

(b) Secure the dowel bar assemblies so movement does not occur while concrete is being placed. See Standard Plate 1103.
2301.3

(c) Remove assembly ties and other similar materials that are parallel to the dowel bars so that there is at least a clearance of 150 mm (6 inches) from the anticipated joint centerline to ensure proper joint movement.

(d) Blank

(e) Coat the dowel bars:

(1) With a thin uniform coating of an approved form coating material meeting 3902,

(2) For a minimum of one-half of the dowel length plus 50 mm (2 inches), and

(3) Within 1 hour before covering with concrete.

(f) Mark the location of all doweled contraction joints in order to ensure accurate placement of the weakened plane of the joint during subsequent operations.

F Batching and Mixing

The Contractor shall batch and mix the concrete, and perform all related operations in accordance with 2461 and the following additional requirements.

F1 General

The Contractor shall check measuring equipment before paving operations are started and at any other time when there is evidence of improper operation. The batching and mixing of concrete shall not start until proper operations are ensured. The Engineer may suspend paving when improper operations are observed.

Admixtures shall be agitated in order to ensure homogeneous concentrations. When mixing operations are first started on the Project, the mixer timing device shall be set to produce an operating timed cycle of 75 seconds for all single drum mixers and 55 seconds for all dual drum mixers. This cycle shall remain in effect until the mechanical operating constants of the mixer can be accurately determined. The Engineer will then make such modifications in the cycle as may be necessary to conform to 2461.4C.

Batching and mixing operations shall be suspended whenever satisfactory finishing and curing of the pavement cannot be carried on properly.

F2 Cement Cutoff and Yield

The Contractor shall make positive cement cutoffs, except when the proportioning is performed in a commercial ready-mix plant and the batch is delivered to the construction site in revolving drum agitator type trucks. The positive cement cutoffs shall be made in accordance with the following provisions:

(a) A cement cutoff shall be made when approximately 250 metric tons (500,000 pounds) of cement have been used and again prior to the use of 1000 metric tons (2,000,000 pounds). Thereafter, a cement cutoff shall be made at least every 1500 metric tons (3,000,000 pounds) or once a week, whichever provides the longer time interval between cutoffs.

(b) When bulk cement is delivered directly to the concrete batching plant in
railroad cars or sealed transport trucks, the Contractor shall deliver to the
Engineer copies of the freight bills the same day they are received from
the transporting company.

(c) Blank
d) The Contractor shall advise the Engineer of the method and schedule of
cement unloading. The unloading of cement shall not begin until the
Engineer approves the operation.

Individual cutoffs shall not show an underrun in cement usage exceeding
1.5 percent of the quantity specified, nor shall the final cutoff show an overall
underrun exceeding 1.0 percent. If either one or both of these limitations are
exceeded, the concrete represented thereby will not be paid for at the Contract
unit bid prices. Unless the Engineer determines that the pavement is so
deficient in cement content as to constitute unacceptable work, the defective
concrete will be paid for at an adjusted unit price having the same ratio to the
Contract unit price as the quantity of cement used has to the quantity of
cement required. The quantity required will be the specified quantity less the
allowable underrun. In case both tolerances are exceeded, the price
adjustment will not be applied to both conditions, but only to the one that
produces the greatest payment deduction.

F3 Basic Scale Requirements

The Contractor shall inspect, test, and calibrate the scales according to
1901 and the Mn/DOT Concrete Manual, after being set up. The initial spot
check for accuracy and sensitivity shall be made before starting production
operations. A copy of the inspection certificate shall be furnished to the
Engineer.

F4 Cement Batching

The Contractor shall:
(a) Weigh bulk cement within a tolerance of 1 percent.
(b) Submit the cement records to the Engineer.

F4a Interlocking Device

The Contractor shall furnish an interlocking device when the quantity of
concrete to be produced and placed is more than 750 m³ (1000 cubic yards).

The cutoff gates for cement batching shall be automatic and shall be
controlled by the scale mechanism. The hopper inlet mechanism of the
cement batching equipment shall be interlocked with the discharge gate to
prevent opening the hopper inlet gate while the discharge gate is open. The
hopper discharge mechanism shall be interlocked with the scale mechanism to
prevent:
(1) Opening the discharge gate during filling until the full quantity of the
cement is in the hopper and the scale is balanced.
(2) Opening the discharge gate if the quantity of cement in the hopper is out
of range of the specified tolerance.
(3) Closing the discharge gate until the cement is entirely discharged from
the hopper and the scale is back in zero balance.
2301.3

F4b  Cement Scale and Cement Recorder
The Contractor shall equip the cement scale with an automatic cement recorder that will record the mass of cement in each batch.

The automatic cement recorder shall be graphic, digital, or photographic, and shall meet the requirements shown in the Mn/DOT Concrete Manual. It shall register both empty balance and total mass (weight) of each batch. The recorder shall be located and housed to protect against dust, moisture, and vibration. The housing shall be capable of being locked and, unless the recorder is photographic, the batch mass (weight) shall be observable without unlocking.

The cement scale may be equipped with manual controls for emergency use in the event of trouble with the automatic controls. In the event of trouble with the automatic controls, manual weighing will be permitted for a period not to exceed 5 days, provided the cement recorder is in proper working order.

In the cement batching operation, the Contractor will be permitted to override the automatic controls infrequently for periods not exceeding 15 minutes duration, provided the cement recorder is in proper working order. In the event of trouble with the cement recorder, the cement batching operation will be permitted to continue for a period not to exceed 1 working day, provided the automatic controls are in proper working order and the batching is performed automatically. The Contractor may substitute a photographic recorder if the malfunctioning recorder cannot be repaired within the 1 working day. The Contractor shall immediately cease batching operations if the substitute recorder is not fully operational.

F5  Aggregate Batching
The batching of aggregates shall conform to 2461.4B4.

F6  Other Cementitious Materials Batching
The batching of any other cementitious materials shall conform to 2301.3F4.

G  Placing Concrete
All main line pavement constructed by standard or vibratory machine placement methods shall be constructed in a single layer of concrete.

The Contractor shall sprinkle the subgrade as necessary to provide a moisture content in the upper 75 mm (3 inches) of the subgrade (at the time of concrete placement) such that there will not be excessive absorption of water from the concrete into the subgrade soil.

The concrete shall be deposited so as to form a continuous mass requiring a minimum of rehandling or redistribution and of sufficient depth to provide the necessary excess for subsequent finishing operations. The concrete shall not be dumped or discharged in any manner that will cause its displacement. Premixed concrete may be hauled to the placement site in dump trucks, subject to 2301.3D.

The concrete along header joints shall be consolidated by internal vibration prior to final finishing.
Manhole and catch basin frames or rings shall be set to the required elevation during the paving operations.

Water shall not be added to the surface of the concrete to aid in finishing without the approval of the Engineer. The Engineer will only give this approval to replace evaporated surface water directly behind the paver caused by a halt in forward progress from a short-term breakdown in equipment or supply of concrete. The Contractor shall supply sufficient trucks to assure a steady forward progress of the paver. Pavement sections where water is added without the approval of the Engineer shall not be eligible for incentive payment for w/c or ride and are subject to the provisions of Mn/DOT 1503 and 1512.

Should placement of concrete be temporarily suspended, the placement operations shall be resumed in such manner that will not result in a cold joint or honeycombing. If the suspension period exceeds 90 minutes, a standard header joint shall be constructed.

When placing concrete adjacent to inplace concrete pavement joints, protect all ends of transverse joints to the satisfaction of the Engineer to prevent concrete mortar from infiltrating into the existing joints and causing compression spalls.

H Fixed-Form Construction

In all cases the concrete shall be struck-off as soon as practicable after it has been deposited on the subgrade, after which it shall be screeded twice. Manual placement methods will be permitted only when the dimensions of the work make the use of standard power-operated equipment impractical or as a temporary measure in cases when the power-operated equipment breaks down. Self-propelled, power-operated finishing equipment will not be required on pavements less than 3 m (10 feet) in width nor when there is less than 2500 m² (3000 square yards) of pavement to be placed.

H1 Vibratory Machine Placement

The following requirements shall apply to fixed-form pavement construction using concrete designed for vibratory machine placement:

H1a Strike-off and Screeding

The Contractor shall use sufficient strike-off and screeding equipment to keep pace with the placement of concrete.

The Contractor shall provide at least one mechanical spreader equipped with a reciprocating screed at least 300 mm (12 inches) wide and with full width vibratory equipment, plus one standard finishing machine. A mechanical spreader shall be a unit designed for the sole purpose of spreading and consolidating the concrete between the side forms to a uniform cross section.

There shall be an initial strike-off, followed by a first and second screeding operation. The machine used for these operations shall carry a proper excess of concrete or mortar ahead of and along the full length of the screeds and vibrators, and the operations shall be conducted in a manner that will not displace or damage joint assemblies. Excess water and laitance brought to the surface by these operations shall be wasted over the forms.
Power-operated finishing machines shall be equipped with either a single reciprocating screed not less than 500 mm (12 inches) wide or with two reciprocating screeds, one of which shall be at least 300 mm (20 inches) wide.

The second screeding movement shall be carried forward for a distance of not less than 30 m (100 feet) at a time, except that, if the rate of paving progress is less than 30 m (100 feet) per hour, the distance shall be equal to 1 hour's paving progress. If the forward progress is such that the second screeding operation cannot be performed properly, the rate of concrete placement shall be reduced or additional screeding equipment shall be used.

H1b Portable Vibrator Operation

Concrete adjacent to side forms and fixed structures shall be consolidated by means of portable vibrators or by "fins" attached to full width vibratory equipment. The portable vibrator shall operate at a speed of not less than 60 Hz (3600 VPM). While in operation, the vibrator head shall not be permitted to come in contact with the subgrade. In the event of failure of the vibrator, and if no replacement unit is available, the concrete in these areas may be consolidated by means of hand spading for the remainder of the day.

H1c Full-Width Vibrator Operation

Full-width vibrators shall operate between 60 (3600 VPM) and 100 Hz (6000 VPM) in the concrete and between 70 (4150 VPM) and 115 Hz (6900 VPM) when checked in air. The vibrators may be either of the surface or internal vibration type. The vibrator impulses shall be delivered directly to the concrete and the intensity of vibration shall be sufficient to consolidate the concrete mass thoroughly and uniformly throughout its entire depth and width.

The rate of progress of the vibratory equipment and the duration of the application shall be so regulated that the concrete is fully but not excessively vibrated. Excessive vibration, as indicated by segregation or undesirable water gain in the upper zone of the pavement, will not be permitted. The operation of vibrators shall be suspended when the forward progress is interrupted.

If the vibratory equipment temporarily fails or if its use is discontinued, the work may continue by using the standard machine placement method of consolidation, provided the concrete mixture is redesigned for that method. Any increase in concrete or cement costs resulting from such change shall be borne by the Contractor.

H1d Pan Finishing

Except as otherwise provided hereinafter, all concrete that has been consolidated and screeded with power-operated machines shall be further smoothed by a pan-type float finisher. The pan-type finishing unit shall include two reciprocating screeds and the pan float. The second screed board and the pan float shall be suspended from the frame of the unit near the mid-span of the wheel base. The pan float shall not be supported by or permitted to ride on the side forms. The screeds on the pan-type finisher will be considered as performing the second screeding operation. The pan-type finishing machine shall be operated in the forward direction only, without
stops or reversals, except in case of emergency.

The use of power-operated pan floats will not be permitted on areas of pavement where the crown or elevation must be adjusted or warped to meet that of an intersecting pavement, or where the number, size, or location of manholes or other appurtenances will interfere with or delay the operation of the float. In such cases, the surface shall be finished with metal-shod long-handled floats.

**H2 Standard Machine Placement**

The concrete shall be designed for standard machine placement. The operations and equipment shall be the same as those specified for the vibratory machine method of placement, except as modified hereinafter.

There shall be at least one mechanical spreader and one standard finishing machine. On single lane construction and on widening lanes, the floating may be performed either with manual or power operated floats. Mechanical spreaders will not be required on pavements constructed 6 m (19 feet) or less in width.

Full width vibratory equipment will not be required. No consolidation of the concrete will be required, other than that obtained through operation of the finishing machine, and except as provided for concrete consolidation by means of the portable vibrator according to 2301.3H.

**H3 Manual Placement**

The concrete shall be designed for manual placement, and the manually operated screeds shall be operated over each section of the pavement so constructed as many times as necessary to produce a surface conforming to the Plan crown and gradient of the pavement.

Manually operated screeds shall be steel-shod and be equipped with vibrators, pull rods, and handles. They shall be shaped as required by the nature of the work.

**J Slipform Construction**

The concrete shall be designed for vibratory machine placement when the slipform method of construction is to be used, and the concrete shall be placed with an approved slipform paver designed to spread, consolidate, screed, and float finish the freshly placed concrete in such manner that a minimum of hand finishing will be necessary to provide a dense and homogenous pavement in conformance with the Contract. The slipform paver shall have (as one of its components) a non-oscillating extrusion plate with an adjustable angle of entry.

Consolidation shall be accomplished with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete. Vibrators shall operate at the frequencies listed for full-width vibrators in 2301.3H. Internal vibrators shall be spaced at 600 mm (24 inches) intervals maximum for slipform machine speeds of less than 5 m (16 feet) per minute and at 450 mm (18 inches) maximum intervals for speeds of 5 m (16 feet) per minute or greater. The outer vibrators shall operate at a distance of 150 to 225 mm (6 -9 inches) from the edge of the pavement.
concrete. An electronic monitoring device displaying the operating frequency of each individual internal vibrator shall be required for concrete pavement that is placed by the slipform method. The monitoring device shall have a readout display near the operator's controls visible to the paver operator and the Contracting Authority. It shall operate continuously while paving, and shall display all the vibrator frequencies with manual and automatic sequencing among all individual vibrators. The monitoring system shall also record at a minimum, the following: clock time, station location, paver track speed and operating frequency of individual vibrators. Recordings shall be made (at a minimum) after each 7.62 m (25 feet) of paving or after each 5 minutes of time. A record of the data (CD) shall be provided to the Contracting Authority upon completion of the concrete paving operation or daily, if requested.

The cost of furnishing, installing, and monitoring vibrators and vibrator monitoring devices shall be considered incidental to the Contract unit price for PCC pavement.

The concrete shall be maintained at a uniform consistency, as will produce no appreciable edge slump or irregular edge alignment. Consistency requirements will be modified as necessary. Edge slump in excess of 5 mm (1/8 inch) will not be allowed.

The slipform paving operations for mixing, delivering, spreading, and extruding the concrete shall be coordinated to provide uniform progress of the paver. If, for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately.

When specified for automatic grade control, the paver shall be so equipped. These automatic controls shall be capable of maintaining the proper elevation at both sides of the paver by controlling the elevation of one side and controlling the crown, or by controlling the elevation of each side independently. The grade reference shall be achieved by means of an erected string line.

Erected string line control shall consist of a tightly stretched wire or string, offset from and parallel to the pavement edge on one or both sides, and set parallel to the established grade for the pavement surface. The Contractor shall set this control reference and shall support the line at intervals as close as necessary to maintain the established grade and alignment. The control line shall be set sufficiently in advance of paving to avoid delays.

K Joint Construction

Unless otherwise indicated in the Plans, all joints shall be perpendicular to the subgrade. Dowel bars shall be placed parallel to the subgrade and parallel to the centerline of the pavement.

Contraction joints shall be spaced at the intervals shown in the Plans except that, adjacent to header joints, reinforced panels, railroad grade crossings, and the free ends of pavement, the spacing shall be shortened as necessary to provide panel lengths not less than 3 m (10 feet) long.

Initial joint sawing shall be approximately 3 mm (1/8 inch) wide and to
the full joint depth. The initial sawing shall be accomplished as soon as the condition of the concrete will permit without raveling and before random cracking occurs. The sequence of initial sawing shall be at the Contractor's option. Widening of the joints to full width shall not be performed until the concrete is at least 24 hours old and shall be delayed longer when the sawing causes raveling of the concrete.

The location of each transverse joint shall be marked in a manner satisfactory to the Engineer, prior to placement of the concrete and, in the case of joints that are to be sawed, the markings shall be transferred to the fresh concrete as soon as the final finishing operations have been completed. Water under nozzle pressure shall be used to remove the sawing residue from each joint and the pavement surface immediately after completing the sawing of that joint.

Preformed joint filler material for expansion joints shall be staked in place in order to maintain its proper position during concrete placement. The filler material shall have a metal shield on the top edge to protect the material and maintain proper alignment. The shield shall be removed after completion of the longitudinal floating over the joint and while the concrete is still plastic.

Transverse joints constructed in the pavement shall be extended through the integrant curb.

When placing concrete adjacent to inplace concrete pavement joints, protect all ends of transverse joints to the satisfaction of the Engineer to prevent concrete mortar from infiltrating into the existing joints and causing compression spalls.

1. **Surface Finishing**

After the concrete has been consolidated, screeded, and floated, the pavement surface shall be given a final finish texture. This final finish shall be obtained by drawing a carpet drag longitudinally along the pavement before the concrete has attained its initial set. The drag shall be mounted on a bridge. The dimensions of the drag shall be the width of the concrete placed by a longitudinal length having sufficient surface contact to produce a texture satisfactory to the Engineer.

The carpeting for the carpet drag shall be an artificial grass type having a molded polyethylene pile face with a blade length of 15 to 25 mm (5/8 - 1 inch) and a total minimum mass of 2.35 kg/m² (weight of 70 ounces per square yard). The backing shall be of a strong, durable material not subject to rot, that shall be adequately bonded to the facing to withstand use as specified.

In addition to and immediately following the carpet drag, provide the pavement surface with a transverse metal-tine texture. This operation requires a mechanized device providing a randomized spacing of 16-26 mm (approximately 5/8 - 1 inch). The required tine width is 2-3 mm (approximately 1/12 - 1/8 inch) and the required tine depth is 3-8 mm (approximately 1/8 - 5/16 inch) with care not to dislodge coarse aggregate particles. Manual methods for achieving similar result may be used on ramps and other locations approved by the Engineer. Other texturing equipment
may be approved for use provided an equivalent texture is obtained.

The above specified metal-tine texturing will not be required on such subsidiary paving areas as cross-overs and parking lanes as the Engineer exempts, or on certain restricted speed limit areas (under 55 km/h (35 miles per hour)) as specifically exempted in the Contract or by the Engineer.

M Concrete Curing and Protection

The Contractor shall:

(1) Cure and protect the concrete by the blanket curing method or one of the membrane curing methods.
(2) Cure the entire pavement surface and edges as soon as surface conditions permit after the finishing operations.
(3) Continue curing and protecting the concrete for at least 72 hours.
(4) Place the curing media on the pavement edges within 30 minutes after removal of the forms when side forms are used.
(5) Extend the minimum curing period to 96 hours when fly ash or Portland-pozzolan cement substitutions are used.
(6) Use the extreme service membrane curing method after September 15 north of the 46 degree parallel, after October 1 south of the 46 degree parallel, and before April 15.
(7) Provide sufficient curing blankets as described in 2301.3M1 to readily protect the concrete from rain and cold temperature when the membrane curing method is used.

M1 Blanket Curing Method

The pavement surfaces shall be covered with waterproof paper or plastic sheeting as soon as possible (without marring the pavement) after completion of the finishing operations.

The curing blankets shall be in such a condition and shall be so placed as to provide an airtight and moisture proof covering that will prevent loss of water vapor from the underlying pavement during the curing period. When placed, the adjoining blankets shall overlap at least ½ m (18 inches). This lap shall be secured with a windrow of earth to form a closed joint, and each blanket shall have a windrow of earth along the edges of the pavement to hold the blanket in place. Additional mounds of earth shall be placed at random over the blanket to prevent displacement or billowing of the blankets by the wind. After removal of forms, the extra width provided in the blankets or the stringer strips shall be folded down over the sides of the pavement and be secured by a continuous windrow of earth as a seal. Plowing of this windrow into place will not be permitted.

M2 Membrane and Extreme Service Membrane Curing Method

The exposed surfaces of the concrete shall be coated with membrane curing compound immediately after the last texturing operation. The only exception is when the concrete must be protected from adverse weather conditions and the Contractor elects to do this by placing plastic sheeting over the concrete; the curing membrane must then be applied immediately after the sheeting is removed. The compound shall be applied with an approved fully-automatic spraying machine, at the minimum rate of 4 m²/L (150 square
feet per gallon) of surface area.

Hand operated spray equipment may be used for applying the compound on pavement edges and irregular shaped surfaces.

Before being placed in the spray equipment, the compound shall be thoroughly mixed in the shipping containers by the use of compressed air, or by other approved means. All emulsion type cures shall be protected from freezing while in storage on the job site and while in the spray equipment.

The equipment shall be operated in a manner that will direct the membrane compound to the surface from two different lateral directions. When a single set of nozzles is mounted on a bar that extends longitudinally over the pavement, the compound shall be applied in two passes of the nozzles over the surface, one in each direction. When two sets of nozzles are mounted on two transverse lines over the pavement in a staggered manner and the membrane compound from either set of nozzles will uniformly cover the pavement surface, application may be accomplished in one pass of the unit. If used, the spray bar drive system shall operate independently of the wheels or track drive system. The equipment shall also include a storage tank with an agitator, a filter system, check valve nozzles, and a shield to control loss of material by wind action.

Should any spot check indicate a deficiency in material usage appreciably below the specified minimum rate, the surface area in question shall be resprayed or shall be covered with curing blankets. Also, should the membrane film become damaged at any time within the required curing period, the damaged areas shall be repaired immediately by respraying.

Joint Sealing

The Contractor shall not seal joints until they have been inspected and approved by the Engineer. At the time they are sealed, the concrete shall be surface dry and the joints shall be thoroughly cleaned of all debris, dirt, dust, and other foreign matter, including accumulations of concrete. Just before the joints are sealed, the Contractor shall clean the joints with a jet of compressed air under pressure of not less than 580 kPa (85 pounds per square inch). The Contractor shall seal integral or tied curb joints with the same joint sealer as used to seal the pavement joints.

Table 2301-N defines what type of sealant shall be used in the longitudinal joints based on what sealant type is used in the transverse joints.
2301.3

Table 2301-N

<table>
<thead>
<tr>
<th>If the transverse joints is:</th>
<th>Seal the longitudinal joints with:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3721 – Preformed Elastomeric</td>
<td>3723 – Hot Pour</td>
</tr>
<tr>
<td>3722 – Silicone</td>
<td>3723 – Hot Pour</td>
</tr>
<tr>
<td>3725 – Hot Pour</td>
<td>3725 – Hot Pour</td>
</tr>
</tbody>
</table>

If the type of sealant for transverse joints is not specified elsewhere in the Contract, the Contractor shall select an approved 3722 silicone sealant from the list of approved products available on Mn/DOT’s Concrete Engineering Unit website.

When any fraction of the coarse aggregate in the concrete mixture is Class B aggregate, joint sealing with 3722 silicone is not allowed.

The handling and placing of joint sealer material shall be performed in accordance with the following provisions:

N1 Hot Poured Sealers

Hot poured sealers shall be heated in a double-boiler type kettle or melter having the space between inner and outer shells filled with oil or other heat transfer medium. The heating equipment shall include automatic temperature control, mechanical agitation, and recirculating pump provisions. Since some materials are subject to damage by overheating, reheating, or prolonged heating, proper care and equipment shall be used as recommended by the manufacturer of the sealer material.

Prior to final compressed air cleaning, the joint walls shall be lightly sandblasted.

The ambient temperature of the pavement shall be above 4°C (39°F) during application of the sealer.

N2 Silicone Sealers

Silicone sealers shall be installed according to manufacturers recommendations.

Joints shall be filled in a neat, workmanlike manner and in conformance with the tolerances shown in the Plans. The use of a backup material or bond-breaker in the bottom of the joint will be required to control the depth of sealant, achieve the desired shape of the sealant, and support the sealant against indentation and sag. The backup and bond-breaker materials shall be compatible with the sealer. Any joints filled above permissible level shall be corrected by removing and replacing the sealer at no expense to the Department.

As the joint filling operations progress, the sealant surface shall be dusted with talc or be covered with single layer paper tissue to prevent small incompressible particles (stone pebbles and chips) from bonding to the exposed tacky surface.

Heating and filling operations shall be coordinated so that no more sealer material is melted than can be used the same day. Once the sealer material has been heated to application temperature it shall be so maintained until it is
placed. The sealer material shall be placed within 4 hours after the initial heating to the application temperature.

**N3 Preformed Sealers**

The seals shall be furnished in one continuous length for each joint, except that:

(a) In contraction joints, butt splices will be permitted at longitudinal joints, and

(b) In expansion joints, one butt splice per lane width will be permitted, provided the splice is made by factory methods that have been approved by the Materials Engineer.

In its final position in the joint, the upper corners of the preformed seals shall be below the pavement surface as shown in the Plans, and the walls of the seal shall not fold over at the top of the joint.

Stretching of the sealer material in the installation process shall not exceed 5 percent of the joint length.

Wherever an expansion joint abuts aggregate or bituminous surfaced shoulders, the ends of the expansion joint shall be sealed in the same manner as the top portion of the joint. A wedge-shaped section shall be removed from the bottom part of the seal where it makes a right angle turn from the top to the side of the joint. The seal shall extend to the bottom of the pavement. No shouldering shall be placed in the areas of the expansion joints until the vertical joint ends have been so sealed.

**N4 Preformed E-8 Expansion Joint Sealer**

The preformed material utilized for sealing the E-8 expansion joints shall be one of the following or an approved equal:

(A) "Pressure-Relief"

(B) "Eva Seal"

Material shall be installed according to the manufacturers recommendations.

**P  Workmanship and Quality**

**P1a Surface Requirements**

The Engineer will only accept pavement that meets the specified requirements within permissible tolerances for payment at the Contract bid prices. Pavement that fails to meet the minimum requirements when tested in the prescribed manner is considered defective. Defective pavement is subject to the provisions made herein for correction or adjusted payment. In addition, the concrete incorporated in the work is subject to 2461.

The Engineer will determine the limits of each individual defective pavement area and, when such areas are subject to price adjustment, the area is computed to the nearest whole square meter (square yard), except that areas of less than 1 m² (square yard) are considered 1 m² (square yard). The condition of each individual defective area of pavement is assessed based on the greatest deficiency within that area.

If any random or uncontrolled crack occurs in concrete pavement, the Engineer may require replacement of the pavement or portions thereof or require repairs and/or may require a reduced payment. If the Engineer
approves repair of the pavement, the Contractor shall repair the pavement using dowel load-transfer techniques listed in the latest Department's Rehabilitation Standards/Details. The Contractor shall submit to the Engineer for approval, the specific standard technique intended for repair. After approval by the Engineer, the Contractor shall perform replacement or repair work at no expense to the Department. The Contractor shall replace failed repairs at no expense to the Department. Acceptance of the repairs shall comply with the acceptance procedure for the pavement portion of the Project.

P1b Surface Smoothness

After completion of the initial curing period and prior to the opening of the roadway to traffic, the Contractor shall test the pavement surface for surface smoothness and ride quality. Surface Smoothness and Ride Quality shall be measured with a 7.62 m (25 foot) California type profilograph, or a Lightweight Inertial Profiler (IP), which produces a profilogram (profile trace of the surface tested). Either type of device must be certified according to the procedure on file in the Mn/DOT Concrete Engineering Unit. See 2301.3P1c to determine if ride quality is required.

The Contractor shall furnish a properly calibrated, documented, and certified 7.62 m (25 foot) wheel base, California type, computerized profilograph or Lightweight Inertial Profiler (IP) and competent operator in its operation to measure pavement surface deviations in the longitudinal direction. The computer shall smooth the profile using a third-order Butterworth filter with a cutoff wavelength of 0.6096 m (2.0 feet). The computer shall generate a profile index using 0.2 inch blanking band and shall use a 7.62 mm (0.3 inch) bump threshold to identify “must grind” locations. Operate the profilograph in accordance with the manufacturer's instructions and at a speed no greater than a normal walk. Operate the IP at the optimum speed as defined by the manufacturer. To determine the profile index for mainline pavement, irregular pavement and ramps, make one pass in the right wheel path (2.7 m (9 feet) from center line). Run the profilograph or IP in the direction of driving traffic.

Make runs continuous and stop approximately 30 m (100 feet) prior to a construction header. Evaluate construction headers for smoothness on the next subsequent pass. Evaluate for smoothness all terminal headers that tie into existing pavement and the existing portland cement concrete pavement existing approximately 15 m (50 feet) adjacent to the terminal header. Bridge approach panels and bridge surfaces are exempt from these requirements; however, paving start-up areas are not exempt. Lift the test wheel and clearly label the profilogram to mark the beginning and end of each trace, each equation and each 152.4 m (500 foot) marker. Completely label each trace to show the Project number, stationing, lane, wheel pass, date paved, date tested and the operator's name. Make runs within 48 hours of pavement placement.

Turn over the profile index (California Test Method 526 on file) test results and the trace to the Engineer within 48 hours of each run. The trace shall include identification of all bumps and dips and the signature of the
operator. This data is also used for ride quality determination when required. The Engineer may test the entire Project length by a Mn/DOT certified independent source. If the Engineer determines that the Contractor's certified test results are inaccurate, the Contractor is charged for this work at a rate of $500 per lane 1.6093 km (1 mile), with a minimum charge of $1000.

When the profile trace shows a successive, uninterrupted bump, dip, or dip, bump combination (up to a maximum of 3 alternating trace deviations that relate to one bump or dip on the roadway), identify and evaluate these occurrences as one event.

In the longitudinal direction, determine deviations according to California Test Method 526. In the transverse direction, determine deviations using a 0.9144 m (3 foot) straight edge.

The Contractor shall correct all pavement areas represented by bumps having deviations of 7.62 mm (0.3 inches) or more in 7.62 m (25 feet) in the longitudinal direction, or 7.62 mm (0.3 inches) in 0.9144 m (3 feet) in the transverse direction using an approved texture planing grinding device consisting of multiple diamond blades.

Bumps between 7.62 mm (0.3 inches) and 10.16 mm (0.4 inches) may remain in place without correction or penalty in sections with a speed limit of greater than 68 km/h (42 MPH) if the ride is satisfactory in the judgment of the Engineer.

Bumps between 7.62 mm (0.3 inches) and 13 mm (½ inches) may remain in place without correction or penalty in sections with a speed limit of less than 68 km/h (42 miles per hour) if the ride is satisfactory in the judgment of the Engineer. For uncorrected bumps greater than 13 mm (½ inches) which the Engineer allows to remain in place, the Engineer will assess a $900 penalty for each bump in each traffic lane.

If the Engineer orders, the Contractor shall correct all pavement areas represented by dips of 13 mm to 25 mm (½ inch to 1.0 inch) in 7.62 m (25 feet) in the longitudinal direction, or in 0.9144 m (3 feet) in the transverse direction by removal and replacement of the pavement or by using an approved texture planing grinding device consisting of multiple diamond blades. If the Engineer does not order corrective action, the Contractor is assessed a $900 penalty per lane for each uncorrected dip between 13 mm to 25 mm (½ inch to 1.0 inch). If dips exceed 25 mm (1 inch), the Contractor shall remove and replace the pavement.

At no cost to the Agency, the Contractor shall remove all bumps and dips described above, surface test and provide necessary additional corrective work to achieve the required surface smoothness or riding quality.

All costs relative to Contractor providing the profilograph and the appropriate profile index and traces are included in the unit bid price for 2301.502, Concrete Pavement, Standard Width and Item 2301.503, Concrete Pavement, Irregular Width.

P1c  Ride Quality

The Engineer will determine the final ride quality based on the results of the California profilograph or IP data provided under 2301.3P1b as modified.
2301.3

herein. Paving Projects less than 0.8 km (½ mile) in continuous length and those portions of a paving project where the posted vehicle speed is anticipated to be less than 68 km/h (42 miles per hour), as determined by the Engineer are exempted from these riding quality requirements. The occurrence of bridges shall not interrupt the continuity determination, but the bridge surface and approach panels are not included in the ride quality determination. All pavements within 75 m (250 feet) of a terminal header that is not adjacent to a paved surface are exempt.

(1) Each lane is divided into 0.1609 km (one-tenth mile) sections and tested by the California profilograph or IP.

(2) Remaining subsections shorter than 0.1609 km (one-tenth mile) is tested according to (1) above, but is prorated for equivalency in the riding quality.

(3) Sections or subsections not excluded, which have riding quality greater than 63.13 mm/km (4.00 in/mile) but less than or equal to 94.70 mm/km (6.00 in/mile) as measured by the California profilograph or IP are accepted at the unit bid price.

(4) Sections or subsections not excluded, which have riding quality greater than 94.70 mm/km (6.00 in/mile) but less than or equal to 126.26 mm/km (8.00 in/mile) as measured by the California profilograph or IP are accepted at the unit bid price less a payment deduction determined according to Table 2301-P1.

(5) Sections or subsections that have a profile index greater than 126.26 mm/km (8.00 in/mile) will require removal and replacement or texture planing to a profile index of 94.70 mm/km (6.00 in/mile) or less at the Contractor’s option. Sections or subsections that have a profile index greater than 94.70 mm/km (6.00 in/mile) may be texture planed to eliminate payment reductions. Planing to provide a bonus is not acceptable.

(6) Sections or subsections not excluded, which exhibit an exceptional riding quality less than 63.13 mm/km (4.00 in/mile), when tested by the California profilograph or IP, are paid at the unit bid price plus a bonus according to Table 2301-P1.
The ride quality determination by the California profilograph method requires that the profilograph or IP is computerized to assimilate and store pavement profile data. All mainline pavement except those sections exempt above, are subject to (1) thru (6) above.

For easy review by the Engineer, the Contractor shall provide a profile index test summary report including the: station, length, square meters (square yards) represented, and price adjustment for each 0.1609 km (one-tenth mile) section. Adjacent lane results are reported in an adjacent column on the summary report.

No section or subsection will receive a riding quality bonus if more than 5 percent of the section or subsection is corrected by surface texture planing. Texture planed areas of sections are not eligible for incentive bonuses.

<table>
<thead>
<tr>
<th>Table 2301-P1 (Metric)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2301.3P1c Profile Index – 0.2 Inch Blanking Band</td>
</tr>
<tr>
<td>PI (millimeters per kilometer)</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>0.00 – 63.13</td>
</tr>
<tr>
<td>63.13 – 94.70</td>
</tr>
<tr>
<td>94.70 – 126.26</td>
</tr>
<tr>
<td>&gt;126.26</td>
</tr>
<tr>
<td>** Remove and Replace or Diamond Grind to a PI of 94.70 or less</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2301-P1 (English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2301.3P1c Profile Index – 0.2 Inch Blanking Band</td>
</tr>
<tr>
<td>PI (inches per mile)</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>0.0 – 4.0</td>
</tr>
<tr>
<td>4.0 – 6.0</td>
</tr>
<tr>
<td>6.0 – 8.0</td>
</tr>
<tr>
<td>&gt;8.0</td>
</tr>
<tr>
<td>** Remove and Replace or Diamond Grind to a PI of 6.00 or less</td>
</tr>
</tbody>
</table>
2301.3

P2 Thickness Requirements

The finished pavement thickness will conform to the thickness shown in the Plans or as modified, in writing, by the Engineer. Modifications by the Engineer will be considered as being the plan thickness. Prior to the final acceptance of the work, the Contractor will core the pavement, as marked by the Department, for use as test specimens to verify the pavement thickness.

Coring will not begin until the new pavement has attained an age of 7 days or until control beams have attained a flexural strength of 3450 kPa (500 pounds per square inch). The Contractor will be responsible for filling the core holes with 3U18 concrete or another concrete mix approved by the Engineer. The Contractor will be responsible for all traffic control related to coring. All unacceptable cores and cores taken to delineate deficient pavement as outlined in 2301.3P2 or 2301.3P3 will be at the Contractor's expense. Coring will be in accordance with the following procedure:

The Contractor will determine the number of cores required and their location using a random number procedure. The number of cores required will be calculated as follows:

(a) On each Project (and on each roadbed of a divided highway), main line pavement of each width, thickness and type will be divided into a series of 1500 m (5,000 foot) sections and one fractional section (or one fractional section if the total length is less than 1500 m (5,000 feet)), beginning at the point nearest the end of the Project shown in the Plans as the Beginning of the Project. Each loop and each ramp at each grade separation will be considered as one fractional section provided the thickness is the same; however a minimum of one core must be taken from each loop and/or ramp.

(b) One random core will be drilled from each 300 meter (1,000 foot) increment in each traffic lane of each 1500 meter (5,000 foot) section. In each fractional section over 150 meter (500 feet) in length, random cores will be drilled at the minimum rate of one core per 300 meter (1,000 feet) of traffic lane, but not less than a total of three cores.

(c) Selective cores may be taken as the Engineer directs, in addition to the random core program described above, but they will not be considered or used in computing the average thickness of acceptable pavement sections.

The Contractor will cut 100 mm (4 inch) nominal diameter cores at marked locations, other size cores will not be accepted. The cores will then be laid next to their holes in a curing condition (e.g., wrapped in wet burlap).

NOTE: If the age of the concrete pavement is older than 28 days, the cores will not be required to be stored in a curing condition. The Contractor will take precautions to ensure the quality of the cores. Cores that are out of round, have ridges, not perpendicular, etc. will not be accepted.

The Engineer will field measure the core thickness and verify (Field ID Number) the cores. Exploratory cores will be taken if the field measurements show any thin pavement, as described herein.
The contractor, accompanied by the Engineer, will pick up the cores and store them in a curing condition (water tank, 15-25° C (60-80°F)) if necessary, at the Department's field office.

The Contractor, accompanied by the Engineer, will transport the cores to the Mn/DOT's Office of Materials in a manner that will ensure their integrity. Examples of this would be to transport the cores in a bed of wet sand or to band the cores in a pyramid shape on a pallet, wet down and cover with plastic.

The contractor will be responsible for supplying all materials required for ensuring the integrity of the cores.

The pavement thickness will be determined by measuring the length of the cores in accordance with the procedure on file at the Office of Materials. This procedure provides for obtaining the average length of the core in one operation by the use of nine probes that are interconnected in a hydraulic linkage. The core length will be recorded to the nearest millimeter (0.05 inch).

Whenever any core shows a length deficiency of more than 10 mm (½ inch) from the planned thickness, exploratory cores will be taken. The first exploratory cores at any location will be taken 5 m (10 feet) on each side of the deficient core location and at the same distance from the pavement centerline, and one will be taken in the adjacent traffic lane if it was placed in the same operation. If the length of each one of the first exploratory cores is equal to or greater than the plan thickness of the pavement minus 10 mm (½ inch), no additional cores will be taken in that location. If any or all of these cores are not within such limitations, additional exploratory cores will be taken at intervals of 5 to 10 m (10-25 feet), as directed by the Engineer, at the same distance from the pavement centerline in the same lane as the original core. The coring will proceed in the direction of the deficiency until cores of satisfactory length are obtained.

Wherever the cores show a thickness deficiency greater than 10 mm (½ inch), the pavement will be considered to be defective. The defective pavement area will be considered as the entire area surrounding the deficient core (or cores) within a traffic lane and between acceptable cores. The remaining areas in an increment where the cores show a thickness deficiency no greater than 10 mm (½ inch) will be considered as acceptable pavement.

Where the cores are deficient in length by more than 10 mm (½ inch) and the concrete also has an air content less than 3.0 percent, the Contractor will remove and replace the defective pavement.

Where the cores are found to be deficient in length by more than 10 mm (½ inch) and the pavement represented by those cores is not required to be removed and replaced for other deficiencies, the Contractor may at his option either remove and replace the defective pavement or leave it in place in consideration of the payment deductions provided for herein, with the exception that the Engineer may order the removal and replacement of any pavement that is deficient in thickness by more than 25 mm (1 inch), in which case the following deductions will not apply.
Where the cores show a thickness deficiency exceeding 10 mm (½ inch), but less than 25 mm (1 inch), the pavement represented by those cores will not be excluded from the pay quantities; however, a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and $25.00 per square meter ($20.00 per square yard). Pavement represented by cores showing a thickness deficiency of 25 mm (1 inch) or more will be excluded from all payments plus a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and $25.00 per square meter ($20.00 per square yard). These deductions will be assessed in lieu of removing and replacing the areas of pavement which are deficient in thickness.

All acceptable random core lengths (not over 10 mm (½ inch) thickness deficiency) in each increment of a section or fractional section will be used to compute the average pavement thickness in each increment, except that where the length of any core exceeds the Plan thickness by more than 5 mm (0.30 inch), that core length will be limited to the Plan thickness plus 5 mm (0.30 inch). The average pavement thickness for each section or fractional section will be computed as the summation of the average thicknesses of the individual increments in the section or fractional section divided by the number of increments.

Whenever the average thickness of the acceptable pavement in a particular section or fractional section of the mainline pavement is found to be less than the Plan thickness by more than 3 mm (0.10 inch) or when the average thickness of the acceptable pavement in a fractional section of a Loop or Ramp is found to be less than the Plan thickness by more than 5 mm (¼ inch), the acceptable pavement in that section or fractional section (excluding any areas of defective pavement whether or not they have been removed and replaced acceptably) will be paid for at the Contract bid price, less a payment deduction determined in accordance with the following schedule:

**TABLE 2301-3**

<table>
<thead>
<tr>
<th>Thickness Deficiency Exceeding the Permissible Deviations</th>
<th>Deduction Per Square meter (square yard) of Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mm and below (0.01 to 0.08 inch, Incl.)</td>
<td>$0.20</td>
</tr>
<tr>
<td>Over 2 mm to 4 mm (0.08 to 0.16 inch, Incl.)</td>
<td>0.40</td>
</tr>
<tr>
<td>Over 4 mm to 6 mm (0.16 to 0.24 inch, Incl.)</td>
<td>0.60</td>
</tr>
<tr>
<td>Over 6 mm to 8 mm (0.24 to 0.32 inch, Incl.)</td>
<td>0.80</td>
</tr>
<tr>
<td>Over 8 mm to 10 mm (0.33 to 0.40 inch, Incl.)</td>
<td>1.00</td>
</tr>
</tbody>
</table>
2301.4 METHOD OF MEASUREMENT

Concrete pavement construction will be measured in terms of the several items of work as provided for herein, with all measurements being subject to adjustment as provided for in 2301.3P.

A Concrete Pavement

Concrete pavement will be measured by area based on the specified dimensions, including the area covered by integrant curb, and the area thus obtained will represent the surface area of the pavement as constructed. Irregular width pavement will be measured and paid for separately, if so indicated in the item name, but the pavement of every thickness and type will be included under the same item.

Included in the standard width measurement will be all uniform width pavement. Irregular width pavement will include all tapers and irregular shapes.

B Structural Concrete

Structural Concrete will be measured by volume based on the Plan thicknesses and the computed areas of concrete pavement. High early strength concrete sections will be measured separately only when and to the extent that separate compensation is provided therefor. Otherwise, the volumes of all pavement will be included in a single pay item, without regard to grade or strength of concrete or the type, width, and thickness of pavement.

C Pavement Reinforcement

Pavement reinforcement will be measured by area of pavement constructed with metal reinforcement. Areas will be measured separately by type of reinforcement as shown in the Plans, without regard to the number of layers used, and with no allowance for laps, splices, waste, and supporting devices.

D Expansion Joints

Expansion joints of each design designation, as detailed in the Plans, will be measured separately by length along the joint line.

E Reinforcement Bars

Reinforcement bars will be measured by mass (weight) prior to coating with epoxy, in accordance with 2472.4A. No measurement will be made under this item of those bars that are paid for as pavement reinforcement.

F Integrant Curb

Integrant curb of each design will be measured separately by length.

G Dowel Bars

Dowel bars will be measured by the actual number of individual dowels placed. No measurement will be made under this item for dowels that are paid for as a part of expansion joint construction.

H Bridge Approach Panels

When the Proposal contains an item (or items) for construction of bridge approach panels, their construction will be measured and paid for separately as complete in place items. Measurements will be as indicated in the
Proposal, either by the number of complete panels of each design, or by the total area of all panels of the same basic design. In the absence of such items, the panel construction will be measured for payment under the several items provided for pavement construction.

J Concrete Coring

The Engineer will measure the number of cores designated in the Contract or ordered by the Engineer that are acceptably taken, identified, and delivered as required.

K Permanent Terminal Headers

Measurement will be made by the meter (linear foot) of terminal header constructed as specified.

2301.5 BASIS OF PAYMENT

Payment for concrete pavement under 2301.501, 2301.502, or 2301.503, at the Contract bid prices per unit of measure will be compensation in full for all costs of constructing the pavement as specified, exclusive of those costs that are compensated for separately under other Contract items. The bid price includes all costs of fine grading, forming, spreading, screeding, finishing, curing, and protecting (the concrete, together with any other costs incidental to the pavement construction that are not covered by other items.

Payment for structural concrete at the Contract price per unit of measure will be compensation in full for all costs of producing, delivering, and depositing the concrete as specified, including all costs of the batch materials, mixing operations, and other incidentals involved in furnishing concrete for the work, except as otherwise provided by the following:

(a) Blank

(b) Blank

(c) High Early Concrete Mixes - Separate Pay Item: No extra compensation will be provided for the additional cement required in the production of high early strength concrete furnished as a separate pay item.

(d) High Early Concrete Mixes - Engineer's Ordered: In absence of a separate pay item for high early strength concrete, compensation will be provided in the amount of 20 percent above the Contract cubic meter (yard) price for standard strength concrete for the quantity ordered by the Engineer. The Contractor will also receive compensation for additional cement when the total cementitious exceeds 130% of the minimum cement content for the concrete mixture designation involved at a rate of invoice plus 15 percent. The Contractor shall also be compensated for the difference in cost of substituting cement for fly ash at the rate of the differences of the increased invoice costs plus 15 percent.

(e) Blank

(f) High Early Concrete Mixes – Contractor Requested, Engineer Approved: No extra compensation will be provided for high early strength concrete when requested by the Contractor.

Payment for pavement reinforcement of each type specified at the Contract prices per unit of measure of pavement in which the reinforcement is
placed will be compensation in full for all costs of furnishing and placing the metal reinforcement as specified, including all costs of tie wires, supporting devices, splicing, intermediate strike-off, and any other operations or materials incidental to furnishing and placing the reinforcement.

Payment for expansion joints of each design designation at the Contract price per unit of measure will be compensation in full for all costs of constructing the joints complete in place as detailed in the Plans, including the furnishing and placing of all required materials such as dowel bar assemblies, filler, and sealer materials.

Payment for dowel bars and reinforcement bars at the Contract prices will be compensation in full for all costs of furnishing and placing the materials as specified. No payment will be made under these items for those quantities that are compensated for on a complete unit basis as a part of other Contract items.

Payment for integrant curb at the Contract price per unit of measure for each design specified will be compensation in full for all costs of furnishing and placing the concrete, forming and finishing the curb, protecting and curing the concrete, and any other costs incidental to the completed curb.

Payment for construction of bridge approach panels at the Contract price per each panel complete in place, or at the Contract price per unit of measure for all panels, will be compensation in full for all costs of constructing the bridge approach panels as detailed in the Plans, including the costs of furnishing and placing concrete and steel, construction of integrant curb, terminal headers, concrete sills, protecting and curing the concrete, and other incidental work not specifically included for payment under other Contract items.

Payment for permanent terminal headers shall be compensation in full for all excavation, material and labor costs relative thereto.

The Department will pay the Contract unit price for each measured core. The Contractor shall accept this payment as compensation in full or all costs of material, labor, and equipment necessary to take the cores, deliver the cores as directed, fill core holes, provide traffic control, and provide other incidentals to the concrete coring.

Payment for concrete pavement construction will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2301.501</td>
<td>Concrete Pavement</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2301.502</td>
<td>Concrete Pavement, Standard Width</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2301.503</td>
<td>Concrete Pavement, Irregular Width</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2301.511</td>
<td>Structural Concrete</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2301.513</td>
<td>Structural Concrete, HE (High Early Strength)</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2301.521</td>
<td>Pavement Reinforcement, Type_</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Unit</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>2301.529</td>
<td>Reinforcement Bars (Epoxy Coated)</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2301.531</td>
<td>Expansion Joints, Design</td>
<td>meter (linear foot)</td>
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<tr>
<td>2301.538</td>
<td>Dowel Bar</td>
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</tr>
<tr>
<td>2301.541</td>
<td>Integrand Curb, Design</td>
<td>meter (linear feet)</td>
</tr>
<tr>
<td>2301.545</td>
<td>Concrete Coring</td>
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<tr>
<td>2301.551</td>
<td>Bridge Approach Panel</td>
<td></td>
</tr>
<tr>
<td>2301.553</td>
<td>Bridge Approach Panels</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2301.561</td>
<td>Permanent Terminal Header</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2301.562</td>
<td>Concrete Shoulder</td>
<td>square meter (square yard)</td>
</tr>
</tbody>
</table>
2321.2

2321
Road-Mixed Bituminous Surface

2321.1 DESCRIPTION
This work shall consist of constructing one or more courses of road-mixed bituminous surfacing on a prepared base.

Subject to approval of the Engineer, hot plant mixtures conforming to 2360 may be substituted for the cold mixture provided for herein, in which case the mixing, spreading, and rolling shall be done in accordance with 2360, with compaction being in conformance with the ordinary compaction method as described therein.

2321.2 MATERIALS

A Aggregate
The aggregate shall conform to 2360 mixture type SPWEB240, with the exception that the aggregate for any course other than a wearing course may consist of Class 5 aggregate conforming to 3138 and the following modifications:
(1) Not less than 1 percent nor more than 7 percent of the aggregate shall pass the 75 µm (#200) sieve.
(2) Within the specified gradation limits, the aggregate shall be uniform at the time of mixing.

If so requested by the Engineer, to determine quality and mixture proportions, representative production samples of the aggregate to be used in the production of wearing course mixture shall be submitted to the Materials Laboratory at least 15 days in advance of starting the wearing course mixture production.

B Bituminous Material ................................................... 3151

The bituminous material for the mixture shall conform to the requirements for one of the following kinds and grades, subject to any limitations imposed by the Contract. If any options are permitted, the kind to be used shall be optional with the Contractor, but the grade shall be as designated by the Engineer.
MC Liquid Asphalt ...................................................... MC-250, 800
SC Liquid Asphalt ........................................................... SC-250, 800
Emulsified Asphalt .................................................. SS-1, SS-1h, CSS-1h, CSS-1

C Anti-Stripping Additive ............................................. 3161

If any additive is to be used, it may be added to the bituminous material at either the refinery or the job site. The blending shall be performed at a time and in a manner approved by the Engineer. When the additive is to be added on the job, the combined materials shall be mixed by not less than five complete circulations. No compensation in addition to the Contract prices will be made because of any additive that may be used.
2321.3 CONSTRUCTION REQUIREMENTS

A  General

These requirements provide for the construction of a base course, a leveling course, a binder course, and a wearing course, or any combination thereof, and are based on methods of construction by which the bituminous material is be applied to and mixed with the aggregate by road-mixing methods or in a central mixing plant.

B  Restrictions

Bituminous materials and mixtures shall not be applied to or placed on an untreated subgrade at any time when the moisture content of the top 75 mm (3 inch) of the subgrade is more than 65 percent of optimum moisture.

If emulsified asphalt is used for the mixture, the aggregate shall, at the time the emulsion is applied, contain sufficient moisture to ensure satisfactory mixing. (Note: This may require the addition of water.) If any other bituminous materials are used for the mixture, the aggregate shall not contain more than 2 percent of free moisture at the time the bituminous material is applied.

An anti-stripping additive may be used only with the consent of the Engineer. In this case, the aggregate may contain free moisture up to a maximum of 4 percent.

If mixing is performed on the road by blade-mix methods, the bituminous material shall be applied with distributors.

If the blade-mix method is employed, bituminous material shall be applied and mixing performed only during daylight hours and when the air temperature is 10°C (50°F) or higher if the blade mix method is employed. The bituminous material shall be at least partially mixed with the aggregate before dark on the same day that it is applied.

If the mixing is performed by traveling plant or central mixing plant, it shall be performed when the air temperature is 4°C (40°F) or higher.

Spreading and compacting shall be performed only during daylight hours and when the air temperature is 10°C (50°F) or higher.

All mixtures shall be kept in windrows during rains and shall be free of surface moisture at the time of spreading and rolling operations.

The operations of depositing aggregates on the road, mixing aggregate with bituminous material, and spreading and rolling the mixture shall be conducted only on sections of such length as will meet the approval of the Engineer.

Each course shall be compacted and cured to such a degree that it will not be displaced or otherwise damaged before another course is placed thereon.
In general, no work within the roadbed will be permitted in the spring until seasonal load restrictions on roads in the vicinity have been removed. However, work within the roadbed may be permitted before that time if, in the opinion of the Engineer, it can be conducted without damage to the subgrade.

C  Equipment
C1  Distributor
   The distributor shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface up to 4.5 m (15 feet) at readily determined and controlled rates up to 9.0 L (2.0 gallons) per square meter (square yard), with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.1 L (0.02 gallon) per square meter (square yard). Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices or calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically.
C2  Pneumatic-Tired Rollers
   Pneumatic-tired rollers shall have a mass of not less than 3600 kg/m (200 pounds per inch) of rolling width. "Wobbling wheeled" rollers will not be permitted.
C3  Steel-Wheeled Rollers
   Steel-wheeled rollers shall be of the self-propelled and have a minimum total mass of 7.3 metric tons (8 tons), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN/m (250 pounds per linear inch) of width. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rollers on both sets of wheels.
C4  Motor Graders
   Motor graders shall be of the self-powered type, mounted on pneumatic tires. They shall be equipped with a blade not less than 3 m (10 feet) long and shall have a wheel base of not less than 4.5 m (15 feet). Motor graders used for the final layout and finishing of the surface shall be equipped with smooth pneumatic tires.
C5  Traveling Mixing Plants
   The traveling plant shall be self-propelled and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on pneumatic-tired wheels or smooth tread crawler tracks of such size that the underlying road surface will not be rutted or damaged when the plant is loaded to capacity. The plant shall be so designed and constructed that it will pick up all of the aggregate cleanly from the road without damaging the underlying road surface.
2321.3

The traveling plant shall be capable of constantly measuring the bituminous material accurately, mixing it thoroughly with the aggregate, and depositing the mixture in a uniform windrow.

The traveling plant shall be equipped with sufficient valves and a stub pipe in the bitumen line between the pump and the spray bar to facilitate calibration of the output of the pump. They shall also be equipped with temperature and metering devices that will determine accurately the temperature and quantity of bituminous material being applied to the aggregate.

C6  Central Mixing Plants

When heating of the aggregate is not required, central mixing plants may be of any type that will produce a bituminous mixture conforming to the mix requirements of this Specification. However, as minimum requirements, the plant shall be equipped with temperature and metering devices that will determine accurately the temperature and quantity of bituminous material being applied to the aggregate. Feeding of the aggregate and bituminous materials into the mixer shall be synchronized by interlocking mechanical means or other positive method approved by the Engineer.

D  Treatment of the Surface

D1  Prime Coat

If so indicated in the Plans or directed by the Engineer, a bituminous prime coat shall be applied to the prepared base in accordance with 2358 prior to placement of the first course of bituminous mixture.

D2  Tack Coat

A bituminous tack coat shall be applied to existing bituminous or concrete surfaces and to the surface of each course constructed other than the final course, with the application being done in accordance with 2357 prior to placement of the next course thereon.

E  Depositing and Mixing Aggregate with Bituminous Material

After satisfactory absorption of the prime coat, if used, the required quantity of new aggregate shall be deposited on the road. The new aggregate and float aggregate, if used, shall be thoroughly mixed and then bladed into a single windrow of uniform cross section for measurement and adjustment as directed by the Engineer.

If the mixing is performed by the road-mix method or by a traveling plant that depends on a uniform forward speed to measure the aggregate windrow, a windrow proportioner (evener) shall immediately precede the mixing operations. The windrow shall be evened or shaped until all measured cross-sections taken at 30 m (100 foot) intervals are not less
than 95 percent or more than 105 percent of the average of all measured cross sections for the portion of the windrow involved.

If, on any portion of the Project, the base course is required to carry traffic during the interim period between its completion and the construction of the next course thereon, the bitumen content of the mixture for the base course on that section of the roadbed may be increased, at the option and direction of the Engineer, beyond the maximum limits provided above, but not to exceed the maximum application rate for wearing course mixtures.

The bituminous material shall be applied to the aggregate at a total rate designated by the Engineer, within the following limits:

**TABLE 2321-1**

**BITUMINOUS APPLICATION RATE**

<table>
<thead>
<tr>
<th>Kind of Bituminous Material</th>
<th>Rate in Liters per Metric Ton (Gallons/ton) of Dry Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base, Leveling Binder Courses</td>
</tr>
<tr>
<td>SC</td>
<td>---</td>
</tr>
<tr>
<td>MC</td>
<td>33 to 46 (8 to 11)</td>
</tr>
<tr>
<td>SS, CSS</td>
<td>42 to 58 (10 to 14)</td>
</tr>
</tbody>
</table>

If the method of mixing employs equipment requiring the bituminous material to be applied in a separate operation, no single application of bituminous material shall be applied to the aggregate in a quantity exceeding 2.3 L/m² (½ gallons per square yard). The number and rate of applications shall be as directed by the Engineer. After each application, the bituminous material and aggregate shall be mixed sufficiently to produce a mixture of uniform color and, after the last application, the mixing shall continue until all particles of the aggregate are thoroughly coated and the mixture is free from fat or lean spots, balls, and uncoated particles.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below:
2321.3

### TABLE 2321-2

<table>
<thead>
<tr>
<th>Type of Bituminous Material</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Asphalt MC-250, SC-250</td>
<td>40-105°C (105-220°F)</td>
</tr>
<tr>
<td>Liquid Asphalt MC-800, SC-800</td>
<td>60-125°C (135-255°F)</td>
</tr>
<tr>
<td>Emulsified Asphalt SS-1, SS-1h</td>
<td>20 to 70°C (70 to 160°F)</td>
</tr>
<tr>
<td>Emulsified Asphalt CSS-1, CSS-1h</td>
<td>20-70°C (70-160°F)</td>
</tr>
</tbody>
</table>

During the application of bituminous material, the changing of speed or the shifting of gears will not be permitted.

#### F. Spreading

Before spreading the mixture, aeration by manipulation will be required until the mixture has become tacky and free of surface moisture to a degree satisfactory to the Engineer.

The bituminous mixture shall be spread without segregation to produce a layer of uniform thickness and the specified cross section.

The contact surface of curbs, concrete pavements, or other fixed structures shall be painted with a thin uniform coat of liquid bituminous material just before any bituminous mixture is placed against them.

After final compaction, all bituminous surfaces adjacent to gutters, manholes, pavement headers, or other fixed structures shall be slightly higher (but not to exceed 6 mm (¼ inch)) than the surface of such structures.

#### G. Rolling

Rolling shall begin at the time the mixture is being spread and continue until after the mixture has been shaped to the required cross-section.

Each course shall be thoroughly and uniformly compacted for its full thickness with pneumatic-tired rollers traveling at speeds not to exceed 8 km/h (5 miles per hour). The final rolling on the last course constructed under the Contract shall be performed with steel wheeled rollers traveling at speeds not to exceed 5 km/h (3 miles per hour). The rolling shall begin at the lower edge of the course and progress toward the upper edge or centerline. Each pass of the roller shall overlap the preceding pass by at least half the width of the roller and shall terminate at least 1 m (3 feet) in advance of or to the rear of the termination of the preceding pass.

The entire surface shall be rolled until there is no further compaction and until all roller marks are eliminated. Rolling shall be discontinued whenever it begins to produce excessive crushing or pulverizing of the aggregate or displacement of the mixture. In places inaccessible to the roller, compaction equal to that obtained with rollers shall be secured by means of mechanical tampers.

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As necessary to prevent adhesion of the mixture to the roller wheels, the contact surfaces of the wheels shall be kept properly moistened, using water or a water solution containing small quantities of detergent or other approved material.

During the final spreading and compacting operations on each course, the Contractor shall check the thickness and surface for conformance with the thickness and surface requirements specified in 2321.3H. Any area that does not conform may be corrected by loosening the compacted surface, adding more mixture or reshaping the mixture, and recompacting. Lean, fat, or segregated areas shall be removed and replaced with new material. All corrections shall be made at no expense to the Department.

H Thickness and Surface Requirements

After compaction, the finished surface of any course shall show no variation greater than 6 mm (¼ inch) from the edge of a 3 m (10 foot) straightedge laid thereon parallel to the centerline.

After compaction, the alignment of the outside edges of any course shall be such that the distance between the edge and the established centerline shall not vary more than 75 mm (3 inches) from the distance shown in the Plans for that course.

After compaction, no portion of any course other than a leveling course shall vary from the thickness shown in the Plans for that course by more than 13 mm (½ inch). No individual test shall show a thickness deficiency of more than 13 mm (½ inch). On any area where tests show a thickness in excess of the Plan thickness plus 13 mm (½ inch), the Department reserves the right to exclude from the final pay quantities the materials used in the excess mixture, above that required to construct the course in that area to a thickness equal to the Plan thickness plus 13 mm (½ inch).

I Blank

J Seal Coat

When specified in the Contract or ordered by the Engineer, designated areas of the finished surface shall be given a light bituminous seal coat in accordance with 2356.

If the Contract does not provide for application of a seal coat with cover aggregate, or if weather conditions at the time the seal coat would be applied in the normal sequence of operations do not permit its application at the time, the Contractor shall apply a fog seal if the Engineer so directs, using bituminous material of any kind and grade approved by the Engineer. Slow curing liquid asphalt will not be approved for use as fog seal material. The time and rate of application shall be as directed by the Engineer, with the rate of application not to exceed ½ L/m² (0.1 gallon per square yard).
2321.3

K  Aggregate in Stockpiles
When the Contract contains an item for stockpile aggregate, the Contractor shall, in addition to the aggregate required for the bituminous surfacing, produce and deliver aggregate of the class specified to the Department at the designated sites. Delivery shall be made when and as approved by the Engineer. Construction of stockpiles shall be as directed by the Engineer.

2321.4  METHOD OF MEASUREMENT
A  Aggregate
Aggregate will be measured, as indicated in the Proposal, by mass or LV of material deposited on the road. When mixing is performed in a hot-mix plant, the measured weights will include the weight of the bituminous material incorporated into the mixture.

B  Bituminous Material
Bituminous materials will be measured by volume. Bituminous material used for fog seal will be measured and included for payment with the measured quantity of bituminous material for mixture.

C  Stockpile Aggregate
Stockpile aggregate of each class specified will be measured as indicated in the Proposal, by mass or loose volume of material delivered in stockpiles.

2321.5  BASIS OF PAYMENT
Payment for the accepted quantities of aggregate and bituminous material incorporated in the mixture at the Contract prices per unit of measure will be compensation in full for all costs of constructing the bituminous surfacing as specified.

Payment for stockpile aggregate of each class specified, at the Contract prices per unit of measure, will be compensation in full for all costs of producing and delivering the material to the Department at the designated sites, including all costs of constructing the stockpiles as specified.

Payment for the road-mixed bituminous surface will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2321.503</td>
<td>Bituminous Material for Mixture</td>
<td>liter (gallon)</td>
</tr>
<tr>
<td>2321.506</td>
<td>Aggregate</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2321.507</td>
<td>Aggregate</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2321.511</td>
<td>Stockpile Aggregate, Class___</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2321.513</td>
<td>Stockpile Aggregate, Class___</td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>
2355

Bituminous Fog Seal

2355.1 DESCRIPTION
This work shall consist of treating an existing bituminous pavement to seal the surface.

2355.2 MATERIALS
A  Bituminous Material................................................... 3151
The bituminous material for fog seal shall be one of the following kinds and grades conforming to 3151.
RC liquid Asphalt............................................................. RC-70
Emulsified Asphalt
   Anionic ................................................................. SS-1, SS-1h
   Cationic........................................................................ CSS-1, CSS-1h

2355.3 CONSTRUCTION REQUIREMENTS
A  Restrictions
Fog seal operations shall be conducted in a manner that will offer the least inconvenience to traffic, with movement in at least one direction permitted at all times without pickup or tracking of the bituminous material.
The fog seal shall not be applied until the road surface and weather conditions are acceptable to the Engineer.
For air temperatures greater than 4°C (40°F), asphalt emulsion shall be used unless it is no longer available for the season. When conditions require that liquid asphalt (RC-70) be used, the Engineer may require a light application of sand to prevent material pickup or tacking.

B  Equipment
The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C  Road Surface Preparations
At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided in the Contract.
All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as approved by the Engineer.

D  Application of Bituminous Material
The bituminous material shall be applied at a uniform rate of
(1) 0.45 to 0.70 L/m² (0.10 to 0.15 gallon per square yard) for diluted asphalt emulsion, or,
(2) 0.45 L/m² (0.10 gallon per square yard) for RC-70 cutback asphalt.
2355.3

The time and rate of application shall be as directed by the Engineer.

The temperature of the bituminous material at the time of application shall be as directed by the Engineer, within the limits specified below:

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Asphalt RC-70</td>
<td>50 to 80°C (120-175°F)</td>
</tr>
<tr>
<td>Emulsified Asphalt</td>
<td>20 to 70°C (120-175°F)</td>
</tr>
</tbody>
</table>

The asphalt emulsion shall be diluted with water, 50 percent by volume, to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.

Sand shall be spread on the newly fogged surface at pedestrian crossings unless otherwise directed by the Engineer.

2355.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material used for fog seal will be measured by volume at 15°C (60°F).

2355.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for fog seal at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified.

Furnishing and applying sand on the newly fogged surfaces shall be at no expense to the Department.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2355.502</td>
<td>Bituminous Material for Fog Seal</td>
<td>liter (gallon)</td>
</tr>
</tbody>
</table>

2356 Bituminous Seal Coat

2356.1 DESCRIPTION

This work shall consist of an application of bituminous material followed by an application of cover aggregate on designated areas of an existing bituminous pavement.

2356.2 MATERIALS

A Bituminous Material

The bituminous material for seal coat shall be one of the following kinds and grades conforming to 3151. When the Contract quantity exceeds 7500 L (2000 gallons), and unless other options are permitted by the Plans or Special Provisions, the kind to be used shall be emulsified asphalt, cationic grades. In all cases the grade to be used shall be as designated by the Engineer.
RC Liquid Asphalt ................................................... RC-250, 800, 3,000
Emulsified Asphalt,
  Anionic ................................................................. RS-1, RS-2
  Cationic ................................................................. CRS-1, CRS-2
Asphalt Cement ..................................................... (penetration as specified)
B Seal Coat Aggregate .................................................. 3127
  The class of aggregate to be used will be shown in the Plans or indicated in the Special Provisions.
C Anti-Stripping Additive .................................................. 3161
  All bituminous material, except emulsions, shall be treated with an approved anti-stripping additive used in such quantity that the treated bituminous material will meet the pertinent requirements of 3161. The additive shall be added to the bituminous material at the refinery in a manner approved by the Engineer.

2356.3 CONSTRUCTION REQUIREMENTS
A Restrictions
  Seal coating operations (including traffic restrictions on the freshly constructed seal coat) shall be conducted:
  (1) Not before May 15 nor after August 31;
  (2) Only during daylight hours;
  (3) When the pavement and air temperature are 20°C (70°F) or higher;
  (4) When the relative humidity is less than 75 percent; and
  (5) When the road surface is dry and clean.
  The seal coating operations shall not be started, and shall be suspended, when any one of the above conditions cannot be met.
B Equipment
B1 Distributor
  The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.
B2 Aggregate Spreader
  The cover aggregate shall be applied with an approved mechanical type aggregate spreader that is capable of distributing the aggregate uniformly to the required width and at the designated rate, with the application sharply defined at the edges.
  The aggregate spreader shall be a self-propelled type mounted on pneumatic-tired wheels that are so located as to operate on the freshly applied aggregate.
B3 Pneumatic-Tired Roller
  The pneumatic-tired roller shall have a compacting width of 1.5 m (5 feet) or more and shall be so constructed that the gross mass of not less than 3500 kg/m (200 pounds per inch) of rolling width can be varied as directed by the Engineer. The tire arrangement shall
be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self-propelled or provided with suitable tractive equipment, unless the Contract specifies a certain type. If more than one roller propelled by a single tractive unit, the combination will be counted as a single roller unit.

B4 Paver Brooms

A rotary power broom shall be provided that is capable of cleaning the road surface prior to spraying bituminous material and to remove loose particles after treatment as required.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided for in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as the Engineer approves.

When specified in the Contract or ordered by the Engineer, a tack coat shall be applied to the prepared road surface in accordance with 2357.

D Application of Bituminous Seal Material

Application of bituminous material shall be governed by the rate at which the cover aggregate is applied and by the provisions made for maintenance of traffic. No traffic shall be permitted on uncovered bituminous material.

Bituminous material shall not be applied until the loaded aggregate spreader is on hand ready to begin application of aggregate immediately, with sufficient truck loads of aggregate at the site to cover the length of the anticipated applications of bituminous material.

The bituminous material for seal coat shall be applied to the road surface at a rate designated by the Engineer, within the limits specified below for the class of aggregate to be used.

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>Emulsified or Liquid Asphalts</th>
<th>AsphaltCement</th>
</tr>
</thead>
<tbody>
<tr>
<td>FA-1</td>
<td>0.68-0.91 (0.15 - 0.20)</td>
<td>-</td>
</tr>
<tr>
<td>FA-2</td>
<td>0.68-1.1 (0.15 - 0.25)</td>
<td>-</td>
</tr>
<tr>
<td>FA-3</td>
<td>0.91-1.6 (0.20 - 0.35)</td>
<td>0.59-0.82 (0.13 - 0.18)</td>
</tr>
<tr>
<td>FA-4</td>
<td>1.4-2.0 (0.30 - 0.45)</td>
<td>0.68-0.91 (0.15 - 0.20)</td>
</tr>
<tr>
<td>FA-5</td>
<td>1.8-2.3 (0.40 - 0.50)</td>
<td>2.0-2.5 (0.45 - 0.55)</td>
</tr>
</tbody>
</table>
To prevent overlapping at the end junction at transverse joints, means shall be provided to ensure positive cutoff for the bituminous material and cover aggregate. A section of building paper or other suitable material shall be placed across the lane to be coated and be positioned so that the forward edge is at the desired joint location. The distributor, traveling at the correct speed, shall start spraying on the building paper so that when the exposed surface is reached, the spray will be full and uniform. The same procedure shall apply to cover aggregate placement. The masking material used shall be removed and be disposed of in a manner approved by the Engineer.

Application of the bituminous material shall produce a uniform film without ridges and skips. Adjustments to the spray bar and nozzles shall be made prior to application of the bituminous material on the areas to be sealed.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below:

- **Asphalt Cement**: 175°C (350 °F) Max.
- **RC Liquid Asphalt**:
  - RC-250: 74 to 105°C (165 to 220 °F)
  - RC-800: 93 to 107°C (200 to 225 °F)
  - RC-3000: 110 to 145°C (230 to 290 °F)
- **Cationic Emulsified Asphalt CRS-1,2**: 52 to 85°C (125 to 185 °F)
- **Anionic Emulsified Asphalt RS-1**: 21 to 60°C (70 to 140 °F)
- **RS-2**: 52 to 85°C (125 to 185 °F)

### E Application of Cover Aggregate

The cover aggregate shall be spread immediately following the application of bituminous material. Under no circumstances shall operations proceed in such manner that the bituminous material remains uncovered for more than 1 minute so as to set-up or dry-out to an extent that will impair retention of the cover aggregate.

The aggregate, at the time of spreading, shall not contain more than 2 percent (by mass) of free surface moisture, except that when FA-1 aggregate or an asphalt emulsion is used, the aggregate shall contain not more than 4 percent of free surface moisture.

The aggregate shall be spread uniformly over the full width of the bituminous application, at a rate designated by the Engineer, within the range of 20 to 25 kg/m² (40 to 50 pounds per square yard) when FA-5 aggregate is used, or at the rate of 14 kg (100 pounds) of aggregate for each liter (gallon) of bituminous material used, per square meter (square yard).
To determine the volumetric rate of application, the mass per volume (truck measure) shall be determined by weighing a measured truck load on a scale furnished or made available by the Contractor.

Immediately after spreading the cover aggregate, any areas having non-uniform coverage shall be corrected to the satisfaction of the Engineer by removing excess material and spreading additional material over deficient areas. Variations in coverage exceeding 10 percent of the designated rate of application shall be corrected as ordered.

F Rolling Operations

Initial rolling shall follow immediately behind the spreading of cover aggregate, with the initial coverage completed within 5 minutes after spreading the aggregate. The surface rolling shall be continued until five complete coverages over the full width have been obtained. All rolling operations on an area shall be completed within 30 minutes after spreading the cover aggregate on that area.

All rolling shall be performed with approved self-propelled, smooth-tread pneumatic-tired rollers. A minimum of two rollers shall be used for rolling operations. The rollers shall not be operated at speeds exceeding 8 km/h (5 miles per hour). Rolling shall begin at the outer edge of the aggregate cover and proceed in a longitudinal direction, working toward the center of the road.

The completed surface shall present a uniform appearance. The surface shall be lightly broomed or otherwise maintained as necessary during the rolling operations to achieve uniform appearance.

G Protection of the Surface

No traffic shall be permitted on the sealed road surface until after all rolling has been completed and the bituminous material has set to a degree satisfactory to the Engineer and will not pick up on vehicle tires.

In addition to other barricades and warning signs required by the Contract, the Department will furnish and deliver to the Project such other barricades and warning signs as the Engineer deems necessary for use in conjunction with the seal coat construction. The Contractor shall erect and maintain those barricades and signs at locations directed by the Engineer.

The Contractor shall furnish traffic cones at least 450 mm (18 inches) in height and place them at intervals of not more than 60 m (200 feet) on the inner longitudinal edge of the freshly applied seal coat. These cones shall be maintained in place until the road is opened to unrestricted use by traffic.
When the road under construction is open to traffic during daylight hours, the Contractor shall furnish a minimum of two flagpersons and a pilot vehicle to direct and guide traffic through the construction zone. One flagger shall be stationed in advance of the seal coat operations and another at the rear barricade at the beginning of the uncovered bituminous material. It shall be the duty of the flagger to stop all traffic and to acquaint the traveling public with the nature of the work underway, the limitations on the road surface available for traffic use, and the reason for reduced driving speed.

The contractor shall provide a Traffic Control Plan consistent with the "Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) and approved by the Engineer."

On the morning following each day of seal coat operations, the Contractor shall sweep the surplus aggregate from the previous day's seal coat construction. This operation shall be conducted while the road surface is still cool, and care shall be exercised that the aggregate that has set is not disturbed. Where sealing is done in municipalities, the Contractor shall dispose of the surplus aggregate in a manner satisfactory to the Engineer.

**2356.4 METHOD OF MEASUREMENT**

**A Bituminous Material**

Bituminous material applied on the road will be measured by volume at 15°C (60°F).

**B Seal Coat Aggregate**

Seal coat aggregate will be measured as indicated in the Proposal, by mass or LV of material deposited on the road.

**2356.5 BASIS OF PAYMENT**

Payment for the accepted quantities of bituminous material (including any required additives) and seal coat aggregate at the appropriate Contract prices will be compensation in full for all costs of constructing the seal coat as specified.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2356.505</td>
<td>Bituminous Material for Seal Coat</td>
<td>liter (gallon)</td>
</tr>
<tr>
<td>2356.507</td>
<td>Seal Coat Aggregate</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2356.509</td>
<td>Seal Coat Aggregate (LV)</td>
<td>cubic meter (yard)</td>
</tr>
</tbody>
</table>

**2357 Bituminous Tack Coat**

**2357.1 DESCRIPTION**

This work shall consist of treating an existing bituminous or concrete surface with bituminous material preparatory to placing a bituminous course or seal coat thereon.
2357.2 MATERIALS

A Bituminous Material

The bituminous material for tack coat shall be one of the following kinds and grades conforming to 3151. When the Contract quantity exceeds 7500 L (2000 gallons), and except during periods of freezing temperatures, the tack coat material to be used will be limited to one of the kinds of emulsified asphalt. Otherwise, the kind to be used shall be optional with the Contractor. The grade to be used shall be as designated by the Engineer.

- MC liquid Asphalt: MC-250, 800
- RC Liquid Asphalt: C-70, 250, 800
- Emulsified Asphalt:
  - Anionic: SS-1, SS-1H, MS-2, RS-1, RS-2
  - Cationic: CSS-1, CSS-1H, CRS-1, CRS-2

2357.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Tack coat operations shall be conducted in a manner that offers the least inconvenience to traffic, with movement in at least one direction permitted at all times without pickup or tracking of the bituminous material. The tack coat shall not be applied when the road surface or weather conditions are unsuitable. The daily application of tack coat shall be limited to approximately the area on which construction of the subsequent bituminous course can reasonably be expected to be completed that day.

B Equipment

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided for in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as the Engineer approves.

Preparatory to placing an abutting bituminous course, the contact surfaces of all fixed structures and the edge of the in-place mixture in all courses at transverse joints and in the wearing course at longitudinal joints shall be given a uniform coating of liquid asphalt or emulsified asphalt, applied by methods that will ensure uniform coating.

D Application of Bituminous Material

The bituminous material shall be applied at a uniform rate not to exceed:

1. 0.23 L/m² (0.05 gallon per square yard) for cutback asphalt and undiluted asphalt emulsion (as supplied from the refinery).
(2) 0.91 L/m² (0.20 gallon per square yard) for diluted asphalt emulsion (with water added in the field).

The time and rate of application shall be as directed by the Engineer.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified following:

**Liquid Asphalt**
- RC-70 .................. 49 to 82ºC (120 to 180º F)
- RC-250, MC-250 .......... 74 to 104ºC (165 to 220º F)
- RC-800, MC-800 ........ 93 to 124ºC (200 to 255º F)

**Emulsified Asphalt**
- SS-1, SS-1H, MS-2, CSS-1, CSS-1H ....... 21 to 71ºC (70 to 160º F)
- RS-1 .......................... 21 to 60ºC (70 to 140º F)
- SS-2, CRS-1, CRS-2 ... 52 to 85ºC (120 to 185º F)

For asphalt Grades SS-1, SS-1H, CSS-1, and CSS-1H, water may be added up to 50 percent by volume to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.

Unless otherwise directed, sand shall be spread on the newly tacked surface at pedestrian crossings.

**2357.4 METHOD OF MEASUREMENT**

**A Bituminous Material**

Bituminous material used for tack coat will be measured by volume at 15ºC (60º F).

**2357.5 BASIS OF PAYMENT**

Payment for the accepted quantity of bituminous material used for tack coat at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified.

Furnishing and applying sand on newly tacked surfaces at pedestrian crossings shall be at no expense to the Department with no direct compensation being made therefore.

Should the Contract fail to include a Contract Item covering payment for the bituminous material used for tack coat, all costs of furnishing and applying bituminous tack coat material will be included in the compensation provided for the bituminous mixture, with no measurement made of the bituminous material used and with no direct compensation being made therefor.

Payment for the tack coat will be made on the basis of the following schedule:
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2357.502</td>
<td>Bituminous Material for Tack Coat</td>
<td>liter, gallon</td>
</tr>
</tbody>
</table>

2358

**Bituminous Prime Coat**

**2358.1 DESCRIPTION**
This work shall consist of treating a prepared base with bituminous material preparatory to placing a bituminous course thereon.

**2358.2 MATERIALS**

A **Bituminous Material**

The bituminous material for the prime coat shall conform to the requirements for one of the following kinds and grades, subject to any limitations imposed by the Contract. If any options are permitted, the kind to be used shall be optional with the Contractor but the grade shall be as designated by the Engineer.

- MC Liquid Asphalt: MC-30, 70

**2358.3 CONSTRUCTION REQUIREMENTS**

A **Restrictions**

Bituminous prime coat shall not be applied at any time when the moisture content of the upper 80 mm (3 inches) of the base is more than 65 percent of optimum moisture, or when the weather or road surface conditions are otherwise unsuitable for proper construction.

When traffic is being maintained over the section of road under construction, not more than 50 percent of the traveled way shall be closed to traffic at any one time, and traffic movement in at least one direction shall be permitted at all times without pick up or tracking of the bituminous material.

B **Equipment**

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C **Road Surface Preparations**

At the time of applying the bituminous material, the subgrade shall be in acceptable condition, with all preparation and maintenance operations completed as required by other provisions of the Contract.

D **Application of Bituminous Material**

The bituminous material shall be applied in a uniform, continuous spread at the rate of 0.45 to 1.35 L per square meter (0.1-0.3 gallons) and in one or two applications, as directed by the Engineer.

Care shall be taken that the application of bituminous material at the junction of spreads is not in excess of the specified quantity. Excess bituminous material shall be squeegeed from the surface. Skipped areas and deficiencies shall be corrected.
The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below.

MC Liquid Asphalt
- MC-30................. 29 to 63°C (85 to 145°F)
- MC-70................. 49 to 82°C (120 to 180°F)

2358.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material for prime coat will be measured by volume at 15°C (60°F).

2358.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for prime coat at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified, exclusive of those costs which are to be compensated for separately under other Contract items.

Payment for the prime coat will be made on the basis of the following schedule.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2358.501</td>
<td>Bituminous Material for Prime Coat</td>
<td>liter (gallon)</td>
</tr>
</tbody>
</table>
2360.1

Plant Mixed Asphalt Pavement

2360.1 DESCRIPTION
This work consists of the construction of one or more pavement courses of hot plant mixed asphalt-aggregate mixture on the approved prepared foundation, base course or existing surface in accordance with the specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer. Mixture design will be either 2360 or 2350 (gyratory or Marshall) as described in the Special Provisions through the mixture designation.

A Mixture Designations
Mixture designations for asphalt mixtures contain the following information:

(1) The first two letters indicate the mixture design type:
SP = Gyratory Mixture Design
LV = Marshall Mixture Design – Low Volume, 50 blow
MV = Marshall Mixture Design – Medium Volume, 50 blow
SM = Gyratory Mixture Design for Stone Matrix Asphalt (SMA)

(2) The third and fourth letters indicate the course:
WE = Wearing and Shoulder Wearing Course
NW = Non-Wearing Course

(3) The fifth letter or number indicates the maximum aggregate size*:
A or 4 = 12.5mm (∅ inch), SP 9.5 mm (3/8 inch)**
B or 3 = 19.0mm (∅ inch), SP 12.5 mm (∅ inch)**
C or 2 = 25.0mm (1 inch), SP 19.0 mm (7/8 inch)**
5 = 9.5mm (3/8 inch), 4.75 mm (#4) nominal size
(Marshall design only)
E = See provision for SMA design

* Letter is used in gyratory designation; number is used in Marshall designation
** Nominal maximum aggregate size

(4) For Gyratory Design:
The sixth digit indicates the Traffic Level (ESAL’s x 10⁶)
The requirements for gyratory mixtures in this specification are based on the 20-year design traffic level of the Project expressed in Equivalent Single Axle Loads (ESAL’s). The five traffic levels are shown below in Table 2360.1-A.
### TABLE 2360.1-A
#### TRAFFIC LEVELS

<table>
<thead>
<tr>
<th>Traffic Level</th>
<th>20 Year Design ESAL’s (1 x 10⁶ ESAL’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2¹</td>
<td>&lt;1</td>
</tr>
<tr>
<td>3²</td>
<td>1 to &lt; 3</td>
</tr>
<tr>
<td>4</td>
<td>3 to &lt; 10</td>
</tr>
<tr>
<td>5</td>
<td>10 to ≤ 30</td>
</tr>
<tr>
<td>6</td>
<td>SMA</td>
</tr>
</tbody>
</table>

1 – (AADT ≤ 2300)  
2 – (2300 < AADT < 6000)

**For Marshall Design:**

- The sixth and seventh digit indicate the Marshall design blows:
  - 50 blow design for both LV and MV mixtures
- The last two digits indicate the air void requirement:
  - 40 = 4.0% for SP and SM Wear mixtures
  - 35 = 3.5% for MV Wear and Non-Wear
  - 30 = 3.0% for LV Wear and Non-Wear and SP Non-Wear and Shoulder
- The letter at the end of the mixture designation identifies the asphalt binder grade:
  - A = PG 52-34
  - B = PG 58-28
  - C = PG 58-34
  - D = PG 58-40
  - E = PG 64-28
  - F = PG 64-34
  - G = PG 64-40
  - H = PG 70-28
  - I = PG 70-34
  - L = PG 64-22

Ex: Gyratory Mixture Designation -- SPWEB540E (Design Type, Lift, Agg Size, Traffic Level, Voids, Binder)

Ex: Marshall Mixture Designation – LVWE35030B (Mix Type, Lift, Agg Size, Marshall blows, Voids, Binder)

Ex: SMA Mixture Designation -- SMWEE640H (Design Type, Lift, Agg Size, Traffic Level, Voids, Binder)
2360.1

B Minimum Lift Thickness

Minimum paving lift thickness will be based on maximum aggregate size:

<table>
<thead>
<tr>
<th>Aggregate Size</th>
<th>Minimum Lift Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, 4*; B, 3*</td>
<td>40 mm (1 ½ inch)</td>
</tr>
<tr>
<td>5*</td>
<td>20 mm (¾ inch)</td>
</tr>
<tr>
<td>C, 2* (for non-wear only)</td>
<td>65 mm (2 ½ inch)</td>
</tr>
</tbody>
</table>

*Marshall designation

2360.2 MATERIALS

A Aggregate

A1 General

The aggregate shall consist of sound, durable particles of gravel and sand, crushed stone and sand, or combinations thereof. It shall be free of objectionable matter such as metal, glass, wood, plastic, brick, rubber, and any other material having similar characteristics. Coarse aggregate shall be free from coatings of clay and silt to the satisfaction of the Engineer.

The Contractor shall not compensate for the lack of fines by adding soil materials such as clay, loam, or silt. Overburden shall not be blended into the asphalt aggregate.

Each different material (source, class, kind, or size) shall be fed at a uniform rate from its storage unit. An individual source, class, type, or size of material shall not be stockpile blended with another source, class, type or size of material.

A2 Classification

The aggregate shall conform to one of the following classifications. The class of aggregate to be used shall be the Contractor’s option unless otherwise specified in the Contract.

A2a Class A

Class A aggregate shall consist of crushed igneous bedrock (specifically; basalt, gabbro, granite, rhyolite, diorite and andesite) and rock from the Sioux Quartzite Formation. Other igneous or metamorphic rock may be used with specific approval of the Engineer. Class A materials may contain no more than 4.0% non-Class A aggregate. This recognizes the fact that some quarries may contain small pockets of non-Class A material within that source. Intentional blending or addition of non-Class A material is strictly prohibited!

A2b Class B

Class B aggregate shall consist of crushed rock from all other bedrock sources such as carbonate and metamorphic rocks. (gneiss or schist)
2360.2

A2c Class C
Class C aggregate shall consist of natural or partly crushed natural gravel obtained from a natural gravel deposit.

A2d Class D
Class D aggregate shall consist of 100 percent crushed natural gravel. The crushed gravel shall be produced from material retained on a square mesh sieve having an opening at least twice as large as the Specification permits for the maximum size of the aggregate in the composite asphalt mixture. The amount of carryover (material finer than) the selected screen shall not exceed ten percent.

A2e Class E
Class E aggregate shall consist of a mixture of any two or more of the above classes of approved aggregate (A, B, and D). The use of Class E aggregate, as well as the relative proportions of the different constituent aggregates, shall be subject to the approval of the Engineer. The relative proportions of the constituent aggregates shall be accurately controlled either by the use of a blending belt approved by the Engineer prior to production or by separately weighing each aggregate during batching operations.

A2f Steel Slag
Steel slag may not exceed 25 percent of the mass of the total aggregate. Stockpiles will be accepted for use if the total expansion, determined by ASTM D4792, is less than 0.50%.

A2g Taconite Tailings (TT)
Taconite tailings shall be obtained from ore that is mined westerly of a north-south line located east of Biwabik, Mn (R15W- R16W); except that taconite tailings from ore mined in southwestern Wisconsin will also be permitted for use.

Approved taconite tailing sources are on file with the Department Bituminous Engineer.

A2h Scrap Asphalt Shingles
Scrap asphalt shingles may be included in both wear and non-wear courses to a maximum of 5 percent of the total weight of mixture. Only scrap asphalt shingles from manufacturing waste are suitable. The percentage of scrap shingles used will be considered part of the maximum allowable RAP percentage. Refer to Section 2360.2 G1 to select a virgin asphalt binder grade (use requirements for > 20% RAP, regardless of total RAP/shingle percentage). Scrap Shingle Specifications are on file in the Bituminous Office.

A2i Crushed Concrete and Salvaged Aggregate
Crushed concrete is allowed as an aggregate source for up to 50 percent of the aggregate in non-wear mixtures. Crushed concrete is not allowed in wearing courses.
Salvaged aggregate is allowed as an aggregate source for up to 100 percent of the aggregate in wear and non-wear mixtures. All salvaged aggregate shall be stockpiled uniformly to limit variation in mixture properties. Salvaged aggregates shall meet quality and crushing requirements as specified herein.

A2j Sewage Sludge Ash (SSA)

Sewage sludge ash is allowed as an aggregate source in both wear and non-wear courses to a maximum of 5 percent of the total weight of mixture. Only SSA that meets the Tier II hazard evaluation criteria as approved by Mn/DOT’s Office of Environmental Services, Environmental Analysis Section, will be allowed for use in the mixture.

Approved waste incinerator ash sources are on file with the Department Bituminous Engineer.

A3 Recycled Asphaltic Pavement Materials (RAP)

The combined RAP and virgin aggregate shall meet the composite fine aggregate angularity or calculated crushed requirements (both coarse and fine aggregate) for the mixture being produced (calculated crushed allowed for Marshall design only). RAP containing any objectionable material, i.e., road tar, metal, glass, wood, plastic, brick, fabric, or any other objectionable material having similar characteristics will not be permitted for use in the asphalt pavement mixture.

Asphalt binder content in the RAP shall be determined according to Mn/DOT Lab Manual Method 1851 or 1852.

B Manufactured Crushed Fines (-4 material)

All Class A, B, D, and E material that passes the 4.75 mm (#4) screen will be considered as crushed fines.

Manufactured Crushed Fines (-4 material) from Class C Aggregate. Produce manufactured crushed fines (-4 material) from a gravel source by passing the gravel over a selected screen, 9.5 mm (3/8 inch) or larger, prior to mechanical crushing. The material which passes the 9.5 mm (3/8 inch) screen shall not be incorporated into the manufactured crushed fines but may be used as it qualifies for natural sand. The amount of carryover (material finer than) the selected screen shall not exceed ten percent.

The material retained on the 9.5 mm (3/8 inch) screen shall be crushed. The material that passes the 4.75 mm (#4) screen, after crushing, will be considered as 100% crushed fines. Material retained on the 4.75 mm (#4) screen after crushing will not be counted as +4 crushing until tested.

C Quality Requirements

C1 Los Angeles Rattler Test................................................AASHTO T96

The Los Angeles Rattler loss on the coarse aggregate fraction
2360.2

(material retained on the 4.75 mm (#4) sieve shall not exceed 40 percent for any individual source used within the mix. An aggregate proportion which passes the 4.75 mm (#4) sieve and exceeds 40 percent LAR loss on the coarse aggregate fraction is prohibited from use in the mixture.

C2 Soundness (Magnesium Sulfate)........................... AASHTO T104

The magnesium sulfate soundness loss at 5 cycles on the coarse aggregate fraction (material retained on the 4.75 mm (#4)) shall not exceed the following for any individual source used within the mix:

a) No more than 14% loss on the 19 mm (¾ inch) to 12.5 mm (½ inch) and larger fractions.

b) No more than 18% loss on the 12.5 mm (½ inch) to 9.5 mm (3/8 inch) fraction.

c) No more than 23% loss on the 9.5 mm (3/8 inch) to 4.75 mm (#4) fraction.

d) No more than 18% for the composite loss. (Applies only if all three size fractions are tested).

* 1) If the composite requirement is met but one or more individual components do not, the source may be accepted if no individual component is more than 110% of the requirement for that component.

2) If each individual component requirement is met but the composite does not, the source may be accepted if the composite is no greater than 110% of the requirement.

An aggregate proportion which passes the 4.75 mm (#4) sieve and exceeds the requirements listed above on the coarse aggregate fraction is prohibited from use in the mixture.

C3 Spall Materials and Lumps ............ Mn/DOT Laboratory Manual

Spall is defined as shale, iron oxide, unsound cherts, pyrite, highly weathered and/or soft phyllite and argillite (may be scratched with a brass pencil), and other materials having similar characteristics.

Lumps are defined as loosely bonded aggregations and clayey masses. If the percent of lumps measured in the stockpile or cold feed exceed the values listed below, asphalt production shall cease and compliance shall be determined by dry batching. This procedure may be repeated at any time at the discretion of the Engineer.

Maximum limits for Spall and lumps, expressed as percentages by mass, are listed in Table 2360.3-B2a.
2360.2

C 4 Insoluble Residue Test. If Class B carbonate material is used in the mix, the minus 0.075 mm (#200) sieve size portion of the insoluble residue shall not exceed 10 percent.

D Aggregate Restrictions

Class B carbonate aggregate restrictions are specified in Table 2360.3-B2a.

E Gradation Requirement

The coarse and fine aggregate shall be combined in such proportions to produce an asphalt mixture meeting all of the requirements defined in this specification and shall conform to the gradation as defined in Table 2360.2-E. Gradation testing shall be conducted in accordance with AASHTO T-11 (-0.075 mm (#200) wash) and T-27.

<table>
<thead>
<tr>
<th>TABLE 2360.2-E</th>
<th>AGGREGATE GRADATION BROAD BANDS (% passing of total washed gradation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size (mm (inch))</td>
<td>A or 4*</td>
</tr>
<tr>
<td>25.0(1&quot;)</td>
<td></td>
</tr>
<tr>
<td>19.0(¾&quot;)</td>
<td>100</td>
</tr>
<tr>
<td>12.5(½&quot;)</td>
<td>100</td>
</tr>
<tr>
<td>9.5(3/8&quot;)</td>
<td>85-100</td>
</tr>
<tr>
<td>4.75 (#4)</td>
<td>25-90</td>
</tr>
<tr>
<td>2.36 (#8)</td>
<td>20-70</td>
</tr>
<tr>
<td>0.075 (#200)</td>
<td>2.0-7.0</td>
</tr>
</tbody>
</table>

*Marshall Designation

1With the approval of the Engineer, the gradation broadband for the maximum aggregate size may be reduced to 97% passing for mixtures containing RAP, when the oversize material is suspected to come from the RAP source. The virgin material must remain 100% passing the maximum aggregate sieve size.

F Additives

An additive is any material added to an asphalt mixture or material, such as mineral filler, hydrated lime, asphalt additives, anti-strip, and similar products that do not have a specific pay item. When a Contract requires additives, compensation is included with the pay items for the appropriate mixture. If the Engineer directs the Contractor to incorporate additives, the compensation will be as Extra Work, at the unit price specified in the proposal. The Department will not compensate the Contractor for additives incorporated at the Contractor's option.
Additives will not be incorporated into the mixture without approval of the Department Bituminous Engineer. Anti-foaming agents shall be added to asphalt cement at the manufacturer's recommended dosage rate. Mineral filler and hydrated lime may be added in a quantity not to exceed 5 percent and 2 percent, respectively, of the total mass of the aggregate. The combination of mineral filler and hydrated lime shall not exceed 5 percent of the total mass of aggregate. The Engineer will approve or disapprove methods for addition of additives.

F1 Mineral Filler................................................................. 3145
F2 Hydrated Lime............................................................. 3145

Hydrated lime used in asphalt mixtures shall meet the requirements of ASTM C977 and have a maximum of eight percent unhydrated oxides (as received basis). The method of introducing and mixing the hydrated lime and aggregate shall be subject to approval by the Engineer prior to beginning mixture production.

F3 Liquid Anti-Strip Additive

When a liquid anti-strip additive is added to the asphalt binder, blending shall be completed before the asphalt binder is mixed with the aggregate. Liquid anti-strip additives that alter the asphalt binder, such that it fails to meet the Performance Grade (PG) requirements, shall not be used. Liquid anti-strip may be added by the supplier at the refinery or by the Contractor at the plant site. The company/supplier adding the additive shall be responsible for testing the binder/additive blend to ensure compliance with the AASHTO M 320, Standard Specification for Performance Graded Asphalt Binder. No paving will be allowed until the asphalt binder/additive blend has been tested and results show that binder/additive blend properties meet the criteria in Section 2360.2G. The testing shall be done in accordance with a Mn/DOT approved Asphalt Binder QC Plan. Requirements for the Asphalt Binder QC Plan are on file in the Bituminous Office.

The following requirements for HMA mixture and asphalt binder must also be met when liquid anti-strip is added at the HMA plant site.

**Mixture Requirements at Design:**

1) The Contractor must design the mixture with the same asphalt binder that will be supplied to the plant site. (Both Laboratory Mixture Design (Option 1) and Modified Mixture Design (Option 2).

2) The Contractor must provide documentation with either design option that includes Tensile Strength Ratio results with the liquid anti-strip dosed at the optimal rate. Documentation must include verification the binder/additive
2360.2

blend meets AASHTO M 320 at the optimal dose rate.

**Contractor Production Testing Requirements for Asphalt Binder/Liquid Anti-Strip Blend:**

1) The Contractor shall, on a daily basis, sample and test the asphalt binder/anti-strip blend. Testing of the blend can be by viscosity, penetration, or dynamic shear rheometer (DSR). When a polymer modified asphalt binder is specified, the Contractor shall use the DSR as the daily QC test.

2) The Contractor shall, on a weekly basis, send the Engineer and Mn/DOT Chemical Laboratory Director a weekly QC report summarizing the results of the daily testing as required in number 1.

3) The Contractor shall, on a bi-weekly basis, test the binder/anti-strip blend to ensure compliance with the AASHTO M 320, Standard Specification for Performance Graded Asphalt Binder (minimum 1/project). Test results shall be sent to the Engineer and Mn/DOT Chemical Laboratory Director.

4) In addition to the sampling requirements listed above, the Contractor shall obtain asphalt binder/anti-strip blend field verification samples according to 2360.4 E12.

**Liquid Anti-Strip Additive Metering System:**

1) The metering system shall include a liquid anti-strip flow meter in addition to an anti-strip pump. The flow meter shall be connected to the liquid anti-strip supply to measure and display only the anti-strip being fed to the asphalt binder.

2) The meter readout shall be positioned for convenient observation.

3) There shall be a means provided for comparing the flow meter readout with the calculated output of the anti-strip pump. See number 7.

4) The system shall display in units of liters (gallons) to the nearest liter (gallon) or in units of metric tons (tons) to the nearest 0.001 metric tons (0.001 tons), the accumulated anti-strip quantity being delivered to the mixer unit.

5) The system shall be calibrated and adjusted to maintain an accuracy of ± one percent error.

6) Calibration shall be required for each plant set-up prior to production of mixture.

7) The Engineer may require, on a daily basis, the Contractor “stick” the anti-strip tank at the end of the days production to verify anti-strip usage quantities.

8) The system shall provide for a convenient method for sampling the binder/anti-strip after blending has occurred.
9) Alternative blending and metering systems must be pre-approved by the Engineer.

**F4 Coating and Anti-Stripping Additive**................................. 3161

**G Asphalt Binder Material**................................................. AASHTO M 320

Asphalt binder material shall meet the requirements of PG asphalt binder testing tolerances, sampling rates, testing procedures, and acceptance criteria based on the most current Mn/DOT Technical Memorandum, titled "Inspection, Sampling, and Acceptance of Bituminous Materials." The PG asphalt binder cannot be modified with air blowing procedures unless the Department Bituminous Engineer approves it. The Contractor shall not use petroleum distillates such as fuel oil, diesel fuel or other fuels in the asphalt tanks. A statement shall be provided by the supplier for recommended laboratory mixing and compaction temperatures and field maximum mixing and compaction temperatures.

**G1 Asphalt Binder Selection Criteria for All Mixtures with RAP**

<table>
<thead>
<tr>
<th>Overlay</th>
<th>Specified PG Asphalt Binder Grade</th>
<th>Virgin Asphalt Binder Grade to be used with RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 20% RAP</td>
<td>&gt; 20% RAP</td>
</tr>
<tr>
<td>64-22</td>
<td>64-22</td>
<td>64-28</td>
</tr>
<tr>
<td>Other PG Grades</td>
<td>No grade adjustment</td>
<td>No grade adjustment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New Construction (1)</th>
<th>Specified PG Asphalt Binder Grade</th>
<th>Virgin Asphalt Binder Grade to be used with RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 20% RAP</td>
<td>&gt; 20% RAP</td>
</tr>
<tr>
<td>52-34</td>
<td>52-34</td>
<td>Not allowed *</td>
</tr>
<tr>
<td>58-28</td>
<td>58-28</td>
<td>58-28</td>
</tr>
<tr>
<td>58-34</td>
<td>58-34</td>
<td>Not allowed *</td>
</tr>
<tr>
<td>64-28</td>
<td>64-28</td>
<td>64-28</td>
</tr>
<tr>
<td>64-34</td>
<td>64-34</td>
<td>Not allowed *</td>
</tr>
<tr>
<td>Other PG Grades</td>
<td>No grade adjustment</td>
<td>Not allowed *</td>
</tr>
</tbody>
</table>

* When approved by the Engineer, the virgin asphalt binder grade can be selected by using the blending chart procedure on file in the Bituminous Office. Mn/DOT may take production samples for information/verification of compliance with a specified asphalt binder grade.

(1) Includes cold inplace recycle, reclaiming, and reconstruction.
2360.3  

2360.3  MIXTURE DESIGN  

A  Mixture Design General  

The asphalt mix may be designed using one of the following two Contractor trial mix design options. Review of mixture designs will be performed in the District Materials Laboratory lab where the Project is located. The addition of aggregates and materials not included in the original mixture submittal is prohibited.

It is the Contractor's responsibility to design a Marshall mixture in accordance with the most current AASHTO T-245, the Asphalt Institute's Mix Design Methods for Asphalt Concrete MS-2, and the Mn/DOT Laboratory Manual such that it meets the requirements of this specification.

For Marshall design, the design air void content of the mixture is dependent on the mixture type, regardless of the location in the pavement structure. Design air void content for LV and MVmixtures is 3.0% and 3.5%, respectively.

It is the Contractor's responsibility to design a gyratory mixture in accordance with the most current AASHTO T-312, the Asphalt Institute's Superpave Mix Design Manual SP-2 (2-hour short term aging period is used for volumetric), and the Mn/DOT Laboratory Manual such that it meets the requirements of this specification.

For gyratory design, the design air void content of the mixture at design shall be 4.0% at the design number of gyrations \(N_{\text{design}}\) for mixtures placed in the upper 100 mm (4 inches) of the finished surface. The design air void content of the mixture at design shall be 3.0% at the design number of gyrations \(N_{\text{design}}\) for mixtures placed at depths more than 100 mm (4 inches) from the surface and on all (wear and nonwear) shoulders that do not carry traffic. If less than 25% of a layer is within 100 mm (4 inches) of the surface, the layer may be considered to be below 100 mm (4 inches) for mix design purposes (non-wear).

B  Laboratory Mixture Design (Option 1)  

Test results and documentation as described in Section 2360.3C shall be submitted with the materials described below for
consideration by the Department Bituminous Engineer or District Materials Engineer to verify compliance with these specifications and to issue a Mixture Design Report.

B1 Aggregate Sample

At least 15 working days prior to the start of asphalt production, the Contractor shall submit to the Department Bituminous Engineer or the District Materials Engineer a 35 kg (80 pound) sample of representative aggregate retained on the 4.75 mm sieve (#4) and a 15 kg (35 pound) sample of material passing the 4.75 mm sieve (#4) for quality testing. The Contractor shall provide 24 hour notice of intent to sample aggregates. These samples will be tested for quality of each source, class, type, and size of virgin and non-asphaltic salvage aggregate source used in the mix design. The Contractor shall retain a companion sample of equal size until a Mixture Design Report is issued. Quality requirements are defined in Section 2360.2C.

Aggregates that require the magnesium sulfate soundness test shall be submitted to the Department Bituminous Engineer or District Materials Engineer at least 30 calendar days prior to the start of asphalt production. Dispute resolution procedures for aggregate qualities are on file in the Bituminous Office.

B2 Mixture Sample

At least 7 working days prior to the start of asphalt production, the Contractor shall submit in writing a proposed Job Mix Formula (JMF) for each combination of aggregates to the Department Bituminous Engineer or District Materials Engineer for review. A Level II Quality Management mix designer must sign the proposed JMF. For each JMF submitted, the Contractor shall include test data to demonstrate conformance to mixture properties as specified in Table’s 2360.3-B2b and 2360.3-B2c. The proposed JMF shall be submitted on forms approved by the Department. In addition, the Contractor shall submit an uncompacted mixture sample plus briquettes compacted at the optimum asphalt content and required compactive effort conforming to the JMF for laboratory examination and evaluation. Mixture sample size and number of compacted briquettes are as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Gyratory Design</th>
<th>Marshall Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Un-compacted Mixture Sample Size</td>
<td>30 kg (75 pounds)</td>
<td>18 kg (40 pounds)</td>
</tr>
<tr>
<td>Number of compacted briquettes</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
2360.3

B2a Mixture Aggregate Requirements

The aggregate fractions shall be sized, graded, and combined in such proportions that the resulting mixture will meet the requirements listed in Section 2360.2-E and Table 2360.3-B2a shown below.

<table>
<thead>
<tr>
<th>Aggregate Blend Property</th>
<th>Traffic Level 2 &amp; LV</th>
<th>Traffic Level 3 &amp; MV</th>
<th>Traffic Level 4</th>
<th>Traffic Level 5</th>
<th>SMA T. Level 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 year Design ESAL’s</td>
<td>&lt;1 million</td>
<td>1 - 3 million</td>
<td>3 - 10 million</td>
<td>10 – 30 million</td>
<td>See SMA Prov.</td>
</tr>
<tr>
<td>Coarse Aggregate Angularity (ASTM D5821) (one face / two face), % Wear (one face / two face), % Non-Wear</td>
<td>30/- 30/-</td>
<td>55 / 55 / -</td>
<td>85 / 80 / 60 / -</td>
<td>95 / 90 / 80 / 75 / -</td>
<td>-</td>
</tr>
<tr>
<td>Fine Aggregate Angularity (FAA) (AASHTO T304, Method A) % Wear % Non-Wear</td>
<td>40(2) 40(2)</td>
<td>42(1) 40(1)</td>
<td>44 40</td>
<td>45 40</td>
<td>-</td>
</tr>
<tr>
<td>Flat and Elongated Particles, max(2) % by weight, (ASTM D 4791)</td>
<td>- 10 (3:1 ratio)</td>
<td>10 (3:1 ratio)</td>
<td>10 (3:1 ratio)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Clay Content(2) (AASHTO T 176)</td>
<td>- -</td>
<td>45 45</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Spall in fraction retained on the 4.75mm (#4) sieve</td>
<td>5.0 5.0</td>
<td>1.0 1.0</td>
<td>1.0 -</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Maximum Spall Content in Total Sample</td>
<td>5.0 5.0</td>
<td>1.0 1.0</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Percent Lumps in fraction retained on the 4.75mm (#4) sieve</td>
<td>0.5 0.5</td>
<td>0.5 0.5</td>
<td>0.5 -</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Class B Carbonate Restrictions</td>
<td>Maximum% -4.75mm (-#4) Final Lift/All other Lifts</td>
<td>100/100 100/100</td>
<td>80/80</td>
<td>50/80</td>
<td>-</td>
</tr>
<tr>
<td>Maximum% +4.75mm (+#4) Final Lift/All other Lifts</td>
<td>100/100 100/100</td>
<td>50/100</td>
<td>0/100</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Gyratory Max. allowable RAP percentage Wear / Non Wear</td>
<td>30/40 30/30</td>
<td>30/30</td>
<td>30/30</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Marshall Max. allowable RAP percentage Wear / Non Wear</td>
<td>30/40 30/30</td>
<td>30/30</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) For Marshall design, the Contractor may determine –4 crushing
by either FAA of uncompacted voids or calculation of crush from the composite blend. The choice must be made prior to start of production. Manufactured crushed fines requirement is 25%. RAP sand will be considered 50% crushed if the angularity index equals or exceeds 40, and 100% crushed if the angularity index equals or exceeds 45.

(2) Not applicable under Marshall design.

B2b Mixture Requirements
Mixture evaluation will be based on the trial mix tests and the corresponding requirements listed in Table 2360.3-B2b and Table 2360.3-B2c.

B2c VMA Criteria
The voids in mineral aggregate (VMA) of the mixture at design and during production shall meet the minimum criteria as shown in Table 2360.3-B2c at the specified compaction level. VMA shall be calculated according to the procedures outlined in Asphalt Institutes SP-2 or MS-2 manual. VMA is a design and acceptance/process control requirement.

B3 Tensile Strength Ratio Sample
Mixture or briquettes that represent the mixture at optimum asphalt content, shall be submitted at least 7 days prior to actual production for verification of moisture sensitivity retained tensile strength ratio (TSR). Material submitted for TSR verification may be tested for maximum specific gravity $G_{mm}$ compliance in addition to TSR results. Failure to meet the $G_{mm}$ tolerance will result in rejection of the submitted mix design. A new mix design submittal will be required and will be subject to provisions described in Section 2360.3C. One of the following options may be used to verify that the tensile strength ratio (TSR) meets the requirements in Table 2360.3-B2b.

Option A) The Contractor will batch material at the design proportions including optimum asphalt. Immediately (before curing) split the sample and allow samples to cool to room temperature. Submit 35 kg (77 pounds) of mixture to the District Materials Laboratory for curing and test verification. Both groups will use a two (2) hour cure time (± 15 minutes) at 144°C (290°F) and follow procedures in ASTM D 4867-92, Mn/DOT modified as defined in the Mn/DOT Laboratory Manual.

Option B) The Contractor batches, cures (as indicated in option A), compacts, and submits briquettes and uncompacted mixture as specified below.
### TABLE 2360.3-B2B

#### MIXTURE REQUIREMENTS

<table>
<thead>
<tr>
<th>Traffic Level</th>
<th>20 year Design ESAL’s</th>
<th>Traffic Level 2</th>
<th>Traffic Level 3</th>
<th>Traffic Level 4</th>
<th>Traffic Level 5</th>
<th>SMA T. Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - 3 million</td>
<td>3 - 10 million</td>
<td>10 – 30 million</td>
<td>See SMA Prov.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic Level 2</td>
<td>≥ 1 million</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic Level 3</td>
<td>1 - 3 million</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic Level 4</td>
<td>3 - 10 million</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic Level 5</td>
<td>10 – 30 million</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Gyratory Mixture Requirements

| Gyration for N<sub>init</sub> | 6 | 7 | 8 | 8 | 8 | - |
| Gyration for N<sub>design</sub> | 40 | 60 | 90 | 100 | - |
| Gyration for N<sub>maximum</sub> | 60 | 90 | 140 | 160 | - |

| Air Voids, % - Wear | 4.0 | 4.0 | 4.0 | 4.0 | - |
| Air Voids, % - Non-Wear & All Shoulder | 3.0 | 3.0 | 3.0 | 3.0 | - |

| % G<sub>mm</sub> at N<sub>init</sub> - Wear | ≤ 91.5 | ≤ 90.5 | ≤ 90.0 | - |
| % G<sub>mm</sub> at N<sub>init</sub> - Non-Wear & All Shoulder | ≤ 92.5 | ≤ 91.5 | ≤ 91.0 | - |

| % G<sub>mm</sub> at N<sub>maximum</sub> - Wear | ≤ 98.0 | ≤ 98.0 | ≤ 98.0 | ≤ 98.0 | - |
| % G<sub>mm</sub> at N<sub>maximum</sub> - Non-Wear & All Shoulder | ≤ 99.0 | ≤ 99.0 | ≤ 99.0 | ≤ 99.0 | - |

| Tensile Strength Ratio (1), min% | 75<sup>(2)</sup> | 75<sup>(2)</sup> | 80<sup>(3)</sup> | 80<sup>(3)</sup> | - |
| Fines/Effective Asphalt | 0.6 - 1.2 | 0.6 - 1.2 | 0.6 - 1.2 | 0.6 - 1.2 | - |
| VFA, % - Wear | 65 - 78 | 65 - 76 | 65 - 76 | 65 - 76 | - |
| Non-Wear | 70 - 83 | 70 - 82 | 70 - 82 | 70 - 82 | - |

| Marshall Mixture Requirements | LV | MV |
| Marshall Blows | 50 | 50 | - | - | - |
| Air Voids, % | 3.0 | 3.5 | - | - | - |

| Tensile Strength Ratio (1), min% | 70<sup>(4)</sup> | 70<sup>(4)</sup> |
| Stability, minimum N (lb f) | 5000<sup>(5)</sup> (1125) | 6000<sup>(6)</sup> (1350) |
| Fines/Effective Asphalt | 0.6 - 1.2 | 0.6 - 1.2 | - | - | - |
| Wear | 0.6 - 1.30 | 0.6 - 1.30 | - | - | - |
| Non-Wear | 0.6 - 1.40 | 0.6 - 1.40 | - | - | - |

1. See Section 2360.4 E9. Use 150 mm (6 inch) specimens for gyratory and 100 mm (4 inch) specimens for Marshall design.
2. Mn/DOT Min = 65<sup>(3)</sup>, Mn/DOT Min = 70<sup>(4)</sup>, Mn/DOT Min = 60<sup>(6)</sup>
TABLE 2360.3-B2C
VOIDS IN MINERAL AGGREGATE (VMA) MIXTURE REQUIREMENTS

<table>
<thead>
<tr>
<th>Gradation</th>
<th>Fine Mixture % Pass 2.36 mm (#8)</th>
<th>VMA Minimum</th>
<th>Coarse Mixture % Pass 2.36 mm (#8)</th>
<th>VMA Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>A or 4*</td>
<td>&gt; 47</td>
<td>15.0**</td>
<td>≤ 47</td>
<td>14.5*</td>
</tr>
<tr>
<td>B or 3*</td>
<td>&gt; 39</td>
<td>14.0</td>
<td>≤ 39</td>
<td>13.5</td>
</tr>
<tr>
<td>C or 2*</td>
<td>&gt; 35</td>
<td>13.0</td>
<td>≤ 35</td>
<td>12.5</td>
</tr>
<tr>
<td>5*</td>
<td>-----</td>
<td>15.0**</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>E</td>
<td>See SMA Provisions</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Marshall designation.

**For LV 4 and LV 5 mixes lower VMA requirements by 0.5%.

TABLE 2360.3-B3
OPTION B MIXTURE REQUIREMENTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Gyrotrary Design</th>
<th>Marshall Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Un-compacted Mixture Sample Size</td>
<td>8,200 g</td>
<td>8,200 g</td>
</tr>
<tr>
<td>Number of compacted briquettes(1)</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Compacted briquette air void content</td>
<td>6.5 – 7.5%</td>
<td>6.0 – 8.0%</td>
</tr>
</tbody>
</table>

(1) 150mm (6 inch) specimens for gyratory design
100mm (4 inch) specimens for Marshall design

B4 Aggregate Specific Gravity

AASHTO T84 and T85, Mn/DOT Modified
The Contractor shall determine the specific gravity of all aggregate used in the mixture.

C Documentation
Each proposed JMF submitted for review under Section 2360.3B and 2360.3D shall include the following documentation and test results.

(1) The name(s) of the individual(s) responsible for the Quality Control of the mixture during production.
(2) The low projects number on which the mixture will be used.
(3) The percentage in units of 1 percent (except the 0.075 mm sieve (#200) in units of 0.1 percent) of aggregate passing each of the specified sieves for each aggregate to be incorporated into the mixture. The gradation of aggregate
from salvaged asphaltic material shall be derived from the material after the residual asphalt has been extracted.

(4) The source and description of the materials to be used. The aggregate pit or quarry source number. The proportion of each material (in percent of total aggregate).

(5) The composite gradation based on (3) and (4) above. Note: Include virgin composite gradation based on (4) and (5) above for mixtures containing RAP.

(6) The bulk (dry) and apparent specific gravities and water absorption (by % weight of dry aggregate) of both coarse and fine aggregate, for each product used in the mixture (including RAP). Use AASHTO T-84 and T-85 Mn/DOT modified as defined in the Mn/DOT Laboratory Manual. The tolerance allowed between the Contractor’s and the Department’s specific gravities are $G_{sb}$ (individual) = 0.040 (+4 AND -4) and $G_{sb}$ (combined) = 0.020.

(7) The composite gradation plotted on a FHWA 0.45 power chart. (Federal form PR-1115)

(8) For mixtures containing RAP include extracted asphalt binder content of the RAP with no retention factor included.

(9) The percentage (in units of 0.1 percent) and PG grade of asphalt binder material to be added, based upon the total mass of the mixture.

(10) When using laboratory mixture design Option 1 (2360.3B) or Option 2 (2360.3D), include the following:

(a) A minimum of three different asphalt binder contents (minimum 0.4 percent between each point), with at least one point at, one above and one below the optimum asphalt binder percentage.

(b) The maximum specific gravity at each asphalt binder content. The theoretical maximum specific gravity used for percent air voids determination shall be calculated based on the average of the effective specific gravities measured by a minimum of two maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt binder content.

(c) The test results for the individual and average bulk specific gravity, density, and heights, of at least two specimens at each asphalt binder content. For Marshall design include the test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at each asphalt binder content.

(d) The percent air voids in the mixture at each asphalt
(e) The percent Voids in Mineral Aggregate (VMA) at each asphalt binder content.

(f) The fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent.

(g) TSR results at the optimum asphalt binder content.

(h) Graphs showing air voids, voids in the mineral aggregate, Gmb, Gmm and unit weight vs. percent asphalt binder content for each of the three asphalt binder contents submitted with trial mix.


If the Contractor chooses to use the add-material option to augment the submitted JMF, the Contractor shall provide samples of the aggregate for quality analysis in accordance with Section 2360.3B1. The Contractor shall provide mix design data for two additional design points per add-material. One point shall show a proportional adjustment to the submitted JMF that includes 5 percent, by mass, add-material at the JMF optimum asphalt percent. The second point shall show a proportional adjustment to the submitted JMF that includes 10 percent, by mass, add-material at the JMF optimum asphalt percent. The following information will be reported for each of these two points:

(a) The maximum specific gravity (average of two tests).

(b) The test results for the individual and average bulk specific gravity, density, and height of at least two specimens at the optimum asphalt binder content. For Marshall design include the test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at the optimum asphalt binder content.

(c) The percent air voids in the mixture for each point.

(d) The Fines to Effective Asphalt ratio calculated to the nearest 0.1 of a percent.

(e) Coarse and Fine Aggregate crushing counts

Up to two add-materials will be allowed per mix design submittal. Aggregate quality and mix characteristics are required for each proposed add-material and shall be submitted at the time of the original trial mix submittal. No mixture sample or briquettes are required for these two additional points.
Additional Documentation for:

Gyratory Design

(G1) The test results from the composite aggregate blend at the proposed JMF proportions indicating compliance with Coarse Aggregate Angularity and Fine Aggregate Angularity as shown in Table 2360.3-B2a.

(G2) The design traffic level and the initial, design, and maximum number of gyrations $N_{initial}$, $N_{design}$, and $N_{maximum}$.

(G3) The temperature ranges the mixture is intended to be discharged from the plant and compacted at the roadway shall be provided by the asphalt binder supplier. Temperatures to be included are, laboratory mixing and compaction temperature ranges and maximum field mixing and compaction temperatures.

(G4) Evidence that the completed mixture will conform to all specified physical requirements as follows:
Design air voids ($V_a$), VMA, VFA, TSR, F/Ae (Fines to effective asphalt ratio), Densification %$G_{mm}$ at $N_{initial}$, $N_{design}$, and $N_{Maximum}$.

(G5) Labeled gyratory densification tables and curves, generated from the gyratory compactor, for all points used in the mixture submittal.

Marshall Design

(M1) The test results from the composite aggregate blend at the proposed JMF proportions indicating compliance with fine aggregate angularity uncompacted voids as shown in Table 2360.3-B2a. Or calculated -4.75 mm (-#4) crushing from the composite blend of the proposed JMF. Selection of either FAA or -4.75 mm (-#4) crushing shall be made at the time of mix design submittal. This selection will dictate the choice of method used for determination of compliance and acceptance for the duration of time the Mixture Design Report is in force. RAP sand will be considered 50% crushed if the angularity index equals or exceeds 40, and 100% crushed if the angularity index equals or exceeds 45.

D Modified Mixture Design (Option 2)
Test results and documentation as described in Section 2360.3C shall be submitted to the Department Bituminous Engineer or the District Materials Engineer to verify compliance with mix design requirements and issue a Mix Design Report. Mixture submittal is not required. The Contractor may use this option if all of the following conditions are met:

a) The aggregates in the proposed Mix Design Report have been used, in part, in other Mix Design Reports. Additionally, the
aggregates must have been previously tested for and meet all applicable quality requirements in the current construction season.

b) The Level II mix designer submitting the mixture design must have a minimum of 2 years experience in mixture design.

c) The Contractor and his representatives cannot have violated the requirements of 1512 Unacceptable and Unauthorized Work relating to mixture design or mixture production within the last 12 month period.

D1 JMF Submittal
At least 2 working days prior to the start of asphalt production, the Contractor shall submit in writing a proposed Job Mix Formula (JMF) for each combination of aggregates to the Department Bituminous Engineer or District Materials Engineer for review. A Level II Quality Management mix designer must sign this proposed JMF. For each JMF submitted, the Contractor shall include documentation as outlined in Section 2360.3C to demonstrate conformance to mixture properties as specified in Table 2360.3-B2b and 2360.3-B2c. The proposed JMF shall be submitted on forms approved by the Department.

D2 Initial Production Test Verification
At the start of production, the testing frequency for the first 1,800 metric tons (2,000 tons) of each mix type shall be as specified in Table 2360.4-D.

All mixture placed on Mn/DOT projects shall meet the specified quality indicators and required field density. Failure to do so will result in reduced payment or removal and replacement with acceptable material.

The Department shall take a mix verification sample within the first four samples at the start of production of each mix type.

D3 Tensile Strength Ratio Sample
See Section 2360.4E9.

D4 Marshall Stability (Marshall Design Only)
On the first day of production, for each different mix design, at the same time the verification sample is obtained, an additional sample shall be obtained for Department evaluation of Marshall stability. This sample may be tested at the discretion of the District Materials Engineer. The Contractor is not required to test stability on production mixture.

If the Marshall stability fails to meet the minimum requirements as listed in Table 2360.3-B2c the Contractor shall stop production immediately. The Contractor will be required to submit a revised mix design, with bituminous mixture at optimum asphalt content, to
the District Materials Laboratory. If the mixture meets the minimum stability requirement production may be resumed. If the stability fails the second time, the Mix Design Report will be revoked. The Contractor will then be required to submit a new mix design according to Laboratory Mixture Design 2360.3B, Option 1. A new Mix Design Report will be issued upon successful verification of the new mixture design submittal.

E Mixture Design Report

A Mixture Design Report consists of the JMF (Job Mix Formula). The JMF includes composite gradation, aggregate component proportions, asphalt binder content of the mixture, design air voids, Voids in Mineral Aggregate, and aggregate bulk specific gravity values. JMF limits will be shown for gradation control sieves, percent asphalt binder content, air voids, and VMA. Issuance of a Mixture Design Report confirms the mixture has been reviewed for and meets volumetric properties only. No guaranty or warranty, either expressed or implied, is made regarding placement and compaction of the mixture.

A Department reviewed Mixture Design Report is required for all paving except for small quantities of material provided under Section 2360.5H. All submitted materials must meet aggregate and mixture design requirements before a Mixture Design Report is issued. The Department will review two trial mix designs per mix type designated in the plan, per Contract at no cost to the Contractor. Additional mix designs will be verified at a cost of $2000 per design, payable to the Commissioner of Transportation.

For city, county, and other agency projects, the Contractor shall provide to the District Materials Laboratory a complete Project proposal including addenda, supplemental agreements, change orders, and any Plan sheets (including typical sections) that affect the mix design. The Department will not start the verification process without this information.

2360.4 MIXTURE QUALITY MANAGEMENT (Quality Control/Quality Assurance)

A Quality Control (QC)

The Contractor shall provide and maintain a quality control program for HMA production. A quality control program is defined as all activities, including mix design, process control inspection, sampling and testing, and necessary adjustments in the process that are related to the production of a hot mix asphalt (HMA) pavement which meets the requirements of the specifications.

A1 Contractor Certified Plant HMA

A1a Certification Procedure

The Contractor shall:
(1) Complete application form and request for plant inspection.
(2) Provide a site map of stockpile locations.
(3) Pass plant and testing facility inspection by having the Plant Inspector and Bituminous Plant Authorized Agent complete and sign the Asphalt Plant Inspection Report (TP 02142-02, TP 02143-02). By signing the Asphalt Plant Inspection Report, the HMA plant authorized agent agrees to calibrate and maintain all plant and laboratory equipment within allowable tolerances set forth in these specifications, Standard Specifications for Construction, and the Mn/DOT Bituminous Manual.
(4) Obtain a Mixture Design Report prior to production.

A1b Maintaining Certification
To maintain certification, the plant must produce, test, and document all certified plant asphalt mixtures in accordance with the above requirements on a continuous basis. Continuous basis means all asphalt mixtures supplied from a certified plant to any Department project with 2360 asphalt mixtures must be sampled and tested in accordance with 2360 requirements and the Schedule of Materials Control.

The Contractor shall assure the plant certification procedure is performed annually after winter suspension and before producing material for a Project. In addition, a first-day sampling and testing frequency rate as stated in Table 2360.4-D shall be followed.

The Contractor shall recertify a plant when it is moved to a new location or a previously occupied location.

A1c Revocation of Plant Certification
The Department Construction Engineer may revoke certification of an asphalt plant when requirements are not being met or records are falsified. The Department may revoke the Technician Certification for the individual involved.

The Department Bituminous Engineer and Department Contract Administrator will maintain a list of companies who have had their asphalt plant certification revoked.

B Quality Assurance (QA)
The Department will perform QA testing as part of the acceptance process. The Engineer is responsible for QA testing, records, and acceptance. The Engineer will accomplish the QA process by:

(1) Conducting Quality assurance and verification sampling and testing.

(2) Observing sampling and tests performed by the QC personnel.
(3) Taking additional samples at any time and any location during production.
(4) Monitoring the required QC summary sheets and control charts.
(5) Verifying calibration of laboratory testing equipment.
(6) Communicating Mn/DOT test results to the Contractor’s QC personnel in a timely manner.
(7) Ensuring Independent Assurance Sampling and testing requirements are met.

C Contractor's Quality Control
C1 Personnel Requirements
Along with the proposed mix design data, the Contractor shall submit to the Engineer an organizational chart listing the names and phone numbers of individuals and alternates responsible for mix design, process control administration, and inspection. The Contractor shall also post a current organizational chart and if required by the Engineer, post a daily roster of individuals performing QC testing in the Contractor’s test facility.

The Contractor’s quality control organization or private testing firm shall have Certified Technicians who have met the requirements on file with the Department’s Technical Certification program. Individuals performing process control testing must be certified as a Level I Bituminous Quality Management (QM) Tester. Individuals performing mix design calculations or mix design adjustments must be certified as Level II Bituminous QM Mix Designer. The Contractor shall have a Certified Level II Bituminous QM Mix Designer available to make any necessary process adjustments. The Contractor shall have a minimum of one person per paving operation certified as a Level II Bituminous Street Inspector.

C2 Laboratory Requirements
The Contractor shall furnish and maintain a laboratory at the plant site or other site as approved by the Engineer. The laboratory shall be furnished with the necessary equipment and supplies for performing Contractor quality control testing. The laboratory equipment shall meet the requirements listed in Section 400 of the Mn/DOT Bituminous Manual and these specifications, including having extraction capabilities. The laboratory shall be calibrated, and operational prior to the beginning of production. In addition to the requirements listed above, the laboratory shall be equipped with a telephone for use by the Contractor or the Engineer. A fax machine and copy machine shall be available for use by the Contractor or the Engineer at the laboratory site. The laboratory shall also include a computer and printer. The computer shall have the following minimum requirements: 1) Intel based with either Celeron or Pentium
IV processor with a minimum processor speed of 1.8 MHZ.  2) CD writer with CD/RW capability and a minimum write speed of 16x.  3) Windows 2000 or Windows XP with Microsoft Excel version 97 or newer. The printer must be able to print control charts.

The Engineer shall be allowed to inspect measuring and testing devices to confirm both calibration and condition. The Contractor shall calibrate and correlate all testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual.

D Sampling and Testing

The Contractor shall ensure that all QC samples are taken at random locations. Random number generation and determination of random sample location shall be consistent with the Mn/DOT Bituminous Manual Section 5-693.7 Table A or Section 5 of ASTM D3665. The Engineer may approve alternate methods of random number generation.

The tests for mixture properties shall be conducted on representative portions of the mix, quartered from a larger sample of mixture taken from behind the paver, or when approved by the Engineer, an alternate sampling location. The procedure for truck box sampling, an alternate sampling location, is on file in the Bituminous Office. When an alternate sampling location is approved and used by the Contractor, the daily verification sample must still be taken from behind the paver.

The Contractor shall obtain a sample of at least 25 kg (55 pounds). This sample may be either split in the field or transported to the test facility by a method to retain heat to facilitate sample quartering procedures. The Contractor shall store and retain mixture bulk samples and companion samples for the Department for a period of 7 working days. The Contractor shall maintain these split samples in containers labeled with companion numbers. The Contractor shall perform QC sampling and testing according to the following schedule.

Determine the planned tonnage for each mixture to be produced during the production day. Divide the planned production by 1000. Round the number to the next higher whole number. This number will be the number of production tests required for that mixture. Required production tests are listed in Table 2360.4-E. Split the planned production into even increments and select sample locations as described above. If actual tonnage exceeds planned tonnage additional tests may be required. During production, mixture volumetric property tests will not be required when mix production is less than 270 metric tons (300 tons). However, production tests will be required when the accumulative tonnage on successive days exceeds 270 metric tons (300 tons).
At the start of production, the testing frequency for the first 1800 metric tons (2,000 tons) of each mix type shall be as follows:

### TABLE 2360.4-D

<table>
<thead>
<tr>
<th>Production Test</th>
<th>Testing Rates</th>
<th>Test Reference</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Specific Gravity</td>
<td>1 test per 450 metric tons (500 tons)</td>
<td>AASHTO T312, T166 Mn/DOT modified</td>
<td>2360.4E2</td>
</tr>
<tr>
<td>Maximum Specific Gravity</td>
<td>1 test per 450 metric tons (500 tons)</td>
<td>AASHTO T209 Mn/DOT modified</td>
<td>2360.4E3</td>
</tr>
<tr>
<td>Air Voids (calculated)</td>
<td>1 test per 450 metric tons (500 tons)</td>
<td>AASHTO T269, T312</td>
<td>2360.4E4</td>
</tr>
<tr>
<td>Asphalt Content</td>
<td>1 test per 450 metric tons (500 tons)</td>
<td>Bit &amp; Lab Manual</td>
<td>2360.4E1</td>
</tr>
<tr>
<td>VMA (Calculated)</td>
<td>1 test per 450 metric tons (500 tons)</td>
<td>AI MS 2 &amp; SP 2</td>
<td>2360.4E5</td>
</tr>
<tr>
<td>Gradation</td>
<td>1 test per 900 metric tons (1000 tons)</td>
<td>AASHTO T11, T27, T30Mn/DOT modified</td>
<td>2360.4E6</td>
</tr>
<tr>
<td>Coarse Aggregate Angularity</td>
<td>1 test per 900 metric tons (1000 tons)</td>
<td>ASTM D5821</td>
<td>2360.4E7</td>
</tr>
<tr>
<td>Fine Aggregate Angularity (FAA)</td>
<td>1 test per 900 metric tons (1000 tons)</td>
<td>AASHTO T304, Method A</td>
<td>2360.4E8</td>
</tr>
</tbody>
</table>

(1) Marshall design allows -4.75mm (-#4) manufactured crushed fines calculation per Mn/DOT Bituminous Manual

**E Production Tests**

When more than one Mn/DOT approved test procedure is available, the Contractor shall select, with the approval of the Engineer, one method at the beginning of the Project and use that method for the entire Project. The Contractor and Engineer may agree to change test procedures during the construction of the Project.
## TABLE 2360.4-E
PRODUCTION SAMPLING AND TESTING RATES

<table>
<thead>
<tr>
<th>Production Test</th>
<th>Sampling/Testing Rates</th>
<th>Test Reference</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Specific Gravity</td>
<td>Divide the planned production by 1000. Round the number to the next higher whole number.</td>
<td>AASHTO T312, T245 T166 Mn/DOT mod</td>
<td>2360.4E2</td>
</tr>
<tr>
<td>Maximum Specific Gravity</td>
<td>&quot;</td>
<td>AASHTO T209 Mn/DOT modified</td>
<td>2360.4E3</td>
</tr>
<tr>
<td>Air Voids (calculated)</td>
<td>&quot;</td>
<td>AASHTO T269, T312</td>
<td>2360.4E4</td>
</tr>
<tr>
<td>Asphalt Content</td>
<td>&quot;</td>
<td>Bit &amp; Lab Manual</td>
<td>2360.4E1</td>
</tr>
<tr>
<td>VMA (Calculated)</td>
<td>&quot;</td>
<td>AI MS 2 &amp; SP 2</td>
<td>2360.4E5</td>
</tr>
<tr>
<td>Gradation</td>
<td>1 gradation per 1,800 metric tons (2,000 tons), or portion thereof (minimum of one per day)</td>
<td>AASHTO T11, T27, T30Mn/DOT modified</td>
<td>2360.4E6</td>
</tr>
<tr>
<td>Coarse Aggregate Angularity</td>
<td>2 tests/day for a minimum of 2 days, then 1 per day if CAA is met. If CAA &gt;8% of requirement, 1 sample/day but test 1/week.</td>
<td>ASTM D5821</td>
<td>2360.4E7</td>
</tr>
<tr>
<td>Fine Aggregate Angularity (FAA)</td>
<td>2 tests/day for a minimum of 2 days, then 1 per day if FAA is met. If FAA &gt;5% of requirement, 1 sample/day but test 1/week.</td>
<td>AASHTO T304, Method A</td>
<td>2360.4E8</td>
</tr>
<tr>
<td>TSR</td>
<td>1st sample at 5,000 tons or by second day of production, then sample at every 18,000 metric tons (20,000 tons)</td>
<td>ASTM D4867 Mn/DOT modified</td>
<td>2360.4E9</td>
</tr>
<tr>
<td>Aggregate Specific Gravity</td>
<td>1 per 9,000 metric tons (10,000 tons)</td>
<td>AASHTO T84 &amp; T85, Mn/DOT modified</td>
<td>2360.4E10</td>
</tr>
<tr>
<td>Mixture Moisture Content</td>
<td>Daily unless exempted by Engineer</td>
<td>Mn/DOT 5-693.950</td>
<td>2360.4E11</td>
</tr>
<tr>
<td>Asphalt Binder</td>
<td>Sample 1st load (each grade) then 1 per 1,000,000 liter (250,000 gallon-sample size 1 quart.)</td>
<td>Mn/DOT 5-693.920</td>
<td>2360.4E12</td>
</tr>
</tbody>
</table>
2360.4

(1) Marshall design allows -4.75mm (-#4) manufactured crushed fines calculation per Mn/DOT Bituminous Manual

E1 Asphalt Binder Content
(a) Spot Check (Virgin only)...............................................................Mn/DOT Bituminous Manual
(b) Incinerator Oven (1).................................................................Mn/DOT Laboratory Manual Method 1853
(c) Chemical Extraction .................................................................Mn/DOT Laboratory Manual Method 1851 or 1852
(d) Meter Method (Virgin only)....................................................Mn/DOT Bituminous Manual

(1) Incinerator Oven may not be used when the percentage of Class B material exceeds 50% within the composite blend, unless a correction factor is determined by the Contractor and approved by the District Materials Engineer.

E2 Marshall Bulk Specific Gravity, Gmb (3 specimens).............AASHTO T166, Mn/DOT Modified, or
E2a Gyratory Bulk Specific Gravity, Gmb (2 specimens)...........AASHTO T312, T166, Mn/DOT Modified
E3 Maximum Specific Gravity, Gmm .......................................AASHTO T209, Mn/DOT Modified

Isolated air voids are calculated using the maximum mixture specific gravity and the corresponding bulk specific gravity from a single test. Individual air voids are calculated from the maximum specific gravity moving average and the bulk specific gravity from that single test.

For gyratory design, compaction shall be conducted to Nmaximum and calculations for %Gmm at Ninitial and Ndesign shall be determined by applying the calculated correction factor as described in the Asphalt Institute SP 2 manual.

Production control for % Gmm at Ninitial and Nmaximum shall not exceed the limit shown in Table 2360.3-B2b by more than 1.0 %. Mixture produced beyond these limits, as measured by the moving average of four tests, may result in a cancellation of the Mix Design Report. A new mix design and submittal that satisfies these specification criteria may be required.

E5 Voids Mineral Aggregate (VMA) (calculation).................Asphalt Institute MS-2, SP-2
E6 Gradation - Blended Aggregate .................................
   ....AASHTO T-11, T-27, and T-30 (all Mn/DOT modified)
   Testing to determine the blended aggregate gradation shall be
determined every 1800 metric tons (2,000 tons), or portion thereof
(minimum of one per day), on samples taken at the same time as the
required mixture sample for a given increment.
All gradations require a - 0.075 mm (#200) wash.
   (a) Virgin Aggregate Mixtures - Drum or Screenless Plants
       Belt Samples or extracted production samples.
   (b) All Other Mixtures:
       1. Hot Bins - Drybatch (Optional)
       2. Incinerator Oven Mn/DOT Laboratory Manual
          Method 1853 (Optional) except samples that contain
          over 50% class B. (1)
       3. Extraction Mn/DOT Laboratory Manual Method
          1851 or 1852 (Optional)
          (1) Incinerator Oven may not be used when the
          percentage of Class B material exceeds 50%
          within the composite blend, unless a correction
          factor is determined by the Contractor and
          approved by the District Materials Engineer.
E7 Coarse Aggregate Angularity ............................... ASTM D5821
   CAA test results shall meet the minimum percent fractured faces
as shown in Table 2360.3-B2a. ASTM D-5821 shall be used to
determine coarse aggregate angularity on the composite blend from
aggregates used in production of hot mix asphalt. Mixtures that
contain virgin aggregates may be tested from composite belt samples.
Mixtures that contain RAP must be tested from extracted aggregates
taken from standard production samples. The percentage of fractured
faces of the composite aggregate blend less than 100% shall be tested
at the following rates:
   (1) Perform two tests per day for each mixture blend for a
       minimum of two days and then one per day if the test
       samples meet CAA requirements.
   (2) If CAA crushing test results exceed 8 percent of the
       requirement, take one sample per day and perform one test
       per week.
   CAA results must be reported on the test summary sheet.
Mixture placed and represented by results below the minimum
requirement, as shown in Table 2360.3-B2a, will be subject to
reduced payment as outlined in Table 2360.4-L3. Tonnage subjected
to reduced payment shall be calculated as the tons placed from the
sample point of the failing test until the sampling point when the test
result is back within specifications.
Fine Aggregate Angularity

FAA test results shall meet the minimum criteria shown in Table 2360.3-B2a. ASTM C1252 Method A shall be used to determine fine aggregate angularity on the composite blend from aggregates used in production of HMA. Mixtures that contain virgin aggregates may be tested from composite belt samples. Mixtures that contain RAP must be tested from extracted aggregates taken from standard production samples. The percentage of uncompacted voids from the composite aggregate blend shall be tested at the following rates.

1. Perform two tests per day for each mixture blend for a minimum of two days and then one per day if the test samples meet FAA requirements.
2. If FAA test results exceed 5 percent of the requirement, take one sample per day and perform one test per week.

FAA results must be reported on the test summary sheet. Mixture placed and represented by results below the minimums, as shown in Table 2360.3-B2a, will be subject to reduced payment as outlined in Table 2360.4-L3. Tonnage is subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within specifications.

- 4.75 mm (-#4) Manufactured Crushed Fines

Under Marshall design, when the -4.75 mm (-#4) crushing is calculated, adjustments in target values from the composite blend must be made at the end of each days paving. If the target quantity (percent of -4.75 mm (-#4) to be crushed) changes due to mixture proportion or composite gradation change, a new target shall be established for the next days paving.

Field Tensile Strength Ratio (TSR)

A TSR sample shall be obtained within the first 4,500 metric tons (5,000 tons) of HMA produced or by the second day of production, whichever comes first, to verify tensile strength ratio (TSR). These samples may be tested at the discretion of the District Materials Engineer. If the Materials Engineer requires the samples to be tested, both the Contractor and the Department will be required to test these samples within 72 hours after it is sampled. Sample size shall be 50 kg (110 pound) minimum and split in half to provide a sample for the Department and the Contractor. The Department companion of this split shall be labeled with the date, time, Project number and approximate cumulative tonnage to date. The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer.
within 24 hours of sampling, as specified by the Engineer. Mixture samples shall be taken from behind the paver unless the Engineer approves an alternate sampling location. Specimen size shall be 100 mm (4 inch) for Marshall mix design and 150 mm (6 inch) for gyratory design. The Contractor may test the sample at a permanent lab site or a field lab site.

Additional HMA mixture samples for TSR evaluation shall be sampled at a rate of 1 per 18,000 metric tons (20,000 tons) increments for all mixtures produced on the Project. These samples may be tested at the discretion of the District Materials Engineer. If the Materials Engineer requires the samples to be tested, both the Contractor and the Department will be required to test these samples.

Minimum acceptable TSR values for production are shown in Table 2360.4-E9. The Contractor shall stop production immediately if minimum TSR requirements are not met. The Contractor will not be allowed to resume production until anti-stripe has been added to the asphalt binder. Determination of who is responsible for the cost of the anti-stripe is based on Mn/DOT and Contractor TSR values as outlined in Tables 2360.4E9A, 2360.4E9B, and 2360.4E9C. When Mn/DOT is responsible for the cost of the anti-stripe, payment will be made only for the cost of the anti-stripe for mixtures placed on that project. Mn/DOT will not reimburse the Contractor for any delay costs associated with making changes related to this testing.

<table>
<thead>
<tr>
<th>TABLE 2360.4-E9</th>
<th>Mixture Type - Minimum TSR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LV and MV Gyratory Traffic Level 2-3 Traffic Level 4-5</td>
</tr>
<tr>
<td>Contractor Mn/DOT Contractor Mn/DOT Contractor Mn/DOT</td>
<td>70% 60% 75% 65% 80% 70%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2360.4-E9A</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV and MV Mixtures</td>
</tr>
<tr>
<td>Mn/DOT TSR</td>
</tr>
<tr>
<td>Mn/DOT MN/DOT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2360.4-E9B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyratory Level 2-3</td>
</tr>
<tr>
<td>Mn/DOT TSR</td>
</tr>
<tr>
<td>Mn/DOT MN/DOT</td>
</tr>
</tbody>
</table>
Another sample shall be taken and tested within the first 450 metric tons (500 tons) after production resumes. If the re-test fails to meet the minimum specified value the Contractor shall stop production immediately. Production cannot resume until the Contractor has discussed, with the Engineer, a proposal for resolving the problem. The Contractor shall not operate below the specified minimum TSR on a continuing basis. A continuing basis shall be defined as 2 or more successive tests failing the TSR requirements.

The following conditions will automatically require a sample to be taken and tested:

1. A proportion change of more than 10 percent (from the currently produced mixture) for a single stockpile aggregate.
2. The discretion of the Engineer.

Dispute resolution procedures for TSR are on file in the Bituminous Office.

E10 Aggregate Specific Gravity (Gsb) ..............................................
.................................AASHTO T84 and T85, Mn/DOT modified

Samples of all aggregate stockpiles shall be collected on each aggregate used in the production mixture, at a rate of one sample per 9,000 metric tons (10,000 tons) mixture produced. These samples shall be taken at random as directed by the Engineer. These representative stockpile samples shall be 40 kg (90 pounds) of each aggregate component. Each sample shall be split in half to provide a sample for the Department and the Contractor. The Department companion shall be labeled with date, time, Project number and approximate cumulative tonnage to date.

The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer within 48 hours of sampling, as specified by the Engineer. These samples may be tested. Tested samples will be compared to the Contractor’s values on the Mix Design Report. If the results deviate beyond the tolerance specified in Table 2360.4-M, the dispute resolution procedure on file in the Bituminous Office will be utilized. Any mixture placed following notification of new specific gravity values will be based upon Department results unless proven incorrect. The Contractor shall be notified when new specific gravity values become available and what impact this will have on the calculated VMA.
E11 Moisture Content .................................. Mn/DOT 5-693.950

Provide a mixture with a moisture content not greater than 0.3 percent. The moisture content in the mixture shall be measured behind the paver or alternate approved sampling method on file in the Bituminous Office. Sampling and testing shall be conducted by the Contractor on a daily basis unless exempted by the Engineer. Sampling and testing is suggested when rain on stockpiles exceed more than 5 mm (0.2 inch) in a 24 hour period. The sample shall be stored in an airtight container. Microwave testing is prohibited.

HMA that exceeds 0.3% moisture content is unacceptable. The Contractor shall take appropriate action to remove excess water from the mixture. This action may include reducing the production rate, mixing stockpile aggregates prior to placement into the feed bins, and use of covered stockpiles.

E12 Asphalt Binder Samples

The Contractor shall sample the first shipment of each type of asphalt binder, then sample at a rate of one per 1,000,000 liters (250,000 gallons); sample size shall be 1.0 L (1 quart). All samples shall be taken in accordance with the Mn/DOT Bituminous Manual 5-693.920. Sampling shall be conducted by Contractor and monitored by the Inspector. Promptly submit the sample to the Department Materials Laboratory in Maplewood. The Contractor shall record sample information on Asphalt Sample Identification Card.

F Documentation (Records)

The Contractor shall maintain documentation, including test summary sheets and control charts, on an ongoing basis. The Contractor shall also maintain a file of gyratory specimen heights for all gyratory compacted samples and test worksheets. Reports, records, and diaries developed during the progress of construction activities for the Project, shall be filed as directed by the Engineer and will become the property of the Department. The Contractor shall:

1. Number test results in accordance with standard Department procedures and record on forms approved/supplied by the Department.

2. Facsimile all production test results on test summary sheets to the District Materials Laboratory and to other sites as requested by the Engineer, by 11 AM of the day following production.

2a) Include the following production test results and mixture information on the Department approved test summary sheet.
1. Percent passing on sieves listed in Table 2360.2-E.
2. Coarse and fine aggregate crushing.
3. Maximum specific gravity \( G_{\text{mm}} \).
4. Bulk specific gravity \( G_{\text{mb}} \).
5. Percent asphalt binder content \( P_b \).
6. Calculated production air voids \( V_a \). Gyratory design shall also include \( \% G_{\text{mm}} \) at \( N_{\text{initial}} \), \( \% G_{\text{mm}} \) at \( N_{\text{design}} \), and \( \% G_{\text{mm}} \) at \( N_{\text{maximum}} \).
7. Calculated voids in mineral aggregate \( V_{\text{MA}} \).
8. Composite aggregate specific gravity \( G_{sb} \) reflecting current proportions.
9. Aggregate proportions in use at the time of sampling.
10. Tons where sampled.
11. Cumulative tons.
11a. Tons Represented by Test.
12. Fines to effective asphalt ratio \( F/A_e \).
13. Signature Line for Mn/DOT and Contractor Representative.
14. Mixture Moisture Content.
15. Mn/DOT verification sample test result.

(2b) Submit copies of all failing test results to the Engineer on a daily basis.

(3) Provide the Engineer with asphalt manifests of BOL's on a daily basis.

(4) Provide a daily plant diary to include a description of QC actions taken (adjustment of cold feed percentages, changes in JMF's, etc.) include all changes or adjustments on the test summary sheets.

(5) Provide weekly truck scale spot checks.

(6) Provide a Department approved accounting system for all mixes and provide a daily and final Project summary of material quantities and types.

(6a) Provide a final hardcopy summary of all quality control test summary sheets and control charts at completion of bituminous operations on the Project to the Engineer. Because Certified Plant test data often represents test data for multiple projects, it may be necessary to make duplicate copies of the data for each project. The Contractor shall also submit a diskette of the quality control summary sheets, control charts and density worksheets to the Bituminous Engineer.

(7) Furnish an automated weigh scale and computer generated weigh ticket. The ticket shall indicate project number, mix designation (including binder grade), Mixture Design
Report#, truck identification and tare, net mass, date and time of loading. Any deviations from the minimum information to be provided on the computer generated weigh ticket must be approved by the Engineer in writing.

(8) Charts and records for a mixture produced at one plant site shall be continued from contract to contract.

G Documentation (Control Charts)
The following data shall be recorded on the standardized control charts, all control charts and summary sheets shall be computer generated using software approved by the Engineer. Software is available from the Mn/DOT Bituminous Office website.

1. Blended aggregate gradation, include sieves shown in Table 2360.2-E for specified mixture.
2. Percent asphalt binder content ($P_b$).
3. Maximum specific gravity ($G_{max}$).
4. Production air voids ($V_a$).
5. VMA.

Individual test results shall be plotted for each test point. A solid line shall connect individual points. The moving average for each test variable shall be plotted starting with the fourth test. A dashed line shall connect the moving average points. The Department's quality assurance and verification test results shall be plotted with asterisks. Specification JMF limits shall be indicated on the control charts using a dotted line. The Engineer may waive the plotting of control charts.

H JMF Limits
The production air voids and VMA are based upon the minimum specified requirements as shown in Tables 2360.3-B2b and 2360.3B2c. Gradations and asphalt binder content limits are based upon the current Department reviewed Mixture Design Report. Gradation control sieves include each sieve shown in Table 2360.2-E.

The mixture production targets are listed on the Mixture Design Report. JMF limits are the target plus or minus the limits shown in Table 2360.4-H. JMF limits are used as the criteria for acceptance of materials based on the moving average. A moving average is the average of the last four test results.

I JMF Bands
JMF Bands are defined as the area between the target, as identified on the Mixture Design Report, and the JMF limits.
TABLE 2360.4-H
JMF LIMITS (N=4)

<table>
<thead>
<tr>
<th>Item</th>
<th>JMF Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMA, %</td>
<td>- 0.3</td>
</tr>
<tr>
<td>Production Air Voids, %</td>
<td>± 1.0</td>
</tr>
<tr>
<td>Asphalt Binder Content, %</td>
<td>- 0.4</td>
</tr>
<tr>
<td>Sieve - % Passing*</td>
<td></td>
</tr>
<tr>
<td>25, 19, 12.5, 9.5, 4.75 mm (1 inch, ¾ inch, ½ inch, 3/8 inch, #4)</td>
<td>± 7</td>
</tr>
<tr>
<td>2.36 mm (#8)</td>
<td>± 6</td>
</tr>
<tr>
<td>0.075 mm (#200)</td>
<td>± 2.0</td>
</tr>
</tbody>
</table>

*JMF limits are not allowed outside the broadband requirements in Table 2360.2-E.

J JMF Adjustment

The Contractor shall begin mixture production with the materials (gradation, asphalt content, and aggregate proportions) closely conforming to the reviewed Mixture Design Report. Closely conforming shall be defined as aggregate proportions within 5 percent of the design proportions (1) and other mixture parameters within the JMF limits in Table 2360.4-H. This requirement may be waived if the Contractor provides the District Materials Laboratory with prior documented production data showing how production affects the mixture properties or if the Contractor provides the District Materials Laboratory with a written justification or explanation of material changes since the original mixture submittal.

(1) The Contractor shall begin mixture production using all aggregate proportions included on the Mixture Design Report unless the aggregate proportion is shown as 0 percent.

If, during production, the Contractor determines from results of QC tests that adjustments to the mix design are necessary to achieve the specified properties, the following provisions shall apply. No adjustments are allowed using aggregates or materials not part of the original mix design.

The Contractor shall make a request for a JMF adjustment to the Department Bituminous Engineer or District Materials Engineer. The requested change will be reviewed for the Department by a Certified Level II Bituminous QM Mix Designer. If the request meets the design requirements in Tables 2360.3-B2a and 2360.3-B2b, a revised Mixture Design Report shall be issued. Each trial mixture design submittal as described in Section 2360.3A may have three JMF adjustments per mixture per project without charge. Additional JMF adjustments requested must be accompanied with a $500 fee per each additional JMF adjustment, payable to the Commissioner of
Transportation.  

If a JMF change is requested for the 0.075 mm (#200) sieve, the Fines to Effective Asphalt Ratio shall be determined on the moving average from the previous four gradation tests conducted during actual production. The adjusted JMF shall be within the mixture specification gradation design broadbands shown in Section 2360.2E. Should a redesign of the mixture become necessary, a new JMF shall be submitted. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the minimum VMA requirement for the mixture being produced.

Adjustments will be made as a result of an interactive process between the Contractor, Engineer, and District Materials Engineer. Consecutive requests for JMF adjustments, without production data, are not allowed. The calculation of the moving average shall continue after the JMF has been approved.

J1 JMF Adjustment for Proportion Change > 10% 

If a JMF adjustment is requested for a proportion change exceeding 10% (from the currently produced mixture) for a single stockpile aggregate, supporting production test data from a minimum of four tests run at an accelerated testing rate of 1 test per 450 metric tons (500 tons) must be included with the request for adjustment. In addition to the requirements listed above, acceptable verification and approval of the requested JMF will be based on individual and moving average test results. Individual test results must be within twice the requested JMF limits for percent asphalt binder, production air voids, and VMA. Individual gradation must be within twice the requested JMF bands. The moving average values must be within the control limits of Table 2360.4-H. The calculation of the moving average shall continue after the change in proportions.

If the mixture meets the specified quality indicators, the request for JMF adjustment will be signed by the District Materials Laboratory and considered effective from the point the proportion change was made. Failure to meet the quality indicators will result in reduced payment or removal and replacement with acceptable material. Consecutive requests for JMF adjustments without production data is not allowed.

K Corrective Action -- Percent Asphalt Binder Content, VMA, and Gradation and Production Air Voids

When the moving average values trend toward the JMF limits, the Contractor shall take corrective action. The corrective action taken shall be documented on summary sheets and, if applicable, a request for JMF adjustment shall be submitted to the District Materials Engineer for review and approval. All tests shall be part of the project files and shall be included in the moving average
calculations. The Contractor shall notify the Engineer whenever the moving average values exceed the JMF limits.

L Failing Materials
The determination of price adjustments for failing materials will be based on the criteria outlined in this Section. Material acceptance is based on individual and moving average test results. Isolated test results are used for acceptance of air voids at the start of mixture production. Generally, individual test results which are more than twice the JMF bands are considered failing. Moving average test results are considered failing when they exceed the JMF limits.

If the moving average values exceed the JMF limits, the Contractor shall stop production and make adjustments. The Contractor shall restart production only after notifying the Engineer of the adjustments that have been made. Testing shall resume at the accelerated rates and for the tests listed in Table 2360.4-D for the next 1800 metric tons (2,000 tons) of mixture produced. The calculation of the moving average shall continue after the stop in production.

Mixture produced where the moving average of four exceeds the JMF limits shall be considered unsatisfactory and subject to requirements of Section 2360.4L4, L5, L6, and L7. Individual test failures are discussed in Section 2360.4L1, L2, and L3.

When the total production of a mixture type for the entire project requires less than four tests, a moving average will be established based on the tests taken. Acceptance of material will be consistent with the criteria outlined in Section 2360.4L and will be based on the following modifications to the JMF limits: For two tests, establish the new JMF limits by multiplying the JMF limits listed in Table 2360.4-H by 1.41; for three tests, establish the new JMF limits by multiplying the JMF limits listed in Table 2360.4-H by 1.15. For moving average gradation, the modified JMF limit cannot exceed the broadband requirements in Table 2360.2-E.

When the Contractor's testing data fails to meet specified tolerances as listed in Table 2360.4-M, quality assurance/verification data shall be used in place of the Contractor's data to determine the appropriate payment factor.

L1 Isolated Failures at Mixture Start-Up – Production Air Voids
At the start-up of mixture production, before a moving average of four can be established the first three (3) isolated test results for production air voids will be used for acceptance. Isolated production air voids are calculated by using the maximum mixture specific gravity and the corresponding bulk specific gravity from that single test. After four (4) samples have been tested and a moving average of four can be established, acceptance will be based on individual and
moving average production air voids.

If, at the start of production, any of the first three (3) isolated test results for production air voids exceeds twice the JMF bands from the target listed on the Mixture Design Report, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the isolated test result is back within twice the JMF bands. When the failure occurs at the first test, after the start of production, the tonnage subjected to reduce payment shall be calculated as described above and shall include the tonnage from the start of production.

When isolated air voids are less than 1.0% or greater than 7.0% the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. To better define the area to be removed and replaced the Engineer may require the Contractor to test inplace mixture. This may include testing mixture placed prior to the failing test result. Reduced payment will be 50 percent of the Contract bid price.

L2 Individual Failure at Mixture Start-Up – VMA

At the start-up of mixture production, before a moving average of four can be established, the first three (3) individual test results for VMA will be used for acceptance. After 4 samples have been tested and a moving average of four can be established, acceptance will be based on individual and moving average VMA.

If, at the start of production, any of the first three (3) individual VMA test results exceeds twice the JMF bands from the target listed on the Mixture Design Report, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the test results are back within twice the JMF limits. When the failure occurs at the first test, after the start of production, the tonnage subjected to reduce payment shall be calculated as described above and shall include the tonnage from the start of production.

L3 Individual Failure - Gradation, Percent Asphalt Binder, Production Air Voids, and VMA

If the individual gradation test exceeds twice the JMF bands from the target listed on the Mixture Design Report the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage represented by the individual test.
TABLE 2360.4-L3
REDUCED PAYMENT SCHEDULE FOR INDIVIDUAL TEST RESULTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Pay Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation</td>
<td>95 %</td>
</tr>
<tr>
<td>Coarse and Fine Aggregate Crushing</td>
<td>90 %</td>
</tr>
<tr>
<td>VMA</td>
<td>85 %</td>
</tr>
<tr>
<td>Asphalt Binder Content</td>
<td>85 %</td>
</tr>
<tr>
<td>Production Air Voids (individual(^1) and isolated(^2))</td>
<td>70 %</td>
</tr>
</tbody>
</table>

\(^1\) Lowest Pay Factor applies when there are multiple reductions on a single test.

\(^2\) Individual air voids are calculated using the moving average maximum specific gravity and the bulk specific gravity from that single test.

\(^3\) Isolated air voids are calculated from the maximum specific gravity and the bulk specific gravity from that single test. Isolated void test results are used for acceptance only for the first 3 tests after mixture production start-up.

If the individual tests for percent asphalt binder content, production air voids, or VMA exceeds twice the JMF bands from the target listed on the Mix Design Report the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the test result is back within twice the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall be calculated as described above and shall include the tonnage from the start of production that day.

When individual air voids are less than 1.0% or greater than 7.0% the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. To better define the area to be removed and replaced the Engineer may require the Contractor to test inplace mixture. This may include testing mixture placed prior to the failing test result. Reduced payment will be 50 percent of the Contract bid price.
L4  Moving Average Failure at Mixture Start-Up – Production Air Voids

When a moving average failure occurs within any of the first 3 moving average results after mixture start-up (tests 4, 5, 6), the mixture will be considered acceptable if the individual air void, corresponding to the moving average failure is within the JMF limits. If the individual air void is not within the JMF limit, the mixture will be considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. The Engineer may waive the penalty if the isolated air void corresponding to the individual air void is within the JMF limit. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 50 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of the failing moving average result and corresponding individual air void beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit.

L5  Moving Average Failure at Mixture Start-Up - VMA

When a moving average failure occurs within any of the first 3 moving average results after mixture start-up (tests 4, 5, 6), the mixture will be considered acceptable if the individual VMA, corresponding to the moving average failure is within the JMF limits. If the individual VMA is not within the JMF limit, the mixture will be considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 75 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of the failing moving average result and corresponding individual VMA beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit.

L6  Moving Average Failure - Production Air Voids

A moving average production air void failure occurs when the individual production air void moving average of four exceeds the JMF limit. This mixture is considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 50 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving
average value that exceeded the JMF limit to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

### TABLE 2360.4-L6
REDUCED PAYMENT SCHEDULE FOR MOVING AVERAGE TEST RESULTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Pay Factor (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation</td>
<td>75 % (3)</td>
</tr>
<tr>
<td>Coarse and Fine Aggregate Crushing</td>
<td>NA (individual failures only)</td>
</tr>
<tr>
<td>VMA (2)</td>
<td>75 %</td>
</tr>
<tr>
<td>Asphalt Binder Content</td>
<td>75 %</td>
</tr>
<tr>
<td>Production Air Voids (2)</td>
<td>50 %</td>
</tr>
</tbody>
</table>

(1) Lowest Pay Factor applies when there are multiple reductions on a single test.
(2) See criteria for mixture production start-up.
(3) Excluding the 0.075 mm (No. 200) sieve, use 95% pay factor if failure is within ± 1% of aggregate gradation broadband, Table 2360.2-E.

L7 Moving Average Failure - Percent Asphalt Binder Content, VMA, and Gradation
For mixture properties including asphalt binder content, VMA, and gradation, where the moving average of four exceeds the JMF limits, the mixture is considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 75 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving average value that exceeded the JMF limit, to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

L8 Coarse and Fine Aggregate Crushing Failure
If any test result for Coarse Aggregate Angularity, Fine Aggregate Angularity or -4.75mm (-#4) calculated crushing fail to meet minimum requirements in Table 2360.3-B2a, all material placed
is subject to reduced payment as outlined in Table 2360.4-L3. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within specifications. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

M Quality Assurance
The Engineer will periodically witness the sampling and testing being performed by the Contractor. If the Engineer observes that the sampling and quality control tests are not being performed in accordance with the applicable test procedures, the Engineer may stop production until corrective action is taken. The Engineer will notify the Contractor of observed deficiencies promptly, both verbally and in writing.

The Engineer may obtain additional samples, at any time, to determine quality levels. These additional samples or verification samples are described in Section 2360.4N. For mixture, the Contractor shall test their portion immediately.

All testing and data analysis shall be performed by the Certified Level I Bituminous Quality Management (QM) Technician. Certification shall be in accordance with the Mn/DOT Technical Certification Program. The Department shall post a chart giving the names and telephone numbers for the personnel responsible for the Quality assurance program.

The Engineer shall calibrate and correlate all laboratory testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual.

N Verification Testing
A verification sample is a sample, which is sampled and tested by Mn/DOT to assure compliance of the Contractor’s Quality Control program. A verification companion is a companion sample, to Mn/DOT’s verification sample, provided to the Contractor. The Contractor is required to test and use this verification companion sample as part of the QC program. The verification companion sample will replace the next scheduled QC sample. It is recommended enough material be sampled to accommodate retesting should the samples fail to meet requirements as described below.
### TABLE 2360.4-M
ALLOWABLE DIFFERENCES (TOLERANCES) BETWEEN CONTRACTOR AND MN/DOT TEST RESULTS*

<table>
<thead>
<tr>
<th>Item</th>
<th>Allowable Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixture Bulk Specific Gravity ($G_{mb}$)</td>
<td>0.030</td>
</tr>
<tr>
<td>Mixture Maximum Specific Gravity ($G_{mm}$)</td>
<td>0.019</td>
</tr>
<tr>
<td>VMA (Calculated)</td>
<td>1.2</td>
</tr>
<tr>
<td>Fine Aggregate Angularity, uncompacted voids (U) %</td>
<td>1</td>
</tr>
<tr>
<td>Coarse Aggregate Angularity, % fractured faces (%P) (%)</td>
<td>15</td>
</tr>
<tr>
<td>Aggregate Individual Bulk Specific Gravity (+4.75mm (+ #4))</td>
<td>0.040</td>
</tr>
<tr>
<td>Aggregate Individual Bulk Specific Gravity (-4.75mm (- #4))</td>
<td>0.040</td>
</tr>
<tr>
<td>Aggregate combined blend Specific Gravity ($G_{sb}$)</td>
<td>0.020</td>
</tr>
<tr>
<td>Tensile Strength Ratio (TSR) %</td>
<td>See Table 2360.3-B2b</td>
</tr>
<tr>
<td><strong>Asphalt Binder Content</strong></td>
<td></td>
</tr>
<tr>
<td>Meter Method, %</td>
<td>0.2</td>
</tr>
<tr>
<td>Spot Check Method, %</td>
<td>0.2</td>
</tr>
<tr>
<td>Chemical Extraction Methods, %</td>
<td>0.4</td>
</tr>
<tr>
<td>Incinerator Oven, %</td>
<td>0.3</td>
</tr>
<tr>
<td>Chemical vs. Meter, Spot Check, or Incinerator methods</td>
<td>0.4</td>
</tr>
<tr>
<td>Incinerator Oven vs. Spot Check</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Gradation Sieve % passing</strong></td>
<td></td>
</tr>
<tr>
<td>25.0, 19.0, 12.5, 9.5 mm (1 inch, ¾ inch, ⅜ inch, 3/8 inch)</td>
<td>6</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>5</td>
</tr>
<tr>
<td>2.36 mm (#8)</td>
<td>4</td>
</tr>
<tr>
<td>0.075 mm (#200)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*Test tolerances listed are for single test comparisons.

Verification testing shall be performed on at least one set of production tests Section 2360.4E, excluding sections E9, E10, E11, and E12, on a daily basis per mix type. The verification companion sample will be used to verify the requirements of Tables 2360.2-E, 2360.3-B2a, 2360.3-B2b, and 2360.3-B2c and will be compared to the Verification sample for compliance with allowable tolerances as specified in Table 2360.4-M. These include the mixture properties of
G_{mm} (mixture max gravity), G_{mb} (mixture bulk gravity), asphalt binder content, VMA (calculated), Coarse and Fine Aggregate crushing, and gradation. For Coarse and Fine Aggregate crushing that meets the requirements of Section 2360.4E7 and 2360.4E8 the one test per week shall be performed on a verification companion. These do not include the aggregate bulk specific gravity G_{sb}, fines to effective asphalt, or the tensile strength ratio (TSR). Asphalt binder content and gradation must be determined by either extraction method 2360.4E1b or 2360.4E1c. Asphalt content from the verification test result must be used to determine VMA.

The Department’s verification test results will be available to the Contractor within 2 working days from the time the sample is delivered to the District Laboratory for G_{mm} mixture max gravity, G_{mb} mixture bulk gravity, air voids (calculated), asphalt binder content, VMA (calculated). Gradation and crushing results will be provided to the Contractor within 3 Mn/DOT working days. Once the verification test results are available, they will be included on the test summary sheet. These results and those from the Contractor’s verification companion will be compared for allowable tolerances as specified in Table 2360.4-M. If the tolerances are met, the verification process is complete.

If the tolerances between Department and Contractor are not met, retests of the material shall be conducted by the Department. If the retests fail to meet tolerances, the Department’s verification test results will be substituted for the Contractor’s results in the QC program and used for acceptance. Only those parameters out of tolerance will be substituted and, if applicable, volumetric properties will be recalculated (1).

When tolerances from the verification sample retests are not met, an investigation will begin immediately to determine the cause of the difference. Testing equipment, procedures, worksheets, gyratory specimen height sheets, and personnel will be reviewed to determine the source of the problem. The District Materials Engineer may also require a hot-cold comparison of mixture properties be performed. The procedure for hot-cold comparisons is as follows:

The hot-cold comparison sample will be split into three representative portions. The Engineer will observe the Contractor testing the sample. One part shall be compacted immediately while still hot (additional heating maybe required to raise the temperature of the sample to compaction temperature). The second and third part will be allowed to cool to air temperature. The Contractor will retain the second part and the third part will be transported to the District Materials Laboratory. On the same day and at approximately the same
time the Contractor and the District Materials Laboratory will heat their samples to compaction temperature and compact them. From this information a calibration factor will be developed to compare the specific gravity of the hot compacted samples to reheated compacted samples. Each test will involve a minimum of three Marshall specimens or two gyratory specimens. This test may be repeated at the discretion of the Contractor or the District Materials Engineer.

**Note:** Care must be taken when reheating samples for mixture properties analysis tests. Mix samples should be reheated to 70°C (160°F) to allow splitting of the sample into representative fractions for the various tests. Overheating of the mixture portions to be tested for maximum specific gravity (Rice Test) may result in additional asphalt being absorbed in the aggregate.

The Department will test the previously collected QA samples until they meet the tolerances or the remaining samples are all tested. Once these samples are tested, the department will test QA samples subsequent to the verification sample until tolerances are met. Acceptance will be based on QC data with substitution of Department test results for those parameters out of tolerance \(^{(1)}\). If reestablishment of test result tolerances is not achieved within 48 hours, the Contractor shall cease mixture production and placement until the problem is resolved.

\(^{(1)}\) If, through analysis of data, it is determined there is a bias in the test results, the Engineer will determine which results are appropriate and shall govern. Methods to analyze data for determination of bias are on file in the Bituminous Office.

**2360.5 CONSTRUCTION REQUIREMENTS**

***A General***

The following construction requirements provide for the construction of all courses. When construction is under traffic, the requirements of Mn/DOT 2221.3D will apply.

***B Restrictions***

In general, no work within the roadway will be permitted in the spring until seasonal load restrictions on roads in the vicinity have been removed. However, work within the roadbed may be permitted before that time if, in the opinion of the Engineer, it can be done without damage to the subgrade. HMA shall not be placed when, in the opinion of the Engineer, the weather or roadbed conditions are unfavorable.
No asphalt pavement wearing course (final wearing course if multiple wearing courses) shall be placed after October 15th in that part of the state north of an east-west line between Browns Valley and Holyoke, nor after November 1st south of that line. The Engineer may waive these restrictions when:

1. The asphalt mixture is not being placed on the traveled portion of the roadway, or
2. The roadway involved will not be open to traffic during the following winter, or
3. The Engineer directs in writing the mixture be placed.

The Contractor shall not use petroleum distillates such as kerosene and fuel oil to prevent adhesion of asphalt mixtures in pavement hoppers, truck beds, or on the contact surfaces of the compaction equipment. Anti-adhesive agent must meet the criteria for "Effect on Asphalt" as described in the most recent Asphalt Release Agent Report on file in Mn/DOT’s Office of Environmental Services and the Bituminous Office.

C Equipment
C1  Asphalt Mixing Plants
C1a  Requirement for All Plants
   The Contractor shall test and calibrate all scales according to Mn/DOT 1901, except as otherwise designated by the Contract.
C1a(1)  Equipment for the Preparation of the Aggregate
   Add mineral filler to the mixture using a storage silo equipped with a device to ensure a constant and uniform feed.
C1a(2)  Equipment for the Preparation of Asphalt Material
   Tanks for storage of asphalt material at the plant shall be equipped to heat the material and maintain the material at the required temperatures. The discharge end of the circulating line shall be below the surface of the asphalt material. Provide agitation for modified asphalt, when used, if recommended by the supplier.
   An outage table or chart and measuring stick shall be provided for each storage or working tank. Tanks shall be equipped with provisions for taking of asphalt binder material samples. After delivery of asphalt binder material to the Project, the Contractor shall not heat the material above 175°C (350°F). For modified asphalt, the maximum storage temperature shall not exceed the recommendation of the asphalt supplier.
C1a(3)  Asphalt Binder Control
   When asphalt binder material is proportioned by volume, the plant shall be equipped with either a working tank or a metering system for determining asphalt binder content of the mixture.
   The working tank shall have a capacity between 3,800 L (1,000 gallons) and 7,600 L (2,000 gallons). The working tank shall be
calibrated and supplied with a calibrated measuring stick. The tank may be connected to a mixing unit and used only during spot check operations, but it shall be available at all times. Any feedback shall be returned to the working tank during spot check operations.

The metering system shall consist of at least one approved asphalt binder flow meter in addition to the asphalt binder pump. The flow meter shall be connected to the asphalt binder supply to measure and display only the asphalt binder being fed to the mixer unit. The meter readout shall be positioned for convenient observation. Means shall be provided for comparing the flow meter readout with the calculated output of the asphalt binder pump. In addition, the system shall display in liters (gallons) or to the nearest 0.001 metric tons (0.001 tons), the accumulated asphalt binder quantity being delivered to the mixer unit. The system shall be calibrated and adjusted to maintain an accuracy of ± one percent error. This calibration shall be required for each plant set-up prior to production of mixture.

C1a(4) Dryer: The aggregate shall be free of unburned fuel.
C1a(5) Thermometric Equipment:
   The plant shall be equipped with a sufficient number of thermometric instruments to ensure temperature control of the aggregate and the asphalt binder material.
C1a(6) Pollution Controls
C1a(6)(a) Pollution ............................................................... 1717
C1a(7) Surge and Storage Bins
   The plant may include facilities to store hot asphalt mixture for coordinating the rate of production with the paving operations. Storage of the hot mixture will be permitted for a period not to exceed 18 hours, provided the following requirements are met:
   (a) Hot mix storage facilities shall be designed and operated to prevent segregation of the mix, drainage of the asphalt from the mix, and to prevent excessive cooling or overheating of the mixture.
   (b) The temperature of the mixture at time of discharge from the storage facility shall be within a tolerance of 5°C (9°F) of the temperature when discharged from the silo or mixer.

C2 Placement and Hauling Equipment
   All equipment shall be serviced away from the paving site to prevent contamination of the mixture. Units that drip fuel, oil, or grease shall be removed from the paved surface until such leakage is corrected.
C2a Asphalt Pavers
   Asphalt pavers shall be self-contained, power-propelled units, with an operational vibratory screed, capable of spreading and
finishing courses of asphalt plant mix material in widths applicable to
the specified typical sections and thicknesses, indicated in the
Contract.

The screed or strike-off assembly shall produce a finished surface
of the required evenness and texture without tearing, shoving, or
gouging. For mainline paving, screed extensions and auger
extensions are required if the paving width on either side of the paver
is greater than the basic screed unless otherwise directed by the
Engineer. Strike-off only extension assemblies are not allowed for
mainline wearing course paving, unless directed by the Engineer.

Automatic screed control by means of an erected string line shall
only be required when stated in the Contract.

All pavers shall be equipped with an approved automatic screed
control. The automatic controls shall include a system of
sensor-operated devices, which follow reference lines, or surfaces on
one or both sides of the paver as required. The speed of the paver
shall be adjusted to produce the best results.

All mixtures shall be spread without segregation to the cross
sections shown in the plans. In general, leveling layers shall be
spread by the method producing the best results as approved by the
Engineer. The objective is to secure a smooth base of uniform grade
and cross section so that subsequent courses will be uniform in
thickness. The leveling layer may be spread with a properly
equipped paver or, when approved by the Engineer, a motor grader
equipped with a leveling device, or with other means for controlling
the surface elevation of the leveling layer.

All mixtures shall be spread, to the fullest extent practicable, by
an asphalt paver. When approved by the Engineer, mixtures may be
spread by a motor grader in areas that are inaccessible to a paver such
as on driveway entrances, irregular areas, short isolated areas or when
the quantity of mixture makes it impractical to place with a paver.

On shoulder surfacing and uniform width widening, when the
placement width is too narrow for a paver, the mixture in each course
shall be spread with an approved mechanical device.

The placement of each course shall be completed over the full
width of the section under construction on each day's run unless
otherwise directed by the Engineer.

C2b Trucks

Trucks for hauling asphalt mixtures shall have tight, clean, and
smooth beds. Mixture shall not be allowed to adhere to the truck
beds. Adherence may be prevented by spraying the truck bed with an
anti-adhesive agent in accordance with Section 2360.5B. Each truck
shall be equipped with a cover of canvas or other suitable material to
protect the mixture from weather. The cover shall extend at least
300 mm (1 foot) over the sides and be attached to tie-downs unless
the truck is furnished with a mechanical or automated covering
system, which prevents airflow underneath by stretching the cover
tightly on the top of or inside the sideboards. The cover shall be used
when directed by the Engineer.

C2c Motor Graders

Motor graders shall be self-propelled and have pneumatic-tires
with a tread depth of 13 mm (½ inch) or less. They shall be equipped
with a blade not less than 3 m (10 feet) in length and shall have a
wheelbase of not less than 4.5 m (15 feet).

D Treatment of the Surface

D1 Tack Coat

An asphalt tack coat shall be applied to existing asphalt and
concrete surfaces, and to the surface of each course or lift
constructed, except for the final course or lift, according to Mn/DOT
2357. Emulsified asphalt tack coats shall be allowed to break, as
indicated by a color change from brown to black, before a subsequent
lift is placed.

The contact surfaces of all fixed structures and the edge of the in-
place mixture in all courses at transverse joints and longitudinal joints
shall be given a uniform but not excessive coating of liquid asphalt or
emulsified asphalt before placing the adjoining mixture.

E Compaction Operations

After being spread, each course shall be compacted to the
required density. The rollers shall, as practicable, be operated
continuously so all areas are thoroughly compacted to the required
density. When not operating, the rollers shall not stand on the
uncompacted mixture or newly rolled pavement having a surface
temperature exceeding 60°C (140°F). Rolling with steel-wheeled
rollers shall be discontinued if it produces excessive crushing or
pulverizing of the aggregate or displacement of the mixture.

To prevent adhesion of the mixture to the steel roller wheels, the
contact surfaces of the wheels shall be kept properly moistened using
water or a water solution containing small quantities of a detergent or
other approved material.

To secure a true surface, variations such as depressions or high
areas, which may develop during rolling operations, and lean, fat or
segregated areas shall be corrected by removing and replacing the
material in the defective area. All such corrections shall be
accomplished as directed by the Engineer at no expense to the
Department.

When mixtures are spread by a motor grader, pneumatic-tired
rollers shall compact the mixture simultaneously with the spreading
operation.
F Construction Joints

Joints shall be thoroughly compacted to produce a neat, tightly bonded joint that meets surface tolerances. Both transverse and longitudinal joints are subject to density requirements as outlined in Section 2360.6 Pavement Density.

F1 Transverse Joints

A transverse joint (full paver width at right angles to the centerline) shall be constructed when mixture placement operations are suspended. The forward end of the freshly laid strip shall be thoroughly compacted by rolling before the mixture has cooled. When work is resumed, the end shall be cut vertically for the full depth of the layer unless a formed edge is constructed as approved by the Engineer.

F2 Longitudinal Joints

Longitudinal joints between strips shall be parallel to the centerline. In multiple lift construction, the longitudinal joints between strips in each lift shall be constructed not less than 150 mm (6 inches) measured transversely from the longitudinal joints in the previously placed lift. When the wearing course is constructed in an even number of strips, one longitudinal joint shall be on the centerline of the road. When it is constructed in an odd number of strips, the centerline of one strip shall be on the centerline of the road, provided that no joint is located in the wheel path area of a traffic lane. Longitudinal joints in multiple lift construction over Portland cement concrete pavements may be aligned directly over the concrete pavement longitudinal joints at the discretion of the Engineer.

At longitudinal joints formed by placing multiple strips, the adjoining surface being laid shall, after final compacting, be slightly higher (but not to exceed 3 mm (1/8 inch)) than the previously placed strip. When constructing a strip adjoining a previously placed strip or a concrete pavement, any fresh mixture that overlaps a previously placed strip or pavement shall be removed (to the longitudinal joint line) before any rolling is done.

G Asphalt Mixture Production (FOB Department Trucks)

For asphalt mixture production, the Contractor shall, in addition to the asphalt mixture required on the Project, produce and deliver asphalt mixture to the Department. The mixture shall be the mixture being produced and shall be loaded on Department furnished trucks at the mixing plant at a time agreed on by the Engineer and Contractor. The Engineer will notify the Contractor of the total quantity of mixture desired not less than 2 weeks prior to completion of the wearing course construction. The Engineer will not accept the asphalt mixture if it is inappropriate for the Department's intended use.
H Small Quantity HMA Paving

Unless otherwise indicated in the Special Provisions, the following provision for a small quantity of asphalt mixture shall apply.

A Mixture Design Report is not required for planned project quantities less than 191,200 m$^2$ mm$^3$ (9,000 square yard inches (4,500 square yards per 2 inch thickness, etc)) or 450 metric tons (500 tons). However, the Contractor shall verify in writing the asphalt mixture delivered to the project meets the requirements of Table 2360.3-B2a and Table 2360.3-B2b. The Department will obtain samples, as determined by the Engineer, to verify percent design air voids and gradation. These results will be used for material acceptance. Air voids will be subject to the requirements of Section 2360.4L1b for isolated air voids and a gradation falling outside the requirements of Table 2360.2-E will be subject to payment as indicated in Table 2360.4-L2b.

2360.6 PAVEMENT DENSITY

A General

All pavements will be compacted in accordance with the Maximum Density Method unless otherwise specified in the Contract special provisions or as noted in Section 2360.6C.

B Maximum Density Method

All courses or layers of plant mixed asphalt mixtures for which the Maximum Density Method is used shall be compacted to a density not less than the percentage shown in the Table of Required Density, Table 2360.6-B2, for the applicable mixture and course.

B1 Maximum Density Determination

The Density requirements listed in Table 2360.6B2 are percent of maximum specific gravity ($G_{max}$) based on the individual lot. The Maximum specific gravity value used to calculate the percentage density for the lot shall be the average value obtained from the maximum gravity results from production tests taken during that days paving. If only one or two maximum specific gravity values were obtained that day, then the moving average value (at that test point) shall be used. If three or more maximum specific gravity values are obtained that day, then the average of those tests alone shall be used as indicated above.
B1a Pavement Density Determination

The density of each lot shall be expressed as a percentage of the maximum specific gravity (\% G_mm) obtained by dividing the average bulk specific gravity for the lot by the maximum specific gravity multiplied by 100. (maximum specific gravity basis is the average G_mm of QC tests done on the day that the individual lot was paved as described above). Determination of the bulk specific gravity of the cores shall be in accordance with AASHTO T-166, Mn/DOT modified. For coarse graded mixtures the Engineer may require determination of bulk specific gravity of the cores be in accordance with ASTM D1188, Mn/DOT modified. ASTM D6752 Mn/DOT modified (Corelok) is also allowed for determination of bulk specific gravity of coarse graded mixtures. Selection of the test method to determine coarse graded mixture bulk specific gravity shall be agreed upon at the time of mix design submittal. Both the Contractor and Mn/DOT shall use the same test method to determine bulk specific gravity. The determination of coarse and fine graded mixtures will be based on the percentage of material passing the 2.365 mm sieve (\#8) as defined in Table 2360.3-B2c.

Compaction operations shall be completed within 8 hours of mixture placement and before core samples are obtained for density determination. Only pneumatic tired or static steel rollers are permitted for any compactive effort performed between 6 and 8 hours after mixture placement.

Compacted mixtures represented by samples or tests having deficient densities shall not be re-rolled. The Contractor shall not operate below the specified minimum density on a continuing basis. A continual basis shall be defined as all lots in a day’s production failing to meet minimum density or more than 50% of lots on multiple days which fail to meet minimum density requirements. Production shall be stopped until the source of the problem is determined and corrective action is taken to bring the work into compliance with specified minimum required density.

B2 Required Density

Minimum density requirements for both gyratory (SP) and Marshall designed mixtures are listed in Table 2360.6-B2.

Unless otherwise indicated in the Plans or Special Provisions, shoulders wider than 1.8 meters (6 feet) paved shall be compacted by the Maximum Density Method. When shoulders are required to be compacted by the Maximum Density Method and are paved in a separate operation or have a different required minimum density than the driving lane, the lot tonnage placed on the shoulder shall be delineated in separate lots from the driving lanes for the day paving was conducted.
2360.6

Unless otherwise indicated in the Plans or Special Provisions a narrow shoulder, 1.8 meter (6 feet) or less wide, that is paved in the same pass as a driving lane or that is paved separately will be compacted by the Ordinary Compaction Method. Mixture compacted under Ordinary Compaction is excluded from lot density requirements and that tonnage is also excluded from incentive/disincentive payment.

If the Plans or Special Provisions indicate a narrow shoulder is to be compacted by the Maximum Density Method, the minimum required density is listed in Table 2360.6-B2. If the minimum required density of the shoulder is different than the driving lane, the tonnage placed on the shoulder shall be delineated in separate lots from the driving lane.

Echelon paving (two pavers running next to each other in adjacent lanes) shall be considered separate operations.

<table>
<thead>
<tr>
<th>TABLE 2360.6-B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>REQUIRED MINIMUM DENSITY</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Location from surface*</td>
</tr>
<tr>
<td>% Gmm</td>
</tr>
</tbody>
</table>

* SP Mixtures only

** If less than 25% of a layer is within 100 mm (4 inches) of the surface, the layer may be considered to be below 100 mm (4 inches) for mix design purposes.

(1) Minimum reduced by one percent on the first lift constructed over PCC pavements.

(2) Minimum reduced by one percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold inplace recycled base courses and first lift of an overlay on a roadway with a 6.35 metric ton (7 ton) or less spring load restriction (roadway includes shoulders).

B2a Lots & Core Locations

Divide the days production into equal lots as shown in Table 2360.6-B2a. The Engineer may require additional density lots be established to isolate areas affected by equipment malfunction/breakdown, heavy rain, or other factors that may affect the normal compaction operations. Obtain three cores in each lot. Two cores will be taken from random locations selected by the Engineer. The third core, a companion core, shall be taken within 0.3
### TABLE 2360.6-B2A

<table>
<thead>
<tr>
<th>Daily Production</th>
<th>Lots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric (ton)</td>
<td>(English (Ton))</td>
</tr>
<tr>
<td>270* – 545</td>
<td>(300* – 600)</td>
</tr>
<tr>
<td>546 – 910</td>
<td>(601 – 1,000)</td>
</tr>
<tr>
<td>911 – 1,455</td>
<td>(1,001 – 1,600)</td>
</tr>
<tr>
<td>1,456 – 3,275</td>
<td>(1,601 – 3,600)</td>
</tr>
<tr>
<td>3,276 – 4,545</td>
<td>(3,601 – 5,000)</td>
</tr>
<tr>
<td>4,546 +</td>
<td>(5,001 +)</td>
</tr>
</tbody>
</table>

*When mix production is less than 270 metric tons (300 tons), establish 1st lot when accumulative tonnage exceeds 270 metric tons (300 tons).*

meters (1 foot) longitudinally from either of the first two cores. The companion cores shall be given to the Department Street Inspector immediately upon completion of coring and sawing. The random locations will be determined by the Engineer using statistically derived stratified random number tables or other approved methods of random number generation. These will also be used for partial lots. Both transverse and longitudinal joints are subject to maximum density requirements. If the random core location falls on an unsupported joint, at the time of compaction, (the edge of the mat being placed does not butt up against another mat, pavement surface, etc.) cut the core with the outer edge of the core barrel 0.3 meters (1 foot) away (laterally) from the edge of the top of the mat (joint). If the random core location falls on a confined joint (edge of the mat being placed butts up against another mat, pavement surface, curb and gutter, or fixed face), cut with the outer edge of the core barrel 150 mm ± 12.5 mm (6 inches ± ½ inch) from the edge of the top of the mat (ex. center of 100 mm (4 inch) core barrel 200 mm ± 12.5 mm (8 ± ½ inches) from the edge of the top of the mat). Cores will not be taken within 300 mm (1 foot) of any unsupported edge The Contractor shall be responsible for maintenance of traffic, coring, patching the core holes, and sawing the cores if necessary to the proper thickness prior to density testing.

#### B3 Core Testing

Cores will be taken and tested by the Contractor. Core locations will be determined and marked by the Engineer. The Contractor shall schedule the approximate time of testing during normal project work hours so that the Engineer may observe and record the saturated surface dry and immersed weight of the cores.

Density determination will be made by the end of the next working day after placement and compaction. If multiple layers are
placed in a single day, cores shall be sawn and separated for each layer, tested and reported by the end of the next working day.

The Contractor will cut pavement samples from the completed work with power equipment, and restore the surface by the end of the next working day with new, well compacted mixture without additional compensation. Failure to restore the surface within 24 hours of coring shall subject the Contractor to a fine of $100 per working day, per lot, until the core holes are restored. Cores shall be cut using a 100 mm (4 inch) minimum outer diameter coring device. All samples shall be marked with the lot number and core number or letter. The cores shall be transported to the laboratory as soon as possible to prevent damage due to improper handling or exposure to heat. These companion cores may be tested by the Inspector on Department scales or transported to the Department’s Field Laboratory or District Materials Laboratory.

Measure each core three times for thickness prior to saw cutting, report the average lift thickness on the core sheet. The average thickness will contribute to thickness compliance as described in Section 2360.7A.

If the Department companion core test result for bulk specific gravity ($G_{mb}$) deviates beyond the allowable tolerance of 0.030, substitute Department companion result for Contractor’s core result and then average the Department result with the non-companion result for the lot density acceptance. If, through analysis of data, it is determined there is a bias in the test results, the Engineer will determine which results are appropriate and shall govern.

If the $G_{mb}$ tolerance fails in more than 2 lots in a day of either consistently high or low differences between the companion cores then an investigation to determine the source of errors shall be conducted. Companion cores samples shall be increased to two per lot and tested until investigation is complete and tolerances are met.

The Engineer may allow recoring of a sample only when the core has been damaged through no fault of the Contractor, either during the coring process or in transit to the laboratory.

### B4 Maximum Density Acceptance and Payment Schedule

The density of compacted mixture shall be accepted by pavement cores on a lot basis.

The Contractor’s cores will be used for acceptance if the determined bulk specific gravity ($G_{mb}$) from AASHTO T-166, Mn/DOT modified or ASTM D1188 is within $\pm 0.030$ of the state companion $G_{mb}$ value. Payment for lot densities of compacted mixture shall be determined from Table 2360.6-B4 or 2360.6-B4A. Incentive and disincentive payments are for both wearing and non-wearing courses.
When the density requirement has been reduced by one percent, per Table 2360.6-B2, footnote 1 & 2, payment adjustments for lot densities will be made as specified in Table 2360.6-B4A. Incentive payments are excluded when the minimum density has been reduced. However, at the Contractors request and with approval of the Engineer, the reduced density requirement may be waived and density evaluated under Table 2360.6-B4, including incentives, for first lift constructed on aggregate base, reclaimed or cold inplace recycled base courses and first lift of an overlay on a roadway with a 6.35 metric ton (7 ton) or less spring load restriction (reduced density shall not be waived for the first lift constructed on PCC pavements). The request and approval shall be made after the first days paving and before the third days paving begins. Once the request has been approved, evaluation of density will be in accordance with Table 2360.6-B2 (excluding footnote 2) and Table 2360.6-B4, and will remain in effect for the duration of mixture placement on that lift. The Contractor will also be responsible for compliance with any construction requirements on subsequent lifts.

<table>
<thead>
<tr>
<th>TABLE 2360.6-B4</th>
<th>PAYMENT SCHEDULE FOR MAXIMUM DENSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of Max Specific Gravity (2)</td>
<td>Percent of Max Specific Gravity (2)</td>
</tr>
<tr>
<td>SP Wear (≤100 mm (4 inches) from Surface)</td>
<td>SP Non-Wear (&gt;100 mm (4 inches) from Surface)</td>
</tr>
<tr>
<td>All MV &amp; LV, SP Shld (4% Void)</td>
<td>SP Shoulders (3% Void)</td>
</tr>
<tr>
<td>93.6 and above</td>
<td>94.6 and above</td>
</tr>
<tr>
<td>93.1 - 93.5</td>
<td>94.1 - 94.5</td>
</tr>
<tr>
<td>92.0 - 93.0</td>
<td>93.0 - 94.0</td>
</tr>
<tr>
<td>91.0 - 91.9</td>
<td>92.0 - 92.9</td>
</tr>
<tr>
<td>90.5 - 90.9</td>
<td>91.5 - 91.9</td>
</tr>
<tr>
<td>90.0 - 90.4</td>
<td>91.0 - 91.4</td>
</tr>
<tr>
<td>89.5 - 89.9</td>
<td>90.5 - 90.9</td>
</tr>
<tr>
<td>89.0 - 89.4</td>
<td>90.0 - 90.4</td>
</tr>
</tbody>
</table>
| Less than 89.0 (4) | Less than 90.0 | ""
<table>
<thead>
<tr>
<th>Percent of Max Specific Gravity (2)</th>
<th>Percent of Max Specific Gravity (2)</th>
<th>% Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP Wear (≤100 mm (4 inches) from Surface)</td>
<td>SP Non-Wear (&gt;100 mm (4 inches) from Surface)</td>
<td>All MV &amp; LV, SP Shld (4% Void)</td>
</tr>
<tr>
<td>91.0 and above</td>
<td>92.0 and above</td>
<td>100</td>
</tr>
<tr>
<td>90.0 - 90.9</td>
<td>91.0 - 91.9</td>
<td>98</td>
</tr>
<tr>
<td>89.7 - 89.9</td>
<td>90.5 - 90.9</td>
<td>95</td>
</tr>
<tr>
<td>89.4 - 89.6</td>
<td>90.0 - 90.4</td>
<td>91</td>
</tr>
<tr>
<td>89.2 - 89.3</td>
<td>89.5 - 89.9</td>
<td>85</td>
</tr>
<tr>
<td>89.0 - 89.1</td>
<td>89.0 - 89.4</td>
<td>70</td>
</tr>
<tr>
<td>Less than 89.0 (4)</td>
<td>Less than 89.0 (4)</td>
<td></td>
</tr>
</tbody>
</table>

(1) Minimum reduced by one percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold inplace recycled base courses and first lift of an overlay on a roadway with a 6.35 metric ton (7 ton) or less spring load restriction (roadway includes shoulders).

Minimum reduced by one percent on the first lift constructed on PCC pavements (reduced density cannot be waived).

(2) In calculating the percent of maximum specific gravity, report to the nearest tenth.

(3) The payment in this portion of the specification shall apply only if the day’s weighted average individual production air voids are within - 0.5 percent of the target air void value. The weighted average air voids shall be based on all the mixture production tests (2360.4e) for the corresponding day and shall be weighted by the tons the corresponding test represents.

(4) The HMA material represented by the lot shall be paid at a 70% pay factor, unless a single core density is less than 87.0% of the maximum specific gravity (Gmm). If a single core density is less than 87.0% of Gmm, the material shall be removed and replaced by the Contractor at their expense with mixture that meets the density requirements; or the Engineer may permit the unacceptable material to remain inplace with a 50% pay factor. The limits of the area to be removed will be determined by additional core samples. These additional core samples shall be taken at the same offset from centerline as the original core; unless the original low density core was taken within 0.45 m (1 ½ feet) of an edge of the paver pass. In that case, the additional cores shall be taken 0.45 m
(1 ½ feet) from the edge of the paver pass. The densities shall be determined at 15 m (50 foot) intervals, both ahead and back of the point of unacceptable core density (less than 87.0% of Gmm), until a point of acceptable core density (87.0% of Gmm or greater) is found. If the incremental core density testing extends into a previously accepted lot, removal of the unacceptable material will be required; however, the results of these tests shall not be used to recalculate the previously accepted lot density. All costs incurred from additional coring and testing, resulting from unacceptable core density, will be paid by the Contractor. The unacceptable pavement area is to be computed as the product of the longitudinal limits so determined by the 15 m (50 foot) cores and the full width of the paver pass, laying in the traffic lane or lanes. Shoulders shall be exempt from this calculation unless density failure occurred in the shoulder area.

After the unacceptable material (core density less than 87.0% of Gmm) has been removed and replaced, the density of the replacement material will be determined by the average of two cores. Payment for the replacement material will be in accordance with Tables 2360.6-B4 or 2360.6-B4A, whichever applies. There will be no payment for the material removed. The remainder of the original lot shall have a 70% pay factor.

C Ordinary Compaction Method

Ordinary compaction shall be used for layers identified in the typical sections with a minimum planned thickness of less than 40 mm (1 ½ inches), thin lift leveling, wedging layers, patching layers, driveways, areas which cannot be compacted with standard highway construction equipment. Unless otherwise indicated in the Plans or Special Provisions recreational trails shall also be compacted by ordinary compaction. The ordinary compaction method shall not be used on mainline, ramp, or loop paving, unless otherwise designated in the plans or special provisions. When density is evaluated by the ordinary compaction method a control strip shall be used to establish a rolling pattern. This shall be used by the Contractor for the compaction of the asphalt mixture for the layer on which the control strip is constructed, or until a new control strip is constructed. The control strip requirement may be waived by the Engineer in small, localized areas or other areas not conducive to its establishment.

A control strip shall be constructed at the beginning of the work on each lift of each course. Each control strip shall have an area of at
least 330 m² (395 square yards) and shall be of the same thickness as
the lift it represents. The subgrade or pavement course upon which a
tool strip is to be constructed shall have the prior approval of the
Engineer. The control strips shall remain in place and become part of
the completed work.

The materials used in the construction of the control strips shall
conform to the specified requirements for the course. The materials
used in the control strip shall be from the same source and of the
same type as the materials used in the remainder of the course that
the control strip represents.

The equipment used in the construction of the control strips shall
be approved by the Engineer and shall be the same type and mass
used on the remainder of the pavement course represented by the
control strip. A minimum of two rollers shall be required. A rolling
pattern shall be established for each roller. A pneumatic-tired roller
shall be available for compaction operations within 24 hours after
request by the Engineer. The final rolling shall be performed with a
tandem steel-wheeled roller. Areas that are inaccessible to the
conventional type rolling equipment shall be compacted to the
required density by using trench rollers or mechanical tampers.

Construction of the control strips will be as directed by the
Engineer. Compaction shall commence as soon as possible after the
mixture has been spread to the desired thickness and shall continue
until no appreciable increase in density can be obtained by additional
roller’s coverages. Densities will be determined by means of a
portable nuclear testing device or suitable approved alternate and a
growth curve shall be developed to determine the optimum rolling
pattern. The Contractor shall furnish documentation of the growth
curve to the Engineer.

To determine when no appreciable increase in density can be
obtained, two test points shall be established in the control strip on a
random basis and the density at each point shall be measured by a
portable nuclear device or suitable approved alternate after each
roller pass. Rolling shall be suspended when testing shows either a
decline of more than 2% of the maximum specific gravity or when
additional roller passes fail to increase the density.

After said testing is accomplished, rolling on the remainder of
that course shall be done in accordance with the pattern developed in
the test strip for that roller. A separate rolling pattern and time
interval shall be established for each roller.

A new control strip shall be ordered by the Engineer when:
(a) A change in the JMF is made, or
(b) A change in the source of material is made or a change in the
material from the same source is observed.
A new control strip may be ordered by the Engineer or requested by the Contractor when:
(a) Ten days of production have been accepted without construction of a new control strip, or
(b) There are other reasons to believe that a control strip density is not representative of the HMA mixture being placed.

The nuclear testing device shall be furnished and operated by the Contractor. The furnishing of the testing device and the operator will be considered incidental to the furnishing and placement of the HMA mixture and shall not be compensated for separately. The device shall be calibrated according to procedures described in the Mn/DOT Bituminous Manual.

Each course shall be uniformly compacted until there is no further evidence of consolidation and all roller marks are eliminated. When this method is employed, and the quantity of mixture placed by the paver exceeds 100 metric tons (110 tons) per hour, at least two rollers are required for compacting the mixture placed by each paver.

C1 Rollers
The following requirements for rollers apply only when compaction is obtained by the ordinary compaction method.

C2 Steel-Wheeled Rollers
Steel-wheeled rollers shall be self-propelled and has a minimum total mass of 7.3 metric tons (8 tons), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN/m (3,085 lbf per foot) of width. The frequency should be at least 2400 vpm and amplitude setting low. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rollers on both sets of wheels.

C3 Pneumatic-Tired Rollers
The pneumatic-tired roller shall have a compacting width of 1.5 m (5 feet) or more. It shall be so constructed that the gross wheel load force shall be a minimum of 13 kN (3,000 pounds) per wheel for LV and MV mixtures and SP Level 2-3 mixtures and 22 kN (5,000 pounds) per wheel for SP Level 4-6 mixtures and can be varied as directed by the Engineer. The tire arrangement shall be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless otherwise specified in the Contract. If more than one roller is propelled by a single tractive unit, then that combination will be counted as a single roller unit.

C4 Trench Rollers
Trench rollers shall be self propelled and have a mass of not less than 4,400 kg per meter (2,960 pounds per foot) of width.
C5 Mixture Temperature Controls

If compaction is obtained by the ordinary compaction method, the minimum laydown temperature in all courses (as measured behind the paver or spreading machine) of the asphalt mixture shall be in accordance with the temperature requirements of Table 2360.6-C5. Unless directed by the Engineer in writing, no paving is allowed under the Ordinary Compaction Method when the air temperature is below 0°C (32°F).

<table>
<thead>
<tr>
<th>Air Temperature</th>
<th>Compacted Mat Thickness, mm (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C (°F)</td>
<td>25 mm (1 inch)</td>
</tr>
<tr>
<td></td>
<td>40 mm (1 ½ inch)</td>
</tr>
<tr>
<td></td>
<td>50 mm (2 inch)</td>
</tr>
<tr>
<td></td>
<td>≥75 mm (3 inch)</td>
</tr>
<tr>
<td>+0-5 (32-40)</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>129 (265)</td>
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<td></td>
<td>124 (255)</td>
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<td>121 (250)</td>
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<td>118 (245)</td>
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<td>+6-10 (41-50)</td>
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</tr>
<tr>
<td></td>
<td>110 (230)</td>
</tr>
<tr>
<td></td>
<td>107 (225)</td>
</tr>
</tbody>
</table>

(A) Based on approved or specified compacted lift thickness.

(B) A minimum of one pneumatic-tire roller shall be used for intermediate rolling unless otherwise directed by the Engineer. The Engineer may specify or modify in writing (with concurrence from the Department Bituminous Engineer) a minimum laydown temperature.

2360.7 THICKNESS AND SURFACE SMOOTHNESS REQUIREMENTS

A Thickness

After compaction the thickness of each lift shall be within a tolerance of 6 mm (¼ inch) of the thickness shown in the Plans, except that, if automatic grade controls are used, this thickness requirement will not apply to the first lift placed. This thickness requirement will not apply to a leveling lift whether or not automatic grade controls are required. The Engineer may require removal and
replacement, at the Contractor’s expense, of any part of any lift that is constructed to less than the minimum required thickness.

Cores taken for density determination shall be measured for thickness also. Each core shall be measured 3 times for thickness prior to sawing. Report the average of these three measurements. Each lot’s average core thickness shall be documented and submitted to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The average of all core thickness measurements per day per lift will be used to determine daily compliance with thickness specifications.

On that portion of any lift constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the lift to the Plan thickness plus 6 mm (¼ inch) may be excluded from the pay quantities and at the discretion of the Engineer and at the Contractor’s expense may be required to be removed and replaced.

B Surface Requirements

After compaction, the finished surface of each lift shall be reasonably free of segregated, open and torn sections, and shall be smooth and true to the grade and cross section shown on the Plans with the following tolerances:

(1) Where a leveling lift is specified, it shall be constructed to within a tolerance of 15 mm (½ inch) of the elevations and grades established by the Engineer. This requirement shall also apply to the first lift placed other than leveling when automatic controls are used.

(2) The surface of the final two lifts placed shall show no variation greater than 6 mm (¼ inch) from the edge of a 3 m (10 foot) straightedge laid parallel to or at right angles to the centerline. Shoulder surfacing and surfacing on temporary connections and bypasses shall show no variations greater than 6 mm (¼ inch) from the edge of a 3 m (10 foot) straightedge laid parallel to the centerline.

(3) After final compaction, all final lift asphalt wearing surfaces adjacent to concrete pavements shall be slightly higher (but not to exceed 6 mm (¼ inch) than the concrete surface. After final compaction, all asphalt surfaces adjacent to gutters, manholes, pavement headers, or other fixed structures shall be slightly higher (but not to exceed 6 mm (¼ inch) than the surface of the structure.

(4) Transverse joints (construction joints), at the beginning and end of a project, at paving exceptions, or caused by suspension of daily paving operations, shall show no
variation greater than 6 mm (¼ inch) from the edge of a 3 m (10 foot) straightedge centered longitudinally across the transverse joint. The Engineer may require correction by diamond grinding when material is placed outside the above described limitations.

(5) The transverse slope of the surface of each lift, exclusive of the shoulder wearing lift, shall not vary from the slope shown in the Plans by more than 0.4 percent.

(6) The distance between the edge of each lift and the established centerline shall be no less than the Plan distance nor more than 75 mm (3 inches) greater than the Plan distance. In addition, the edge alignment of the wearing lift on tangent sections and on curve sections of 3 degrees or less shall not deviate from the established alignment by more than 25 mm (1 inch) in any 7.5 m (25 foot) section.

(7) The finished surface of each lift shall be reasonably free of segregated and open and torn sections. Any material placed outside the above described limitations shall be removed and replaced after being cut or sawed at no expense to the Department or with the approval of the Engineer, allowed to remain in place at a reduced cost calculated at $12 per square meter ($10 per square yard).

C Pavement Smoothness

C1 General

Pavement smoothness will be evaluated on the final mainline pavement surface using a California type profilograph or Inertial Profiler (IP) with a 5 mm (0.2 inch) blanking band. Unless otherwise authorized by the Engineer, all smoothness testing shall be performed in the presence of the Engineer. The Engineer and the Contractor shall mutually agree upon scheduling of smoothness testing so that testing can be observed. Any testing performed without the Engineer’s presence, unless otherwise authorized, may be ordered restested at the Contractors expense. The following table shows pavement surfaces, which are excluded from profilograph testing, but subject to Section 2360.7B surface requirements.

C1 A Smoothness Requirements

Pavement smoothness requirements will be evaluated by Table 2360.7-C6A, 2360.7-C6B, or 2360.7-C6C. The pavement smoothness table will be identified in the Special Provisions of the proposal.
TABLE 2360.7-C1

PROFILOGRAPH TESTING EXCLUSIONS

<table>
<thead>
<tr>
<th>Pavement Surfaces Excluded From Profilograph Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramps, Loops, Climbing Lanes</td>
</tr>
<tr>
<td>Side Streets, Side Connections</td>
</tr>
<tr>
<td>Turn Lanes, Storage Lanes, Crossovers, Bypass Lanes</td>
</tr>
<tr>
<td>Shoulders</td>
</tr>
<tr>
<td>Acceleration, Deceleration Lanes</td>
</tr>
<tr>
<td>Intersections constructed under traffic – Begin and end the exclusion 30.5 m (100 feet) from the intersection radius</td>
</tr>
<tr>
<td>Sections less than 15.24 m (50 feet) in length</td>
</tr>
<tr>
<td>Projects less than 300 m (1000 feet) in length</td>
</tr>
<tr>
<td>Mainline paving where the normally posted regulatory speed is less than or equal to 70 km/hr (45 miles per hour) -- Begin the exclusion at the sign</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Single lift overlays over concrete.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Curves with a radius less than 289.6 m (950 feet).</td>
</tr>
<tr>
<td>Horizontal Curves with a degree of curvature greater than or equal to 6°.</td>
</tr>
<tr>
<td>Vertical Curves – Absolute value of grade change is 2 % or more and curve length is 91.4 m (300 feet) or less.</td>
</tr>
<tr>
<td>Vertical Curves – Absolute value of grade change is 3 % or more and curve length is 121.9 m (400 feet) or less.</td>
</tr>
<tr>
<td>Vertical Curves – Absolute value of grade change is 4 % or more and curve length is 182.8 m (600 feet) or less.</td>
</tr>
<tr>
<td>Vertical Curves – Absolute value of grade change is 8 % or more and curve length is 213.4 m (700 feet) or less.</td>
</tr>
<tr>
<td>Note: Begin and end the exclusion at the PC (PVC) and PT (PVT), respectively</td>
</tr>
</tbody>
</table>

C2 Measurement

Smoothness will be measured with a 7.62 m (25 foot) California type profilograph or an Inertial Profiler (IP), which produces a profilogram (profile trace of the surface tested). Either type of device must be certified according to the procedure on file in the Bituminous Office. One pass will be made in each lane, 2.74 m (9 feet) from centerline. The profilograph or IP shall be in the direction the traffic will be moving. Each lane will be tested and evaluated separately. The Engineer will determine the length in kilometers (miles) for each mainline traffic lane. The profilograph will be operated at a speed no greater than a normal walk, no greater than 6 km/hr (4 miles per hour). Motive power may be provided manually or by the use of a
propulsion unit approved by the Engineer. The IP will be operated at
the optimum speed as defined by the manufacturer.

C3 Profilograph Testing
The Contractor will furnish a properly calibrated, documented,
and certified 7.62 m (25 foot) California type profilograph or IP. The
profilograph or IP shall be equipped with automatic data reduction
capabilities unless otherwise authorized by the Engineer. Certification
documentation shall be provided to the Engineer on the
first day the profilograph or IP is used on the project. User selected
profilograph or IP settings are on file in the Bituminous Office. The
Contractor will furnish a competent operator, trained in the operation
and evaluation of the 7.62 m (25 foot) California profilograph or IP.

All objects and foreign material on the pavement surface will be
removed by the Contractor prior to testing. The pavement surface
will be divided into sections which represent continuous placement.
A section will terminate or begin 15.24 m (50 feet) before or after a
bridge approach panel, bridge surface, manhole or similar
interruption. These 15.24 m (50 feet) sections, including the
transverse joint, will be evaluated under Section 2360.7B, Surface
Requirements. A day's work joint will be included in the trace with
no special consideration. A section will be separated into segments
of 0.1 km (0.1 mile). A segment will be in only one traffic lane.

A profilogram will be made for each segment of 15.24 m
(50 feet) or more. The profilogram will include the 7.62 m (25 foot)
at the ends of the section only when the Contractor is responsible for
the adjoining surface.

End of run areas not included in the profilograph trace and any
sections of pavement less than 15.24 m (50 feet) in length shall be
checked longitudinally with a 3.028 m (10 foot) straight edge and the
surface shall not deviate from a straight line by more than 6 mm in
3.028 m (½ inch in 10 feet). Transverse joints shall be evaluated by
centering the straightedge longitudinally across the transverse joint.

The profile trace and index for each segment of pavement must
be furnished to the Engineer within 48 hours after each days run.
Identification of all bumps and dips, with signature of the Operator
shall be included with the submitted trace.

The Contractor will submit a final evaluation generated from
approved software, to the Engineer within five days after all mainline
pavement placement. Software is available from the Mn/DOT
Bituminous Office website. The evaluation submitted shall be in
tabular form, with each 0.1 km (0.1 mile) segment occupying a row.
Each row shall include the beginning and ending station for the
segment, the length of the segment, the profile index for the segment,
the profile index incentive/disincentive in dollars for the segment,
and the deductions for bumps in dollars for the segment. Each continuous run will occupy a separate table and each table will have a header that includes the following: the project number, the roadway number or designation, the specified ride table, a lane designation, the mix type of the final lift, the PG binder of the final lift, the date of the profilograph run, and the beginning and ending station of the continuous run. Each table will have a summary at the bottom that includes the following: a subtotal for the profile index incentive/disincentive, a subtotal for the bump deductions, and a total for incentive/disincentive for both profile index and bumps.

The Contractor will be responsible for all traffic control associated with the smoothness testing.

Any portion of the project may be retested if the Engineer determines that the Contractor's test results are in question. If results are found to be inaccurate, the Contractor will be charged at a rate of $155.34 per lane km ($250 per lane mile) that is retested, with a minimum charge of $500.00. If the results are found to be accurate, the Department will be paying the Contractor at a rate of $155.34 per lane km ($250 per lane mile) that is retested, with a minimum charge of $500.00.

C4 Profile Index

The profilograph or IP shall be equipped with automatic data reduction capabilities for determining the profile index (PI) unless otherwise authorized by the Engineer. The profilograph trace will be evaluated for the profile index (PI) and bumps in accordance with California Method 526 on file with the Department Bituminous Engineer. The original trace shall be provided to the Engineer.

A profile index shall be calculated for each segment. If an IP is used the corresponding International Roughness Index (IRI) for each segment shall be submitted to the Bituminous Office. The index will be determined by summing the vertical deviations outside either a 5 mm (0.2 inch) blanking band or outside a zero blanking band depending on the number of lifts in the construction. The units of this index are mm per km (inch per mile). When there is a segment of 76.2 m (250 feet) or less in length, the profilograph or IP measurements for that segment shall be added to and included in the evaluation of the adjacent section to that segment.

Bumps and dips equal to or exceeding 10.2 mm in a 7.62 m (0.4 inch in a 25 foot) span shall be identified separately. When the profile trace shows a successive, uninterrupted bump, dip; or dip, bump combination (up to a maximum of 3 alternating trace deviations that relate to one bump or dip on the roadway), identify and evaluate these occurrences as one event.
C5 Surface Correction

All areas represented by deviations of 28 mm (1.1 inch) or more, as measured by the 7.62 m (25 foot) profilograph or IP, will be corrected by the Contractor.

The Contractor may elect to correct pavement segments having no more than two events or two individual bumps or dips with a vertical deviation of 10.2 to 25 mm (0.4 to 1.0 inch) in a 7.62 m (25 foot) span. Correction of segments with more than two events or two individual bumps or dips, as defined above, will be allowed only when approved by the Engineer. The Contractor will be assessed a penalty for dips or bumps of 10.2 to 25 mm (0.4 to 1.0 inch) that are not corrected. Bumps and dips not corrected will also be included in the evaluation for the segment smoothness. Corrected dips or bumps will be considered satisfactory when the profilogram shows the dips or bumps are less than 10.2 mm in a 7.62 m (0.4 inch in a 25 foot) span.

Bump, dip, and smoothness correction work shall be for the entire traffic lane width. Pavement cross slope shall be maintained through corrective areas.

Corrective work shall be made by diamond grinding unless other methods are approved by the Engineer. Other methods may include; overlaying the area, or replacing the area by milling and inlaying. Any corrective actions by milling and inlay or overlay shall meet the specifications for ride quality over the entire length of the correction, including the first and last 15 m (50 feet). Bumps or dips in excess of 10.2 mm (0.4 inches) at transverse joints at areas of corrective actions utilizing overlay or milling and inlay, shall be removed by diamond grinding. The Contractor shall notify the Engineer prior to commencement of the corrective action. If the surface is corrected by overlay, inlay or replacement, the surface correction shall begin and end with a transverse saw cut.

If the smoothness evaluation indicates that corrective work is necessary for more than 50% of a segment, surface correction will be limited to mill and inlay (40 mm (1 ½ inch) min).

All corrective work shall be subject to the approval of the Engineer. After all required correction work is completed, a final profile index shall be determined. Corrective work and re-evaluation will be at the Contractor’s expense.

C6 Payment

The cost of certified smoothness testing and associated traffic control will be incidental to the cost of the Wear Course Mixture.
The Contractor may receive an incentive payment or be assessed a penalty based on the number of segments and the initial profile index. The total ride incentive shall not exceed 10% of the total mix price for pavement smoothness evaluated under Table 2360.7-C6A, 5% of the total mix price for pavement smoothness evaluated under Table 2360.7-C6B, or 5% of the total mix price for pavement smoothness evaluated under Table 2360.7-C6C. The maximum allowable net incentive (total incentive minus disincentive) payment shall be calculated by multiplying the total tons paved by the mixture price by the appropriate incentive cap. Pay adjustments for incentives will only be based on the initial Profile Index before any corrective work has been performed. Pavement that contains corrective action for profile or bumps is not eligible for incentive pay. These payments or assessments will be based on the following schedules.

The Contractor will not receive a net incentive payment for ride if more than 25% of all density lots for the project fail to meet minimum density requirements.

For each traffic lane, a penalty will be assessed for each bump or dip of 10.2 to 25 mm (0.4 to 1.0 inch) that is not corrected. Penalties, based on the table the profile index is evaluated under, are as follows:

<table>
<thead>
<tr>
<th>Table</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2360.7-C6A:</td>
<td>$900</td>
</tr>
<tr>
<td>Table 2360.7-C6B:</td>
<td>$675</td>
</tr>
<tr>
<td>Table 2360.7-C6C:</td>
<td>$450</td>
</tr>
</tbody>
</table>

Bumps or dips resulting from a construction joint will be assessed a $900 penalty, regardless of the table used for evaluation of pavement smoothness.

The Engineer may, at his discretion, assess a penalty in lieu of requiring the Contractor to take corrective action when the profile index for a segment indicates corrective action is necessary. Penalties, based on the table the profile index is evaluated under, are as follows:

<table>
<thead>
<tr>
<th>Table</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2360.7-C6A:</td>
<td>$560 per 0.1 km</td>
</tr>
<tr>
<td>($900 per 0.1 mile)</td>
<td></td>
</tr>
<tr>
<td>Table 2360.7-C6B:</td>
<td>$420 per 0.1 km</td>
</tr>
<tr>
<td>($675 per 0.1 mile)</td>
<td></td>
</tr>
<tr>
<td>Table 2360.7-C6C:</td>
<td>$280 per 0.1 km</td>
</tr>
<tr>
<td>($450 per 0.1 mile)</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 2360.7-C6A *
INITIAL PROFILE INDEX FOR 5MM (0.2 INCH) BLANKING BAND

<table>
<thead>
<tr>
<th>mm per km per 0.1 km segment</th>
<th>(Inches per mile) (per 0.1 mile segment)</th>
<th>Dollars per Segment (Metric)</th>
<th>Dollars per Segment (English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 13.4</td>
<td>(0.0 – 0.8)</td>
<td>210</td>
<td>(335)</td>
</tr>
<tr>
<td>13.5 – 25.3</td>
<td>(0.9 - 1.6)</td>
<td>145</td>
<td>(225)</td>
</tr>
<tr>
<td>25.4 – 38.7</td>
<td>(1.7 - 2.4)</td>
<td>80</td>
<td>(115)</td>
</tr>
<tr>
<td>38.8 – 78.9</td>
<td>(2.5 - 5.0)</td>
<td>0</td>
<td>(0)</td>
</tr>
<tr>
<td>79.0 – 92.3</td>
<td>(5.1 - 5.8)</td>
<td>(80)</td>
<td>((115))</td>
</tr>
<tr>
<td>92.4 - 105.7</td>
<td>(5.9 - 6.7)</td>
<td>(145)</td>
<td>((225))</td>
</tr>
<tr>
<td>105.8 - 118.3</td>
<td>(6.8 - 7.5)</td>
<td>(210)</td>
<td>((335))</td>
</tr>
<tr>
<td>Over 118.3</td>
<td>(Over 7.5)</td>
<td>Corrective Action</td>
<td>Corrective Action</td>
</tr>
</tbody>
</table>

* Typically, 3-lift minimum construction

### TABLE 2360.7-C6B *
INITIAL PROFILE INDEX FOR 5MM (0.2 INCH) BLANKING BAND

<table>
<thead>
<tr>
<th>mm per km per 0.1 km segment</th>
<th>(Inches per mile) (per 0.1 mile segment)</th>
<th>Dollars per Segment (Metric)</th>
<th>Dollars per Segment (English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 15.8</td>
<td>(0.0 - 1.0)</td>
<td>145</td>
<td>(225)</td>
</tr>
<tr>
<td>15.9 - 31.6</td>
<td>(1.1 - 2.0)</td>
<td>100</td>
<td>(150)</td>
</tr>
<tr>
<td>31.7 - 47.3</td>
<td>(2.1 - 3.0)</td>
<td>55</td>
<td>(75)</td>
</tr>
<tr>
<td>47.4 - 110.5</td>
<td>(3.1 - 7.0)</td>
<td>0</td>
<td>(0)</td>
</tr>
<tr>
<td>110.6 - 126.3</td>
<td>(7.1 - 8.0)</td>
<td>(55)</td>
<td>((75))</td>
</tr>
<tr>
<td>126.4 - 142.0</td>
<td>(8.1 - 9.0)</td>
<td>(100)</td>
<td>((150))</td>
</tr>
<tr>
<td>142.1 - 157.8</td>
<td>(9.1 - 10.0)</td>
<td>(145)</td>
<td>((225))</td>
</tr>
<tr>
<td>Over 157.8</td>
<td>(Over 10.0)</td>
<td>Corrective Action</td>
<td>Corrective Action</td>
</tr>
</tbody>
</table>

* Typically, 2-lift construction
## TABLE 2360.7-C6C *
INITIAL PROFILE INDEX FOR 5MM (0.2 INCH) BLANKING BAND

<table>
<thead>
<tr>
<th>mm per km per 0.1 km segment</th>
<th>(Inches per mile per 0.1 mile segment)</th>
<th>Dollars per Segment (Metric)</th>
<th>Dollars per Segment (English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 31.6</td>
<td>(0.0 - 2.0)</td>
<td>95</td>
<td>(150)</td>
</tr>
<tr>
<td>31.7 - 47.4</td>
<td>(2.1 - 3.0)</td>
<td>65</td>
<td>(100)</td>
</tr>
<tr>
<td>47.5 - 79.0</td>
<td>(3.1 - 5.0)</td>
<td>35</td>
<td>(50)</td>
</tr>
<tr>
<td>79.1 - 158.0</td>
<td>(5.1 - 10.0)</td>
<td>0</td>
<td>(0)</td>
</tr>
<tr>
<td>158.1 - 189.6</td>
<td>(10.1 - 12.0)</td>
<td>(35)</td>
<td>(50)</td>
</tr>
<tr>
<td>189.7 - 221.2</td>
<td>(12.1 - 14.0)</td>
<td>(65)</td>
<td>(100)</td>
</tr>
<tr>
<td>221.3 - 252.8</td>
<td>(14.1-16.0)</td>
<td>(95)</td>
<td>(150)</td>
</tr>
<tr>
<td>Over (252.8)</td>
<td>(Over 16.0)</td>
<td>Corrective Action</td>
<td>Corrective Action</td>
</tr>
</tbody>
</table>

*Typically, single lift construction

### 2360.8 METHOD OF MEASUREMENT

**A Asphalt Mixture**

Asphalt mixture of each type will be measured separately by mass, based on the total quantity of material hauled from the mixing plant, with no deductions being made for the asphalt materials.

**B Blank**

**C Asphalt Mixtures Measured by the Square Meter (Square Yard) per Specified (mm (inch)) and for Mixtures Measured by the (Square Yard inch)**

Asphalt mixture of each type and for each specific lift will be measured separately by area and by thickness on the basis of actual final dimensions placed. The constructed thickness shall meet tolerances set forth in Sections 2360.7A.

### 2360.9 BASIS OF PAYMENT

Payment for the accepted quantities of asphalt mixture used in each course at the Contract prices per unit of material shall be compensation in full for all costs of constructing the asphalt surfacing as specified, including the costs of furnishing and incorporating any asphalt binder, mineral filler, hydrated lime, or anti-stripping additives that may be permitted or required.
If the production lab density at the design gyrations at the recommended or established asphalt content is in excess of 2565 kg/m³ (160 pounds per cubic foot), payment for mixture will be calculated at the following percent of the Contracted unit price.

% Payment = \{100 - \{100 \times (\text{production density at design gyrations} - 2565)\} / 2565\}

% Payment = \{100 - \{100 \times (\text{production density at design gyrations} - 160)\} / 160\} ENGLISH

In the absence of Contract items covering shoulder surfacing and other special construction, the accepted quantities of material used for these purposes will be included for payment with the wearing course materials.

The Contractor is responsible to complete yield checks and monitor thickness determinations so that the constructed dimensions correspond with the required Plan dimensions throughout the entire length of the Project. The tolerances for lift thickness shown in 2360.7A and B, Thickness and Surface Smoothness Requirement is for occasional variations and not for continuous over-running or under-running, unless ordered or Authorized by the Engineer.

Payment for the item of asphalt mixture production at the Contract unit price of mixture produced shall be compensation in full for all costs of producing the mixture and loading it on board the Department's trucks at the mixing plant. The provisions of Mn/DOT 1903 are modified to the extent that the Department will not make a price adjustment in the event of increased or decreased quantities of asphalt mixture items. Payment for plant mixed asphalt surface will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2350.501</td>
<td>Type (1)(2) Wearing Course Mixture</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2350.502</td>
<td>Type (1)(2) Non Wearing Course Mixture</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2350.503</td>
<td>Type (1)(2)(3) Course Mixture</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2350.504</td>
<td>Type (1)(2)(3) Course Mixture</td>
<td>square yard inch</td>
</tr>
<tr>
<td>2350.505</td>
<td>Type (1)(2) Bituminous Mixture for Specified Purpose</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2350.506</td>
<td>Type (1)(2) Bituminous Mixture Production</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2360.501</td>
<td>Type(1)(6) Wearing Course Mixture</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2360.502</td>
<td>Type (1)(6) Non Wearing Course Mixture</td>
<td>metric ton (ton)</td>
</tr>
</tbody>
</table>
2360.503 Type (1) (6) (7) Course Mixture ((8),(4))
(5) mm (inch) thick square meter (square yard)

2360.504 Type (1) (6) (7) Course Mixture ((8),(4))

2360.505 Type (1) (6) Bituminous Mixture for Specified Purpose
metric ton (ton)

2360.506 Type (1) (6) Bituminous Mixture Production
metric ton (ton)

(1) Mixture Design Type (LV, MV, SP or SM as appropriate).
(2) Aggregate size designation, as per Table 2360.2-E.
(3) "Wearing" or "Non Wearing" as appropriate.
(4) AC binder grade designation.
(5) Specified lift thickness.
(6) Aggregate Size Designation, 9.5, 12.5 or 19 as appropriate.
(7) "Wearing" or "Non Wearing" as appropriate.
(8) Traffic Level as per Table 2360-1-A.
Concrete Bridge Construction

2401.1 DESCRIPTION
This work shall consist of constructing those portions of a bridge that are made of concrete, except for concrete piling, special wearing courses, and precast concrete members.

Reference to the "Bridge Deck Slab" means the complete structural slab and wearing course constructed monolithically. Reference to the "Bridge Structural Slab" means only the structural unit upon which will be constructed a separately cast wearing course. "Bridge Slab" means either "Bridge Deck Slab" or "Bridge Structural Slab."

2401.2 MATERIALS
A Concrete .................................................................... 2461
Mix designations shall be as indicated in the Plans for the specific item of work.

Class A coarse aggregate, as defined in 3137.2B, shall be used in all concrete for bridge railings, barriers, posts, curbs, sidewalks, and median strips that are cast separately from the bridge deck.

B Reinforcement Bars .................................................... 3301
C Steel Fabric ................................................................. 3303
D Spiral Reinforcement..................................................... 3305
E Preformed Joint Filler .................................................. 3702
F Concrete Joint Sealer, Hot Poured Type .................. 3723
G Concrete Joint Sealer, Preformed Type ................... 3721
H Concrete Treating Oil ................................................ 3917

2401.3 CONSTRUCTION REQUIREMENTS
A General
The construction requirements for concrete bridges are those specified for the component items of work, subsidiary to the completed structure, contained elsewhere in these Specifications, as well as those herein specified.

Foundation preparations and piling shall be subject to 2451 and 2452, respectively. Metal reinforcement shall be placed in accordance with 2472.

B Falsework and Forms
Whenever "Manual" is referred to in falsework, form, or falsework and form construction, "Manual" means the Falsework and Form section of the Mn/DOT Bridge Construction Manual.

Forms shall be used for all concrete except portions of footings that extend into solid rock. Casting concrete against the side of an earth excavation in lieu of forming will not be permitted. Cofferdam sheets will be considered as forms for footings when the Special Provisions permit the sheets to be driven along the neat line of a footing.
B1 Material Requirements, with Allowable Stresses or Loads

B1a Falsework Piling

All falsework piles shall have a size, soundness, straightness, and absence of structural defects that allows driving to the required bearing without damage to the piles. Falsework piles shall be capable of carrying the design loads without over stressing.

Safe pile-bearing capacities shall be determined from the appropriate formulas in 2452.

Regardless of computed bearing, timber piles shall not be designed to more than 700 N/mm (2 tons per inch) of average diameter (of an individual pile) at cutoff. Timber piles with an average diameter of less than 200 mm (8 inches) at cut-off shall not be used.

Piles shall not be loaded to more than the maximum design loads specified in the Manual for the size and type of pile and under the conditions of use.

B1b Structural Shapes and Fabricated Assemblies

Steel or aluminum shapes shall be straight and shall have a shape suitable for the proposed use. A reduction in safe load capacity, as determined by the Engineer, shall be made for any material or fabricated assembly that has a loss of section due to corrosion, damage, or previous fabrication. In general, shapes used as beams shall not be spliced at points of maximum bending stress. All splices shall develop the net section.

The design of trusses or other fabricated sections and of steel beams shall conform to the applicable design provisions of AASHTO Standard Specifications for Highway Bridges or AASHTO LRFD Bridge Design Specifications. The allowable stresses given in AASHTO Standard Specifications for Highway Bridges may be increased by up to one-third.

Form ties and other steel devices, portions of which must be cast into the concrete, shall be designed and used so as to permit the major part or the entire device to remain permanently in the concrete. When any device passes through a concrete surface exposed to view in the completed structure, the device shall be so designed that all material in the device to a depth of at least 25 mm (1 inch) back of the concrete face can be disengaged and removed without spalling or damaging the concrete.

B1c Lumber

All lumber shall be sound, seasoned wood. The timber species and grade of the lumber used, together with the dimensions and surfacing of the pieces, shall be suitable for the proposed use. Individual pieces shall be free of defects including crook, twist, warp, and variations in dimensions that may adversely affect the strength of the piece or the
appearance of exposed concrete lines and surfaces. The side of all lumber pieces that will contact concrete shall be surfaced and, when form lining is not used, the two edges shall be surfaced or dressed and matched as required to prevent mortar leakage.

Working stresses for lumber shall not exceed the maximums specified in the Manual.

Sheathing lumber, either with or without form lining, shall have a minimum thickness of 25 mm (1 inch) nominal and maximum width of 200 mm (8 inches) for exposed concrete surfaces, except that wider lumber may be used when a single piece will completely cover a concrete surface and adequate provisions are made to prevent cupping and warping of the piece. For special curved surfaces, sheathing may have a thickness less than 25 mm (1 inch) nominal, when approved by the Engineer.

B1d Plywood Sheathing

Plywood used as form sheathing shall have five or more plies and a nominal thickness of not less than 20 mm (¾ inch), and shall be of a concrete form grade (with sanded or overlaid surfaces) specially manufactured for the purpose. Plywood meeting these requirements may be used without backing. For special curved surfaces, and for slab sections between girders or beams, sheathing may have a thickness less than 20 mm (¾ inch) nominal, subject to approval by the Engineer.

B1e Form Lining

When form lining is specified, the form backing shall consist of plywood sheathing in good condition, or the form backing used shall be lined with smooth surfaced material (including plywood of a lesser thickness) that will produce a concrete surface substantially as smooth and uniform as would be obtained by the use of sanded or overlaid plywood sheathing in good condition. The same kind of form lining material shall be used throughout on any exposed concrete face. In any event, the contact surface of the form lining shall be so smooth and free of defects that any irregularities produced by the form face will be obliterated by the specified concrete finishing operations.

Form lining material shall have a uniform thickness. The edge finish and dimensions of form lining sheets or sections, either new or used, shall permit tight and smooth joints between adjacent sheets or sections and joints that will be mortar tight.

Bolt, nail, or rivet heads and weld deposits shall be flush with the form lining face in contact with concrete.

In general, the size of form lining sheets or sections shall be such as to reduce the number of joints required to substantially the same as if 1220 x 2440 mm (4 x 8 foot) plywood sheets had been used for the form lining.
B1f Forms For Circular Columns

Molds of steel, fiber, or other material that are used for forming circular columns shall be capable of withstanding the design concrete pressures without distortion. The concrete surface produced by the use of these forms shall be free of conspicuous ridges and depressions. Fiber molds meeting these requirements may be used when form lining is required. For brands that have not been used, but are proposed for use, the Contractor shall furnish manufacturers’ data showing that the product will produce the required results.

When the performance of any brand produces unsatisfactory results, the use of such brand shall be discontinued, and the Contractor shall make such corrections to the concrete surface as the Engineer may direct.

B1g Chamfer Strips

The chamfer strips shall be uniform in cross section dimensions without rounded corners and shall be smooth on all sides. When wood strips are used, they shall be made of straight grain soft wood, preferably white pine.

B2 Design of Falsework and Forms

Unless otherwise provided, detailed plans for falsework and forms shall be supplied to the Engineer on request, but in no case shall the Contractor be relieved of responsibility for results obtained by the use of these plans.

Falsework members shall be designed to safely carry the following forces:

1. Its own deadload.
2. The deadload of the green concrete, computed at 23.6 kN/m$^3$ (150 pounds per cubic foot).
3. A vertical live load of 0.96 kN/m$^2$ (20 pounds per square foot), applied on the upper concrete surface.
4. The deadload of the forms and other falsework members supported by the members.

Forms shall be designed to safely carry the following forces:

1. Its own deadload.
2. The deadload of green concrete, computed at 23.6 kN/m$^3$ (150 pounds per cubic foot).
3. A vertical live load of 2.4 kN/m$^2$ (50 pounds per square foot) applied on the upper concrete surface.

The specified live load shall be considered a minimum and shall be adjusted where known concentrated loads may produce higher live loads on a member.

The design of falsework and forms shall conform to the Manual with respect to the determination of concrete pressures; standard
2401.3

Formulas to be used; and allowable stresses, deflections, and deviations of alignment. Reliable information as to the performance of the proposed falsework and forms under concrete load may be required for any type of construction not included in the Manual.

Prior to use, the Engineer may require full scale field testing or testing by a reputable laboratory, without cost to the Department, for certain devices or fabrications for which insufficient performance information is available.

B3  Form Lining Requirements

Form lining backed by sheathing shall be nailed sufficiently to prevent bulging of the lining. Plywood 20 mm (¾ inch) or more in thickness shall be fastened to its supports with sufficient nails to ensure stiffness and close contact between the plywood and supports. Edges of sheets and form panels shall be tightly butted without offset and shall be mortar tight. Any open joints shall be patched or sealed with cold water putty or an approved equal. Joints in form lining sections or between adjacent form panels shall follow the same horizontal line whenever practical. When a horizontal joint in form lining is required on all four sides of a square or rectangular column that does not receive a rubbed finish, the joint shall extend on the same level around the column without vertical offset between joints on the four faces. Horizontal joints on all columns of a unit shall be as near to the same level as may be visible to the eye. Joints in form lining shall be truly vertical and horizontal. Pressed wood and hard board shall be prepared for use as recommended by the manufacturer. The screen side shall be in contact with the concrete when a rubbed finish is required, and the smooth side shall be in contact with the concrete when a rubbed finish is not required.

On forms for concrete faces exposed to view, holes for form bolts shall be drilled through sheathing or form lining in a manner that will avoid splintering the face of the form that will be in contact with the concrete. When sheathing may be reversed, splintering shall be avoided on both faces.

Form lining, as defined in 2401.3B1e, shall be used for all formed surfaces except those that will be buried or otherwise hidden from view in the completed structure, such as the back face of abutments, the sides of footings, and the interior surfaces of concrete box beams.

When the Plans require that a concrete surface be divided into panels formed by recessed rustication strips, the joints in the form lining shall be set so as to be covered by the rustications, except when a rubbed surface finish or a special surface finish is specified or is substituted therefore at no additional cost to the Department.
B4 Falsework Requirements

Falsework shall be supported on piling, on ledge rock, on parts of the structure, or on temporary footings.

No welding will be permitted on the primary stress-carrying steel members of the bridge superstructure except as specifically provided for under 2402.

Falsework piling shall be driven to a bearing capacity and penetration that will adequately support the superimposed loads without settlement.

If authorized by the Engineer, temporary footings may be used to support falsework for the structure. Temporary footings will only be authorized when the supporting soil will carry superimposed load without detrimental settlement and the footings are protected from disturbance, freezing, and inundation. Authorization will not be given unless the Contractor submits borings, testing, analysis and calculations for proposed footings which show that detrimental settlement will not occur under maximum construction loads and conditions anticipated at the site. Analysis and calculations shall include soil bearing capacity, anticipated settlement, and sliding resistance. If the Engineer does not authorize use of temporary footings, falsework shall be supported on piling.

All falsework piling in a bent shall be cut off so as to provide uniform bearing for the pile cap. Caps shall be securely fastened to the pile heads or posts. Each falsework bent shall be securely braced with timber of adequate size, and the bents shall be securely braced to adjacent bents.

The width of falsework for superstructures shall be greater than the overall width of the superstructure by an amount that will permit side forms to be braced to the falsework.

On bridges with separate roadways, the form and falsework supports for each roadway slab shall be supported entirely by the beams or girders under that roadway.

Primary supports for concrete slab spans and the bottom slab for concrete box girders shall be located near enough to the construction joints in these slabs so as to preclude conspicuous offsets resulting from differential deflections between adjacent slab sections. In general, the distance from the joint to the nearest primary support shall not be greater than 600 mm (2 feet).

Falsework for slab overhangs for steel beam spans shall be capable of resisting torsional stresses that are particularly critical at the midpoint between diaphragms when the length of overhang is greater than the depth of the fascia beam. Pronounced irregularities caused by these
stresses shall be prevented by the use of knee bracing, cross bracing, struts, ties, or other methods acceptable to the Engineer.

B5 Removal Of Falsework

Falsework supporting concrete structures and concrete members shall not be released until the curing period plus 1 day of drying out time has been completed. Curing time shall be as defined in these Specifications under Concrete Curing and Protection.

No loads shall be placed on concrete members until the curing has been completed and the falsework has been released, except as may be permitted by the Engineer.

Adequate strength for the complete structure will be determined for the last concrete cast that will be affected by the release of falsework.

Supporting falsework shall be loosened and removed in a manner that will permit the concrete to uniformly and gradually take the stresses due to its own mass. Methods of falsework removal likely to cause over stressing of the concrete shall not be used.

The release of falsework shall start at or near the center of a span for the full width of the span and progress simultaneously toward both ends of the span unless otherwise authorized. On continuous span concrete superstructures, with or without cantilevers and hinges, release of falsework shall progress simultaneously and uniformly in all spans unless otherwise authorized.

Falsework piles located within the roadbed shall be removed to an elevation at least 1200 mm (4 feet) below the subgrade. Those located in a stream or lake bed and within the limits of low water shall be removed to the stream or lake bed, except that in established navigation channels, they shall be removed to an elevation at least 600 mm (2 feet) below the established bottom of the channel. Those located outside the above defined limits shall be removed to an elevation at least 600 mm (2 feet) below ground elevation.

All lumber and timber (except timber piles) used for falsework and forms under abutment floor slabs shall be removed. Falsework piles for abutment floor slabs may be left in place. Falsework supports for the top slab of concrete box girder spans shall be completely removed.

Unless otherwise authorized by the Engineer, temporary footings shall be entirely removed, unless their top surfaces are at least 1200 mm (4 feet) below the grading grade or at least 600 mm (2 feet) under other ground surfaces.

All open excavations resulting from the removal of falsework shall, at the Contractor's expense, be backfilled with suitable material and compacted in accordance with 2451.
B6 Form Construction

Forms shall be designed and constructed to safely resist the pressure of fluid concrete under vibration and of other loads incidental to the construction operations. They shall be constructed and erected so as to be mortar tight, so that the finished concrete conforms to the proper dimensions and contours, and so that undulations and waves on exposed finished concrete surfaces do not exceed the maximum shown in the Manual. The forms shall be set true to the designated lines and be rigidly maintained in this position until the concrete has sufficiently hardened.

When vertical construction joints are required in a concrete unit for which a rubbed surface finish is specified, joints in form sections shall be so located that the major part of the forms for any previously cast part of the unit may be removed to permit the initial rubbed surface finish to be performed independent of progress on adjacent concrete casts.

Vertical forms shall be constructed in a manner that will permit their removal independent of any overhead falsework.

Rustication strips and other forms for small recesses on exposed concrete surfaces shall be fastened to forms in a manner that will permit them to remain in place when the form is removed.

Sheathing lumber shall be placed horizontally, except where otherwise authorized by the Engineer.

Splices in wales shall be so constructed that the wale will be effective continuously for its entire length. Splices in each member of a double wale shall be staggered at least one stud space. Splices in studs, when required, shall be so constructed that the stud will be continuous between plates and will meet design requirements.

Openings may be left in the forms for cleaning out extraneous matter or facilitating the placement of concrete, but the number and location of openings shall be first approved. Closures for openings shall be carefully constructed to ensure a tight fit flush with the adjoining surfaces.

Unless otherwise specified, chamfer strips having 20 mm (¾ inch) sides shall be used to form chamfered corners where exposed intersecting concrete surfaces meet at an angle of 90 degrees or less. Chamfered corners will not be required at the corners of beam stools under decks if the corner is formed mortar tight. Similar moldings with 15 mm (½ inch) sides shall be used at all joints that will be exposed to view and are not required to be edged. Moldings shall be securely fastened at intervals not to exceed 150 mm (6 inches).
The method of setting chamfer strips at the tops of pier caps supported on falsework shall provide for adjustment to true bridge seat elevation after the bulk of the cap concrete is in place.

Forms for keyways at construction joints in concrete may be constructed to nominal lumber dimensions and with side bevels of not more than 1:10.

Forms for open joints shall be made readily removable to preclude damage to the joint when the form is removed.

When a construction joint is required between the bridge slab and superimposed concrete casts (such as railings, curbs, and medians), the forms for the superimposed concrete casts (including any forms for offsets at the top edge of the slab) shall not be set to proper elevation and alignment in a span until the bridge slab has been placed in all spans that will appreciably alter the deflection in the span being formed.

Concrete box girder spans and concrete slab spans shall be freed of all temporary supports before grade elevations are set for the curbs, sidewalks, medians, and railings.

Forms for the roadway faces of curbs, sidewalks, and medians cast separately from the slab shall be set and maintained to proper alignment and batter. Nails of any type driven into the hardened concrete shall not be used. A sufficient number of braces and struts shall be used to rigidly maintain the forms to proper line and batter during concrete casting without the use of internal spreaders. Bolts and pins, set or drilled into the slab, shall be removed to a depth of at least 40 mm (1 ½ inches) without spalling or damaging the concrete, after which the holes shall be filled flush with mortar.

When the Plans indicate that a bridge (or portions thereof) is to be constructed to a horizontal curve, the forms for edges of slab, curbs, copings, medians, and railings shall be constructed to their proper degree of curvature within a tolerance of 3 mm in 3000 mm (1/8 inch in 10 feet).

B7 Treatment of Forms

The contact faces of all forms shall be treated with an approved form coating material meeting 3902 prior to placing the reinforcement.

Form lining treated before erection shall be protected from accumulations of dust and dirt.

All faces of forms that will be in contact with concrete shall be thoroughly flushed with water immediately prior to the placement of concrete.

B8 Removal of Forms

Removal of forms, including removal of form ties, shall be carefully done in a manner that will not spall or mar concrete surfaces or break off concrete corners.
Forms for the roadway face of curbs, sidewalks, and medians may be removed as soon as the concrete can retain its molded shape provided weather conditions permit the specified concrete finish to be started immediately after the forms are removed. All other forms shall remain in place for at least 12 hours after the concrete is cast or for a longer time if stripping of the forms would damage the concrete or prevent disengaging the form ties.

Column and wall forms shall be removed before the falsework supports are released from any concrete that will be supported by the column or wall.

When a surface finishing operation is specified to be completed within a definite period of time after casting, the forms on the surface shall be removed as necessary to permit completion of the finishing operation within the specified time, but not sooner than the specified minimum period of time after casting. Forms for rustication, fluting strips, and drain resecces shall not be removed with the face forms but shall remain in place until they can be removed without spalling, chipping, or marring of concrete corners or edges.

Forms for the webs of concrete box girder spans shall be removed, and the web concrete shall be given ordinary surface finish before the forms for the top slab are set in place at that location.

All interior forms in concrete box girder spans shall be completely removed, and the inside of the concrete box girders cleared of all loose material and swept clean.

B9 Re-Use of Forms

The re-use of forms or form materials will be restricted to members or materials that are unimpaired in strength, rigidity, or condition. Conspicuous permanent set of form lining between supports will require removal of the form lining and correction before reuse.

Any open holes in sheathing shall be plugged or covered. All open holes in form lining shall be plugged flush, and blemishes on the form lining surface shall be repaired to a smooth and even surface. Form surfaces in contact with concrete shall be cleaned of all adhering concrete and extraneous matter before reuse.

C Placement of Concrete

C1 General Requirements

Forms, falsework, bracing, and reinforcement bars for the entire concrete cast shall be properly in place, and all necessary concrete placement equipment, finishing equipment, and curing media shall be on hand before concrete placement is started.

The Engineer shall be notified well in advance of the casting of concrete in order to make proper arrangements for the inspection of forms, reinforcement bars, materials, and equipment. No concrete shall
be placed until this inspection has been made and the work approved. Such approval shall not relieve the Contractor of full responsibility for satisfactory results.

Mixing, placing, and finishing of concrete shall be done under adequate lighting conditions.

Concrete shall be transported to and placed in the work in a manner and with equipment that will avoid segregation of the batch materials. Concrete shall be placed in or near its final position in a manner that will avoid displacement of reinforcement and to ensure complete enveloping of the reinforcement in the concrete.

All equipment for transporting, placing, and finishing concrete shall be kept free of foreign matter and coatings of hardened concrete. Water for cleaning the equipment shall be wasted outside the forms.

Forms and reinforcement bars shall be clean, and all debris shall be removed from within the forms before concrete is placed.

Concrete shall be placed under water only when it is used for a cofferdam seal, and then only as provided in the Special Provisions or as specifically permitted by the Engineer.

Earth and porous rock foundations shall be moist at the time concrete is placed on or against them.

When casting footings in solid rock, the rock trench shall be completely filled with the grade of concrete specified for the footing, without the use of side forms.

Concrete between required or permissible joints shall be placed in a continuous operation. In the event of a breakdown, during which time the concrete sets to a degree that it cannot be effectively revibrated, the surface of the concrete that will be covered by fresh concrete shall first be covered with an approved bonding agent or mortar, as determined by the Engineer. Concrete placement shall be so regulated that the pressures caused by the fluid concrete shall not exceed those for which the forms were designed. If, during the placement of concrete, the forms or falsework show signs of overstress or excessive deflection, the casting operations shall be stopped until corrective measures have been taken. Any section of concrete found to be defective or disturbed will be subject to 1512.

Concrete, except for seals, shall be deposited and compacted in continuous horizontal layers. The thickness of each layer placed shall not exceed 300 mm (1 foot), except that in columns and thin walls the thickness may be increased to not more than 1000 mm (3 feet). Concrete placement operations shall be planned and carried on so that concrete may be deposited and compacted before the concrete in the preceding layer (directly below) has taken initial set. Not more than 1 hour shall elapse from the time of placement of concrete at a point in a
layer to the time the concrete in the next overlaying layer is placed at that point. Some modification to these time requirements will be made when it is determined by the Engineer that the concrete mix, admixtures, concrete, air temperature, or humidity conditions may advance or retard the normal time of initial set.

Concrete shall not be dropped from a height of more than 1200 mm (4 feet) unless confined in a vertical mortar-tight, sheet metal down spout or other approved type of pipe or unless the Engineer approves another placement method. Down spouts shall be equipped with suitable hoppers at their inlet end and shall be made in sectional lengths that will permit adjustment of the level of the outlet during concrete placement. The number of down spouts used shall be sufficient to ensure concrete placement at a fairly horizontal level.

Pipes, belts, or chutes that are inclined may be used only when approved means of preventing segregation are provided. Inclined pipes and chutes, and belts either inclined or horizontal, shall discharge into hoppers with vertical down spouts.

Concrete buckets and hoppers shall be so constructed as to permit concrete with the specified slump to be readily discharged at a regulated rate. Concrete buckets shall be placed as close as practical to the point of deposit before discharging. When concrete buckets discharge the concrete directly into or on the forms, the rate of discharge and movement of the bucket shall be controlled, and discharging excess concrete in a pile for rehandling shall be avoided.

Laitance and foreign matter of any nature shall not be permitted to accumulate at any point inside the forms.

Dried or hardened mortar accumulations shall not be mixed with fresh concrete. As the concrete rises in the forms, the form surfaces and reinforcement bars shall be kept reasonably free of mortar spatters that may harden before being incorporated in the mix. Removal of mortar shall be done by methods that are not detrimental to the concrete. Dried mortar and dust accumulations on the form surfaces and reinforcement bars above construction joints shall be removed before placing the next concrete lift, by methods that will not damage the form surfaces or the steel-to-concrete bond at and near the surface of the joint.

Special care shall be exercised to work the coarse aggregate back from the forms and to force the concrete under and around the reinforcement bars without displacing them.

When a wall or column more than 1500 mm (5 feet) tall is cast integrally with a beam, strut, or slab, a time lapse of 30 to 90 minutes, as determined by the Engineer, shall elapse between placement of the concrete to the level of the bottom of the beam, strut, or slab and placement of the concrete above this level.
For caps supported by more than one column, casting of the columns shall proceed uniformly, to provide a similar time delay at all columns before placement of the cap is started.

Before fresh concrete is placed against concrete that has set, the surface of the set concrete shall be thoroughly cleaned of all loose material, laitance, dirt, and other foreign matter. For superstructure concrete, the set concrete shall be cleaned by sandblasting, water blasting, or other approved methods. Care shall be taken during blasting operations to prevent damage to epoxy coating on reinforcement bars. Immediately prior to placing the fresh concrete, the forms for the fresh concrete shall be drawn tight against the set concrete. The contact surfaces of the set concrete shall be kept thoroughly wet until the fresh concrete is deposited.

When the Engineer determines that shock waves from pile driving, blasting, or other operations will be detrimental to concrete, these operations shall either be completed in advance of concrete placement or they shall be suspended until adequate concrete strength is gained.

Runways for concrete transportation shall not be supported by the forms unless authorized.

Concrete railings shall not be placed, without authorization from the Engineer, until the span falsework has been removed and an acceptable bridge slab cure has been obtained.

C2 Cold Weather Protection of Concrete

The Contractor shall place concrete according to the following requirements when placement is before April 15th and after:

(a) October 1st for Projects north of the 46th parallel.
(b) October 15th for Projects south of the 46th parallel.

C2a Cold Weather Protection Plan

The Contractor shall submit for the Engineer's approval a proposed time schedule and plans for cold weather protection of concrete, including maintenance of acceptable temperatures during placement and curing. The Contractor shall not place concrete until the Engineer has approved the Contractor's cold weather protection plan.

C2b General

The Contractor shall:

(1) Preheat the forms, in-place concrete, and items such as the top flanges of beams prior to placing concrete when their surface temperatures are below freezing. The Contractor shall not apply flames directly to concrete or steel.

(2) Provide insulated forms, insulation, or heating and housing facilities as necessary to maintain a minimum concrete temperature of 15°C (60°F) during the curing period. The heated enclosures shall be vented to prevent the buildup of carbon dioxide.
(3) Keep the forms, insulation, and housing enclosure in place until the cold weather protection needs have been fulfilled as determined by the Engineer.

(4) When cold weather protection has been provided, its discontinuance shall be gradual and in a manner such that the rate of temperature reduction adjacent to the concrete surfaces will not be more than 11°C (20°F) during any 12-hour period until the surface temperature reaches that of the atmosphere.

The Engineer will base anticipated concrete placement and curing temperatures on weather forecasts. If weather forecasts are not considered adequate, the Engineer will base the anticipated temperatures on typical temperature data for the time of year at the locality of the structure.

C2c Bridge Slabs, Box Girder Bottom Slabs, and Box Girder Webs

The Contractor shall meet the following requirements regarding the placement and curing of concrete in bridge slabs, box girder bottom slabs, and box girder webs.

C2c(1) Air Temperatures Below 2°C (36°F)

When the air temperature is anticipated to be below 2°C (36°F) the Contractor shall not place concrete until housing is in place and is sufficient to protect the entire area to be poured.

C2c(2) Air Temperatures Above 2°C (36°F) During Placement But Below 1°C (34°F) During Curing

When the air temperature is above 2°C (36°F) during placement but anticipated to fall below 1°C (34°F) during curing, the Contractor shall not place concrete until insulation or housing and heating are in place and are sufficient to protect the concrete from freezing. The Contractor may install insulation and housing upon completion of concrete finishing as provided in the approved cold weather protection plan if it hinders concrete placement.

C2d Bridge Deck Slab

If a bridge deck slab is to be opened to traffic before April 15th, the Contractor shall remove the conventional wet curing media from the slab surface at the end of the curing period. For the next 25 calendar days or until April 15th, whichever comes first, the Contractor shall heat and provide suitable housing to ensure free air circulation above the concrete surface to dry the concrete and prevent the temperature of the concrete from falling below 5°C (40°F).

D Compaction of Concrete

Concrete, except for cofferdam seals, shall be thoroughly compacted by mechanical vibration applied internally. Vibrators shall be operated at a frequency of not less than 75 Hz.
A sufficient number of vibrators shall be used to properly compact each batch, or part thereof, immediately after it is deposited.

The application of a vibrator or vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and imbedded fixtures and into the corners and angles of the forms. Vibration shall be supplemented by as much spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with vibrators.

Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be methodically inserted and withdrawn from the concrete. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but vibrators shall be withdrawn before segregation and localized areas of grout result.

Vibration shall not be applied directly or through reinforcement to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. Vibrators shall not be used to make concrete flow in the forms over distances so great as to cause segregation.

E Joint Construction

Joint construction shall be in accordance with the details and at the locations shown in the Plans or as otherwise provided for hereinbefore, subject to the additional requirements set forth herein.

E1 Transverse Construction Joints

Grooves or saw cuts shall be made at transverse construction joints in the bridge slab unless otherwise directed by the Engineer. The cuts shall be 10 mm (3/8 inch) wide by 25 mm (1 inch) deep for the full width of the roadway between gutter lines, and the cut shall be made directly over the construction joint before the curb forms are placed.

E2 Weakened Plane Joints

When the bridge slab is supported by prestressed I-beams and is designed so as to be continuous over a pier, a 10 mm (3/8 inch) wide by 25 mm (1 inch) deep cut shall be made in the slab from gutter to gutter directly over the pier along its centerline.

Under sidewalks and at other locations where a saw cut cannot be made in the slab, a weakened plane shall be extended and formed using a grooving tool or a removable insert at the time the slab is cast. The insert or groove shall cut the fresh concrete on a straight and true line to
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a depth of 25 mm (1 inch). The insert shall be coated with oil or grease before being placed and shall be withdrawn when the concrete has set sufficiently to retain its shape.

The weakened plane shall be accurately located so as to fall vertically below the proposed sidewalk, curb, or median joint at that location, with the following exception: skewed bridges on which the exterior girders or beams are under the curbs, sidewalks, or medians, and on which the curb, sidewalk, or median joints are normal to the longitudinal axis of the bridge, shall have the weakened plane extended by using a removable insert placed as a continuation of the line to be cut, extending to the centerline of the exterior girders or beams. Outward from the centerline of the exterior girders or beams, the weakened plane shall be common to the joint to be placed in the curb, sidewalk, or median, thus forming an angle in the alignment of the weakened plane. A vertical 13 mm (½ inch) vee shall be formed into the edge of the slab at the end of the weakened plane at that location.

E3 Open or Filled Joints

The concrete faces or armored edges against which preformed filler or sealer material is to be placed shall be constructed truly vertical, straight, and parallel. Where open joints are to be constructed, the distance between faces shall be accurately formed with removable inserts, headers, or templates to provide the required opening for the temperature range prevailing at the time of concrete placement. A tabulation will be included in the Plans or Shop Drawings showing the required openings at various temperatures.

The tabulated joint openings are those required at the time the elastomeric seals are installed. The temperatures listed are those anticipated at the time the slab is to be cast. The Contractor is advised that the joint may widen due to concrete shrinkage.

After the bridge slab adjacent to an elastomeric seal expansion joint is in place and after allowing sufficient time for drying of the concrete subsequent to completion of the curing, the Engineer will measure the constructed joint openings for conformance with the sizes specified in the Plans. Any openings that deviate from the specified size by more than 5 mm (3/16 inch) will be considered unacceptable work. No offsets at joints between segments will be permitted.

Where preformed joint filler is used to form vertical joints, the filler material shall be placed and secured in proper position by methods that will provide adequate anchorage without detrimental effects, such as by using copper nails, copper wire, or other approved means. Cork joint filler shall be anchored with 65 mm (2 ½ inch) long copper nails at about 500 mm (20 inch) centers. Where chamfered corners are required
at joints to be filled with preformed material, the filler shall be trimmed back to the inside of the vee formed by the chamfer strip.

E4  Expansion Joint Devices

Bridge slab expansion joint devices shall be furnished and installed according to the details and at the locations indicated in the Plans. Field assembly and erection of the expansion devices shall be in accordance with 2402.3K.

F  Finish of Concrete

F1  General

Surface finishing shall be done only on properly set concrete and (unless protection for the work is provided) only under approved weather conditions. When the finishing must be done under adverse weather conditions, protection for the work shall be furnished.

F2  Formed Surfaces

F2a  Ordinary Surface Finish

All formed surfaces of concrete structures shall receive ordinary surface finish. All conventionally formed concrete surfaces that are to receive the special surface finish, shall be sandblasted or water-sandblasted prior to the ordinary surface finish to break the surface film and to remove all laitance, form release agent, dirt and other foreign matter that may impede adhesion of the special surface finish. The term "exposed surfaces," as used hereinafter, means exposed to view in the completed structure, above low water and above the final ground line.

Immediately after removal of the forms, the concrete surfaces shall be examined for areas of unsound concrete and defective surfaces due to improper concrete placement, faulty form work, faulty form removal, and other causes. Concrete with porosity, honey comb, or segregated materials shall be removed and replaced, but the ordinary surface finish shall not be started until the Engineer has viewed the extent of the defective concrete and has approved the time and method of repair and the materials to be used. In general, small areas may be repaired with mortar as specified for surface cavities; large areas may require concrete with formed surfaces. A bonding agent, mechanical bonds, or both may be required, and all repair work shall be cured in an approved manner. When defects in a concrete section are so extensive that satisfactory repairs cannot be made, that section will be subject to the Unacceptable Work provisions of 1512.

All fins and irregular projections shall be removed from exposed surfaces and from surfaces that will be waterproofed.

All surface cavities produced by form ties and, on exposed surfaces, any surface cavities (bug holes) with a diameter of 10 mm (\(3/8\) inch)
and larger and smaller surface cavities so closely spaced as to be conspicuous shall be thoroughly cleaned, saturated with water, and filled with mortar. At locations where surface is not exposed or where the Engineer determines that the appearance of the completed structure will not be adversely affected, cavities caused by removal of falsework brackets, form ties or hanger rods may be filled with an approved silicone caulk. The cavities shall be thoroughly cleaned prior to filling with caulk.

The mortar shall consist of 3 parts standard Portland cement, 6 parts mortar sand, and water. The quantity of water used shall produce a mortar consistency as dry as possible to use effectively and, to further reduce plastic shrinkage, the mortar shall be mixed about 1 hour in advance of use.

An approved latex or acrylic-based bonding agent shall be incorporated into the mortar used for performing the ordinary surface finish on all areas that will subsequently receive a special surface finish. The bonding agent shall be added to the mixing water at a ratio of 1 part bonding agent to 3 parts water.

The cavities shall be completely filled with mortar, thoroughly compacted into place, pointed, and trimmed flush with the concrete surface. On exposed surfaces, mortar stains or streaks outside the area of the filled cavity shall be avoided and, if they should occur, they shall be removed.

When the Special Provisions do not specify additional surface finishing on an exposed surface, at the time of completion of all concrete work on the structure, all conspicuous streaks, stains, and blemishes shall be removed from the surface. Additional surface finishing shall also be done on an exposed surface that requires only ordinary surface finish when adjoining form lining sheets present sharply contrasting colors or textures. A modification of sack rubbed surface finish may be required as a corrective measure when the surface appearance remains objectionable after the ordinary surface finish has been completed.

When the ordinary surface finish is performed before the completion of the curing period for the concrete being finished, the finishing shall be done with a minimum of interruption to the curing. F2b Sack Rubbed Surface Finish

Where numerous surface voids are present on an exposed surface, at the Contractor’s option, the sack rubbed finish may be used to fill the smaller voids in lieu of the method described under ordinary surface finish. However, the filling of form tie holes and other large cavities shall be done as specified under ordinary surface finish.
As a preparatory operation, the entire surface shall be ground with a high speed electric disk-type grinder or sandblasted until blemishes, discolorations, and thin mortar films covering surface voids have been removed.

When the structure has been completed to the extent that further blemishes and discolorations on the surface will not result from any remaining construction, the final operations shall be performed as follows:

(1) The surface shall be thoroughly saturated with water and, while the surface is still moist, a mortar mixture (consisting of 1 part standard Portland cement and 1 part mortar sand, with sufficient water added to produce a moderately thick paste) shall be applied to the wetted area with a rubber float, starting at the top. All voids shall be completely filled during this operation. If any portion of the surface shows evidence of becoming dry before the mortar is applied, it shall be rewetted.

(2) After the mortar has set sufficiently to be retained within the voids and before it has become completely dry, the entire surface that has been floated with mortar shall be rubbed with a small burlap sack filled with a dry mix (sand and cement only) of the mortar described above. All mortar in excess of that required to fill the voids shall be removed during the dry mortar sack rubbing operations. In lieu of the dry mix filled burlap sack; any equally effective means of removing the excess mortar will be approved.

(3) The completed surface shall be free of blemishes, discolorations, surface voids, and conspicuous form marks. The surface shall be uniform in texture and appearance except for the difference in texture between filled voids and the remainder of the surface. Surfaces that do not meet these requirements shall be corrected to the satisfaction of the Engineer.

F2c Special Surface Finish

A special surface finish will be required for only those bridges and on those surfaces designated in the Contract. The objective of this operation is to obtain a surface that is reasonably smooth and uniform in texture and appearance.

The special surface finishing shall be performed using a department approved system of commercially packaged mortar, bonding agent, and 100% acrylic paint. The mortar, bonding agent, and water shall be blended in proportions specified by the manufacturer. The 100% acrylic paint shall be blended in at a rate of 3.8 L/22.7 kg (1 gallon per 50 pound) of dry mortar mix. The 100% acrylic paint shall meet the requirements of 3584. The approval requirements for the special surface finish system along with the approved list are on file in the
Concrete Engineering Unit. The materials used for the system shall produce a mixture suitable for spray application to vertical concrete surfaces at the specified coverage rate.

Unless the Department has previously approved the system proposed for use, the Contractor shall have the system tested in a recognized commercial independent testing laboratory in accordance with procedures prescribed by the Department. The time required for the testing is approximately 90 days. No work in conjunction with the surface finish shall be started until the system has been approved. The same materials and application method shall be used for the entire surface specified to be given a special surface finish.

The special surface finish shall not relieve the contractor of full responsibility for performing the ordinary surface finish operations as specified.

The approved materials shall be thoroughly mixed in accordance with the manufacturer’s recommendations. Setting times and re-mixing shall be in accordance with the manufacturer’s requirements. The manufacturer’s technical representative shall be available for recommendations to the contractor prior to and during the work.

The mixture shall be applied in a minimum of two coats by spraying. The initial coat shall cover the entire surface; it shall not be so thick as to cause runs, sags or a “plastered” effect. Follow all other manufacturer recommended application procedures. The total coverage rate for the two coats shall be 0.4 m²/L (16 square feet per gallon) of material.

Special surface finishing operations including any topcoat applications may commence when air temperature is at least 4°C (39°F) with the temperature rising, and shall be suspended when the air temperature is falling and reaches 7°C (45°F).

Application of the special surface finish and any required topcoat application shall not be started until all other work that might mar the special surface finish has been completed, nor until the finishing operations can be carried on continuously from beginning to completion on any one bridge.

The final surface after drying shall be uniform in color and texture, with no evidence of laps or breaks in continuity. Corrective work, as directed by the engineer, will be required over any areas that have not been satisfactorily finished, including as much adjacent area as may be necessary to achieve uniform appearance, and all at the contractor’s expense. This requirement is for all specified special finish operations including both the special surface finishing and any required topcoat application.

F2d Curb, Sidewalk, and Median Finish
The surface finish of formed surfaces of medians, delineator curbs, and the roadway face of curbs and sidewalks shall be as follows:

1. Ordinary surface finish operations shall be started immediately after removal of the forms and shall be carried on continuously to completion. As the ordinary surface finish progresses, it shall be followed by immediately rubbing the surface with a cork float or fine carborundum stone (depending on the set of the concrete) to produce a paste on the surface and to expose and fill all depressions and all surface cavities. The paste shall be floated to a smooth surface free of coarse texture, swirls, and ridges and, before it is set, shall be brushed lightly with a fine bristled brush until all cement films present are removed and the surface has a uniform, fine grained, sanded texture.

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

F2e Railing Finish

Irregularities in any 3000 mm (10 foot) length of the finished concrete railing shall not exceed 6 mm (¼ inch) (horizontal and vertical). Surfaces and edges not meeting this tolerance shall be considered to be unacceptable work. Unacceptable Work shall be removed and replaced with acceptable work when so ordered by the Engineer. Extensive areas with deviations greater than 13 mm (½ inch) shall be removed and replaced. In the absence of an order to remove and replace, the unacceptable work may be left in place with the following price adjustments:

1. For 7 to 13 mm (5/16 to ½ inch) deviation, payment at 75 percent of the Contract price.

2. For minor areas with deviations over 13 mm (½ inch), payment at 50 percent of the Contract price.

F3 Unformed Surfaces

F3a Miscellaneous Unformed Surfaces

All upper horizontal and inclined surfaces that are not formed, except for the surface of bridge slabs and the surface at horizontal construction joints, shall be finished as follows:

Steel trowels and steel shod floats shall not be used. Templates and strike-offs shall be wood, or wood shod, accurately made to fit the required surface contour. Contact surfaces of hand floats and darbies may be of wood, canvas, rubber, or cork. Edgers shall be made of metal, accurately shaped to fit the specified radius and included angle. The metal at the lower lip of the edger (in contact with the form) shall not be so thick as to form any appreciable offset in the surface when the
form is stripped. The edger shall be of sufficient length to prevent waves in the surface resulting from slight variations in pressure at the time the final tooling is done. In lieu of tooling with an edger, an approved type of cove strip, so milled as to leave no appreciable offset with adjacent concrete surfaces, may be used to form rounded corners.

An excess of concrete shall be placed in the forms and compacted by internal vibration. After a delay of about 30 minutes (due consideration being given to weather conditions) the surface shall be struck off and screeded with an accurate template in a manner that will force the coarse aggregate below the finished surface and will leave the surface slightly above finished elevation. The screeding and strike-off operation shall be repeated as necessary to obtain the required elevation and contour (except for edging). Laitance and excess mortar shall be wasted outside of the forms. After the final strike off and screeding, the surface shall be hand floated as necessary to correct irregularities and seal surface tears and, immediately after the water sheen leaves the surface, the surface shall be lightly reworked with a float to a uniform texture, and rounded corners and edges shall be tooled to final radius in a manner that will force the coarse aggregate beneath the finished radius. Trails left by the edging tools shall be removed with the float.

Final texture and finish to the surface shall then be applied as follows: Bridge curbs and sidewalks and the floor slabs, ramps, landings, and stair treads for pedestrian bridges and tunnels shall be brushed (broomed) in a transverse direction, using a fairly stiff bristled brush or broom, so as to produce a slightly serrated surface finish that will not be slippery when wet and a surface that will be uniform throughout in texture and appearance. The final finish on other upper surfaces shall be obtained by brushing the cement film from the surface with a fine bristled brush, and leaving a uniform, fine grained, sanded texture on the surface.

The finished surface shall not vary more than 3 mm (1/8 inch) from a 3000 mm (10 foot) straightedge laid longitudinally on the surface, with transverse surfaces substantially as specified in the Plans.

F3b   Bridge Slabs
F3b(1)   General

Prior to starting concrete placement for a section of bridge slab, and after the strike-off rails or guides have been set to correct elevation, the top reinforcement shall be checked for vertical position by the Contractor in the presence of an inspector by operating the strike-off on the rails or guides. A filler strip, 6 mm (¼ inch) less in thickness than the minimum concrete cover requirements, shall be attached to the bottom of the strike-off during this check as a means of detecting reinforcement bars that may encroach on the required clearance.
Each bridge slab section between joints, between an end bulk-head and a joint, or the entire slab when no joints are specified, shall be placed in a continuous operation proceeding uniformly from edge to edge of the slab or from end to end of the section.

When the sequence of casting the slab sections and the direction in which the slab sections are to be cast is not specified, plans for the proposed casting procedures shall be submitted for approval. Construction that may be affected by alterations to the proposed plans shall not be started until the plans, as submitted, or with required alterations, have been approved.

The entire operation of bridge slab placement and finishing, including the rate of concrete delivery and placement, the placement and finishing equipment used, and the personnel provided for the work shall be so scheduled and the work so performed that the bridge slab section can be placed and properly finished during daylight hours.

When a bridge slab section is supported by two or more spans of continuous beams or girders, the following shall apply:

The rate of concrete placement for continuous pours of two or more spans shall be adequate to ensure that the concrete will remain plastic for at least one-half a span length back of an intermediate support, until placement has proceeded to a point one-half the span length ahead of that support. Approved admixtures, which retard the setting time of the concrete, may be required in order to provide the necessary plasticity.

F3b(2) Strike-Off of Bridge Slab

On bridge slabs, the striking off and screeding of the roadway surface shall closely follow concrete placement and compaction. The roadway surface shall then be rescreened until the surface of the plastic concrete has the required cross-slope and longitudinal profile.

Bleed water or laitance that rises to the surface shall be removed and wasted outside the forms, and, except for this removal and wasting operation, the concrete surface shall not be worked, smoothed, or otherwise disturbed while bleed water and laitance are present on the surface.

Advancement of the concrete placement and the initial strike-off shall be coordinated so that the initial strike-off is never more than 3000 mm (10 feet) behind the concrete placement. The head of concrete shall be maintained parallel with the initially screeded surface. Any excess concrete carried in front of the screed when the head of the concrete is reached shall be left on the concrete surface and mixed with freshly deposited concrete before the fresh concrete is compacted. As the concrete is deposited and compacted it shall be roughly leveled off slightly above the finished surface contour. When low areas are revealed as the initial strike-off operation proceeds, the strike-off
operation shall be delayed to permit filling these areas with additional concrete (not mortar). Walking in the concrete after the initial pass of the screed shall be avoided.

Strike-off and screeding of the surface shall be accomplished by a combined longitudinal and transverse motion of an accurate template while the template is supported on or suspended from suitable rigid guides. Approved mechanically rotated templates may be used in lieu of one of the screeding motion. Screed guides for manual strike-off may be rails, bulk-heads, or the side forms. Guides for power-operated strike-offs (screeds) shall be rails, with provisions for vertical adjustment. Screed rails and screed rail supports shall be so rigid that deflection and settlement under the mass of the equipment operated thereon is negligible. Unless the Engineer approves other locations, the screed rails for power-operated screeds shall be supported on the exterior beams, girders, or webs of the structure. Approval for support of screed rails on the side forms or on any falsework independent of the superstructure will only be given when the relative deflection of the supports is negligible and when undesirable conditions are not introduced. The elevation and longitudinal profile (including any allowance for residual camber and deflection under load) to which the screed rails are set, together with the shape of the screed, shall permit the surface of the plastic concrete to be cut and molded to the required cross-slope, longitudinal profile, and elevation under the strike-off and screeding operations.

On concrete deck girder and concrete slab span bridges, the screed rails shall be constructed so that vertical adjustment of the rails can be made after the concrete is in place. After the concrete is in place over a portion of the falsework, and when the concrete load may affect the elevations, the elevations of the screed rails shall be checked and, when necessary, readjusted to the required elevations before the final screeding of the roadway surface is done.

When an outside webwall of a box girder is under a sidewalk or curb, the Contractor may modify the sidewalk or curb reinforcement in order to accommodate the running rail system for the power strike-off machine. However, any modifications of the reinforcement shall be subject to the approval of the Engineer. Any additional costs involved in reinforcement bars due to the modification shall be at the Contractor's expense.

Screed mounted vibrators, when approved, shall not be used on the initial strike-off and screeding of the surface, and vibration shall be reduced to a minimum during the final screeding of the surface.
A self propelled power-operated strike-off machine shall be used for
screeding the roadway surface of all bridge slabs unless another type of
machine is approved for use by the Engineer.

Screed rails are not required for templates used for strike-off and
screeding of a bridge structural slab as it is overlaid with a subsequent
wearing course. However, if screed rails are used, they shall meet the
requirements of this specification. Templates supported on slab
reinforcement bars will not be permitted unless all of the following
requirements are met:

A. Templates
   The template shall be a product fabricated for the intended purpose
   by a manufacturer with at least 10 years experience. If template length
   exceeds 7315 mm (24 feet), the Contractor shall demonstrate to the
   Engineer that satisfactory adjustment can be made for crown breaks.
   Attached vibrators shall be evenly distributed across template length
   and vibration shall shut-off automatically when forward motion stops.

B. Template Supports
   Supports for templates shall be spaced to provide no appreciable
   sag in the template.
   Portions of template supports in contact with reinforcement shall
   consist of round tubes or rods with a smooth, low friction surface. Skis
   shall have a minimum length of 1520 mm (5 feet) and shall have a
   gradual "turn-up" nose sufficient to prevent entrapment in
   reinforcement.
   Transverse reinforcement bars shall be supported within 150 mm (6 inches)
   of the location where template support skis will ride.

C. Operations
   A manual or powered winch shall provide forward advancement of
   the template. Winch cables shall not be anchored to reinforcement bars.
   Attachments to beams (shear studs, stirrups or lifting cables) may be
   utilized.
   Concrete shall be spread and leveled in front of template so as not
to cause "float" or overriding.

D. Reinforcement
   Top reinforcement shall be securely tied and rigidly supported.
   Prior to beginning placement of concrete, the Contractor shall
demonstrate that equipment and methods to be used will not damage or
   displace reinforcement bars. Any visible deflections of reinforcement
   will require additional bar supports and/or additional supports for
   template.
   When the use of a power-operated strike-off (screed) is specified,
   the screeding motion shall be done mechanically and the equipment
   shall move on flanged or grooved wheels resting on the screed rails.
When the running rails are supported by exterior beams or girders that lie under the roadway slab, the area between the rail and the gutter may be finished without the use of the power-operated screed. In this area suitable guides shall be used to determine the required gutter profile and, after plastic shrinkage has taken place, the area shall be straightened and trued to the required profile and cross-slope.

The screed shall carry a surplus of concrete in front of it during all screeding operations, and rescreeding operations shall be discontinued when no surplus concrete is present.

Manual screeds and reciprocating power-operated screeds shall be operated slowly, with uniform forward travel, and the final screeding shall cover as long a section as practicable without stopping.

F3b(3) Final Finish Texture

After the concrete has been consolidated, screeded and floated the roadway surface of bridge deck slabs shall be given a final finish texture. This final finish shall be obtained by drawing a carpet drag longitudinally along the bridge slab before the concrete has attained its initial set. The drag shall be mounted on a work bridge. The dimensions of the drag shall be the width of the concrete placed by a longitudinal length of 1000 mm (3 feet). The carpet drag shall be adjusted as necessary to produce a texture satisfactory to the Engineer.

The carpet drag shall be an artificial grass type having a molded polyethylene pile face with a blade length of from 15 to 25 mm (5/8 to 1 inch) and a total minimum weight of 2.37 kg/m² (70 ounces per square yard). The backing shall be a strong durable material not subject to rot, that shall be adequately bonded to the facing to withstand use as specified. In lieu of the carpet drag texturing, a coarse broom texturing may be used, subject to approval by the Engineer.

In addition to and immediately following the carpet drag, the bridge deck slab surface shall be given a transverse metal-tine texture. The device used for this operation shall be equipped with 100 to 150 mm (4 to 6 inch) steel tines, 2 to 3 mm (1/12 to 1/8 inch) thick, arranged so as to obtain randomized grooves approximately 3 to 8 mm (1/8 to 5/16 inch) deep, with a variable spacing between tines of approximately 16 to 25 mm (5/8 to 1 inch). The Engineer may approve other texturing equipment provided an equivalent texture is obtained. Tining shall not extend into the areas within 300 mm (1 foot) of curbs.

The roadway surface of bridge structural slabs shall be hand floated only to the extent necessary to close up areas of exposed aggregate. It shall then be textured by methods and equipment approved by the Engineer so as to produce a final surface that is serrated, grooved, or roughened to a greater degree than that normally produced by
conventional brooming, but not to the extent of tearing out or loosening particles of coarse aggregate.

Movement and storage of equipment, vehicles, and materials on bridge structural slabs prior to placement of the wearing course shall be kept to a practical minimum.

The final surface shall have the required crown and shall be free of porous spots and irregularities. When checked with a 3000 mm (10 foot) straightedge placed longitudinally thereon, the surface shall not vary from the straightedge more than 10 mm (3/8 inch) on a bridge structural slab nor more than 3 mm (1/8 inch) on a bridge deck slab. Corrective measures required to meet this tolerance shall also provide comparable appearance and texture.

F3b(4) Bridge Slab Finish Under Curbs, Concrete Railings, Sidewalks, and Medians

The top surface of the bridge slab under curbs, concrete railings, sidewalks, and narrow medians shall be floated to grade, leaving a rough surface but with the coarse aggregate embedded in mortar. At the edge of the slab and under the roadway face of curbs, concrete railings, sidewalks, and narrow medians, a strip 50 mm (2 inches) wide shall be given a smooth finish.

The top surface of the roadway slab directly under wide island type medians shall be prepared in accordance with one of the following alternates, at the Contractor’s option:

(a) A continuous 25 mm (1 inch) x 100 mm (4 inch) keyway shall be formed into the slab concrete along the approximate centerline of the median.

(b) The slab surface shall be sandblasted to remove all laitance and a sand-cement bonding grout applied prior to placing median concrete. Median concrete shall be placed while the bonding grout is still wet.

(c) 13 mm (½ inch) diameter dowels shall be drilled and anchored into the slab along each median gutterline. The dowels shall be placed approximately 300 mm (1 foot) in from the gutterlines at 610 mm (2 foot) centers. Dowels shall be drilled at least 100 mm (4 inches) into the roadway slab and shall project 100 mm (4 inches) into the subsequent median. Dowels shall be either grouted with an approved epoxy or set with approved mechanical anchorages.

F3b(5) Bridge Slab Finish for Bottom Slab Concrete Box Girders

The top surface of the concrete in the bottom slab of concrete box girders shall be struck off to the required grade, and finished to within a 5 mm (¼ inch) tolerance when checked with a 3000 mm (10 foot) straightedge. No further finishing of this surface will be required.
F3b(6) Surface Smoothness Check

After completion of the curing period, the Engineer will check the bridge slab surface for trueness, using a 3000 mm (10 foot) straightedge for transverse checks and a 3000 mm (10 foot) rolling straightedge of the design used by the Department for longitudinal checks. At least two longitudinal checks will be made in each traffic lane and one check near each gutter. These checks will be made after the surface is swept clean and when it is free of all debris. The protective oil treatment, if required, shall not be applied until the trueness checks have been made.

If, as a result of the trueness checks, it is determined that corrective measures will be required, then the oil treatment shall not be applied until the corrective measures have been completed.

Surfaces that are outside of the specified tolerance in a 3000 mm (10 foot) straightedge shall be corrected as required by the following and to the extent approved by the Engineer. High spots shall be milled to the required grade. Concrete in low spots that has been designated for removal shall be removed a minimum of 50 mm (2 inches) below required grade and recast to the proper grade with an approved concrete mixture. In addition, any tining that has been removed shall be restored. Nonconforming areas that are not satisfactorily corrected as provided for herein shall be subject to 1503 and 1512.

Correction by surface grinding or filling will not be permitted where unsatisfactory results are anticipated, nor will such corrective work be allowed to continue when unsatisfactory results are being obtained. Surface grinding and filling, and the preparation of the surface prior to filling, shall be done in a manner approved by the Engineer, with the high spots being removed to the extent approved before any depressions remaining adjacent thereto are filled. Areas corrected by surface grinding to acceptable surface and thickness tolerances shall be coated with an approved surface sealer if a wearing course is not to be placed. Upon completion of the corrective work, the areas shall be acceptable in appearance or they will not be considered as being corrected satisfactorily.

F3b(7) Preparation of Bridge Seats

The bearing areas of bridge seats shall be power ground as necessary to produce a surface that does not vary more than 1.6 mm (1/16 inch) from the required plane for steel base plates or more than 3.2 mm (1/8 inch) for elastomeric bearing pads.

G Concrete Curing and Protection

Newly placed concrete shall be properly cured by providing protection against rapid loss of moisture, freezing temperatures, high temperatures, abrupt temperature changes, vibrations, shock waves, and prematurely applied loads. This protection shall be provided when
directed by the Engineer and for a period of time not less than that specified hereinafter, except as may be otherwise determined and permitted by the Engineer.

The curing time shall be that period of time starting with the completion of concrete placement for a specific section or unit and continuing without interruption until the Engineer has determined that the curing has been satisfactorily completed. For cast-in-place concrete the curing shall continue until the Engineer has determined that the concrete has attained a strength based upon a percentage of anticipated compressive strength given in 2461.3B2. This percentage shall not be less than that shown below for the specified sections or units to which it corresponds:

<table>
<thead>
<tr>
<th>Section or Unit</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Bridge superstructures, except as otherwise specified</td>
<td>65</td>
</tr>
<tr>
<td>Diaphragms and end webs that are not a part of box girders and are cast in advance of the bridge slab</td>
<td>45</td>
</tr>
<tr>
<td>Railing</td>
<td>45</td>
</tr>
</tbody>
</table>

When a permissible construction joint is shown, subsequent concrete placement may begin before the curing period has been completed, unless otherwise specified in the Plans.

Railing concrete shall not be subjected to loading (supporting screed rails, light standards, etc.) until the Engineer has determined that the concrete has attained strength not less than 60 percent of the anticipated compressive strength.

Heavy equipment (such as ready-mix trucks) will not be permitted on the bridge slab until after completion of the curing period. Then the equipment operation shall be in a manner that will minimize shock waves. Mixer revolution shall be restricted to agitation speed.

Equipment with gross mass exceeding 14 metric tons (15 tons) will not be permitted on the bridge slab for box girder and slab span bridges until one week after completion of the curing period.

Some modification of the requirement for continuous curing without interruption may be permitted by the Engineer for the purpose of setting wall or column forms on footings, but only when adequate provisions are made to protect the concrete from freezing or excessive drying during the interruption period. Curing shall be resumed at the earliest opportunity, and shall then be continuous until completion. When heated enclosures are used during the curing period, heaters and other equipment operated within the enclosure shall be vented to prevent the buildup of carbon dioxide.

In the event the curing period terminates during a time of the year when low temperatures will prevent additional strength gain before
opening a bridge to traffic, the curing time for bridge superstructure concrete shall be extended to provide for strength gain equal to 70 percent of its anticipated compressive strength.

Strength gain percentages shall be computed from the Strength Gain Chart in Table 2401-1, except that during freezing or anticipated freezing temperatures, the Engineer may require that the computed strength gain be verified by casting and breaking control cylinders in accordance with 2461.4A5. In the event of discrepancy between these two methods, the Concrete Engineer may be called upon for determination of curing adequacy.

**TABLE 2401-1**

<table>
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<th>Concrete Surface Temp. (B) °C (°F)</th>
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<tr>
<td>16 (60)</td>
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<td>3</td>
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<tr>
<td>7 (45)</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>5</td>
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<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4 (40)</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

*(A)* Table values indicate incremental strength gain for 24-hour periods at temperatures ranging from 4°C (40°F) to 24°C (75°F) when the concrete has previously accumulated a specific strength gain (percent).

*(B)* Represents temperature at the surface of the concrete for the section (or part section) being cured.

*(C)* Represents accumulative strength gain of structural grade concrete made with type I cement as a percentage of its compressive strength if cured 28 days at 24°C (75°F). Table 2401-1 may also be used for concrete mixtures containing up to 15% Class C fly ash as a cement substitution. Strength gain for concrete containing ground granulated blast furnace slag or cement substitutions except as noted above shall be determined by control cylinders.
EXAMPLE --- Average surface temperature for 24-hour period = 16°C (60°F). Previously recorded strength gain = 36 percent. Therefore, incremental strength gain = 9 percent; new accumulative total = 45 percent.

When control cylinders are used to determine if the minimum strength has been attained, in no case shall curing for cast-in-place concrete be considered completed in less than 96 hours for sections or units requiring a minimum of 65 percent of anticipated compressive strength or in less than 72 hours for sections or units requiring a minimum of 45 percent of anticipated compressive strength.

Strength gain shall not be credited for any period of time during which the concrete does not indicate the presence of a surface-moist condition, nor for any period of time when the temperature at the concrete surface is less than 5ºC (40ºF). In the event of exposure of the concrete to freezing temperatures or excessive drying during the curing period, the Engineer will declare the affected section, or partial section, to be defective. Depending on the extent of the damage caused by exposure, as determined by the Engineer, the affected section shall be:

(1) Removed and replaced,
(2) Removed to a depth specified by the Engineer and be replaced as directed,
(3) Sandblasted and overlaid with epoxy mortar or epoxy with sand broadcast,
(4) Covered by an epoxy seal coat,
(5) Subject to a reduction in payment as determined equitable by the Engineer, or
(6) Subjected to any combination of these remedies.

Anchor bolt holes and other depressions that may collect water shall, during periods of freezing temperature, be sealed or temporarily filled with closed cell polystyrene or other satisfactory material.

After completion of tine texturing for bridge deck slabs and after free water has disappeared from the surface, the Contractor shall apply a white pigmented linseed oil listed in the Special Provisions. The rate of application shall be approximately 4 m²/l (150 square feet per gallon) unless otherwise directed by the Engineer. The curing compound or emulsion shall be applied with approved power-operated spray equipment. The curing compound or emulsion is not a substitute for the cure specified below, but is required for moisture retention until the conventional curing material can be placed.
Bridge structural slabs shall have the conventional wet curing (wet burlap or curing blankets) applied as soon as the concrete can be walked on with insignificant damage.

Concrete exposed to a condition causing surface drying during the curing period shall be protected by a wet covering as soon as the set of the concrete will permit. Membrane curing compound will not be considered as an acceptable alternative for wet curing, except for such items as slope paving, footings and other sections that are to be covered with backfill material. Membrane curing compound shall not be used on an area that is to be covered by and bonded to subsequent concrete construction. The preferred method of wet curing is with commercially available blankets of burlap and plastic bonded together.

Regardless of the method used, a moist surface condition must be maintained. Plywood forms left in place during the curing period shall not be permitted to become excessively dry.

Materials used as an aid to the retention of moisture on the surface of the concrete shall conform to the appropriate material requirements of these Specifications. However, when two or more materials (such as Burlene® over curing compound) are used in combination, some deviation from the material requirements may be allowed, subject to approval of the Engineer. (In no event shall the use of an approved curing system relieve the Contractor of the responsibility for maintaining a moist surface condition throughout the curing period.

Only when all requirements specified herein have been fulfilled, as determined by the Engineer, shall the curing period be considered as having been completed.

**H  Slipforming of Bridge Railing**

The Contractor may slipform Type F railing using the following requirements, instead of using conventional forming methods.

**H1  Reinforcement Bars**

The Contractor shall not tack weld reinforcement bars but shall use additional tying to maintain the rigidity of the reinforcement bar cage.

Place reinforcement in accordance with the applicable requirements of 2472.

**H2  Concrete Mix**

The Contractor shall use 3Y16 concrete mix design in the slipformed railing. The Engineer will reject concrete with a slump of more than 30 mm (1 ¼ inches).

**H3  Construction Requirements**

The Contractor shall:

(a) Set the slipformer to the proper grade and alignment.
(b) Verify that the concrete placing equipment is operating properly.
(c) Check the clear distance from the slipform template to the
reinforcement bars in the presence of the Engineer. Attach the fill
strips or other approved devices to the slipformer during this check
as a means of detecting areas of reinforcement bars that might
encroach on the required concrete cover. Make this check for the
full distance that is anticipated to be placed in the subsequent pour,
less any areas of exceptions.
(d) Edge the joints with a small radius edger prior to placing the curing
materials.
(e) Saw-cutting the top portion of the joint to the full depth within 24
hours of the concrete placement to a width of 10 mm (3/8 inch)
with power saws mounted on a frame with guidance provisions.
(f) Seal the joint with an approved silicone sealer. The saw-cut portion
of the joint shall be sealed to a minimum depth of 25 mm (1 inch).
(g) Form the ends of the railing with securely braced conventional
forms with the guardrail plate securely bolted in place.
(h) Conventionally form the railing sections at exceptions (such as deck
drain box outs, light standards, and expansion joint devices) for a
minimum distance of 1200 mm (4 feet) on each side of the
exception.
(i) Maintain the Plan location of the gutter line or face of railing.
However, the Contract or may increase the slab overhangs up to
25 mm (1 inch) and batter the outside of the barrier or railing up to
25 mm (1 inch).
(j) Use either chamfer or radii strips at horizontal and vertical edges.
(k) Restrict the time interval for delivery of ready-mix concrete to no
greater than 1 hour when the air-entraining agent is added to the
mix at the central plant.
(l) Wet cure the railing in accordance with 2401.3G using
commercially available blankets of wet burlap and plastic bonded
together.
(m) Positively secure the curing material to the railing to prevent
moisture loss.

<table>
<thead>
<tr>
<th>I</th>
<th>Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>Joint and Crack Sealing</td>
</tr>
<tr>
<td>J1</td>
<td>Joint Sealing</td>
</tr>
</tbody>
</table>

Joint sealer material of the type specified in the Plans or Special
Provisions shall be placed in accordance with the applicable
requirements of 2301.3N. Furnishing and placing joint sealers shall be
incidental work for which no direct compensation will be made.

All construction joints and saw cuts in the deck, curb face,
sidewalk, and median shall be sealed with concrete joint sealer.
2401.3

J2 Crack Sealing

The Engineer will make a visual inspection of the bridge deck slab, including decks of pedestrian bridges, and will mark all cracks appearing on the top surface of the slabs. All cracks so marked shall be filled with an approved epoxy penetrant sealer prior to application of the treating oil. Application of the epoxy penetrant sealer shall be in accordance with the manufacturer’s recommendations except when otherwise directed by the Engineer.

Furnishing and placing the epoxy penetrant sealer as specified above will be considered to be incidental work for which no direct compensation will be made.

K Protective Oil Treatment

A protective oil treatment will be required on the upper surface of bridge deck slabs, including pedestrian bridges, medians and sidewalks, but will not be required on a separately poured concrete wearing course placed on a bridge structural slab. The treatment of medians and sidewalks shall include the roadway face of the curb, if a curb section is required. Unless other types of treating oil are specified or permitted by Plan or Special Provision, the treating oil shall meet the requirements of 3917, Type II. The treatment shall be made in two equal applications, totaling not less than 3 m²/L (14 square yards per gallon), as soon as conditions permit and when the concrete is clean and dry. The second application shall not be made until the concrete has absorbed the first. Drains shall be plugged when so directed.

Joint sealers shall be in place prior to treating with oil in these areas, and shall be protected during the applications.

2401.4 METHOD OF MEASUREMENT

A Structural Concrete

Measurement of structural concrete will be based on Plan dimensions with each grade or mix measured separately, and with no allowance made for excess quantity beyond the minimum dimensions specified.

Bridge slab concrete, when measured by area, will be based on end-of-slab stationing and out-to-out transverse dimensions of the slab. Sidewalk concrete, when measured by area, will be based on the end-to-end bridge dimension along the centerline of the sidewalk and the overall width of the sidewalk block. Raised median concrete, when measured by area, will be based on the end-to-end slab dimension and overall width of the median. Median barrier concrete measurement will be based on the end-to-end slab dimensions. Measurement of concrete railings or concrete bases for metal railing will be the horizontal lengths between the outside end faces of railings or end posts, whichever is applicable.
No deduction will be made in concrete quantities for the volumes displaced by metal reinforcement, structural steel sections, floor drains, conduits, pile headers, chamfer strips with side dimensions of 50 mm (2 inches) or less, or for variations in camber and deflections for that indicated in the Plans. No increase will be allowed for any extra concrete used to secure true conformity to the Plan requirements of the elevation profile and cross section in the finished roadway slab. Floor thickness shall be considered to be the thickness shown in the Plans as minimum thickness unless other dimensions are shown. Keyways shall not be considered when making quantity computations.

2401.5

**2401.5 BASIS OF PAYMENT**

Payment for structural concrete of each grade mix designated at the Contract prices per unit of measure will be compensation in full for all costs of constructing the bridge structure complete in place as specified, except for those costs that the Contract specifically designates as having been included for payment under separate items for which the Proposal contains specific unit prices.

If the Contractor elects to pour the concrete end diaphragms with the bridge slab, the concrete mix for the diaphragms may be the same as used for the slab, and payment will be made at the Contract bid price for end diaphragm concrete.

Payment for reinforcement bars, steel fabric, and spiral reinforcement, at the Contract prices per unit of measure, will be compensation in full for all costs of furnishing, fabricating, delivering, and placing the metal reinforcement as specified. When the Proposal contains separate items for “delivering” and “placing” reinforcement bars, payment at the delivered price will be compensation in full for all costs of furnishing, fabricating, and delivering the material to the job site, and payment at the placed price will be compensation in full for all costs of placing the material in the structure as specified.

Payment for structure excavation, soil bearing tests, and backfill materials will be made as provided in 2451.5.
### Payment for concrete bridge construction

Payment for concrete bridge construction will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Structural Concrete (Mix No.)</td>
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<td>2401.511</td>
<td>Structural Concrete (Mix No.)</td>
<td>square meter (square foot)</td>
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<tr>
<td>2401.512</td>
<td>Bridge Slab Concrete (Mix No.)</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2401.513</td>
<td>Type ____ Railing Concrete (Mix No.)</td>
<td>meter (foot)</td>
</tr>
<tr>
<td>2401.514</td>
<td>Median Barrier Concrete (Mix No.)</td>
<td>meter (foot)</td>
</tr>
<tr>
<td>2401.515</td>
<td>Sidewalk Concrete (Mix No.)</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2401.516</td>
<td>Raised Median Concrete (Mix No.)</td>
<td>square meter (square foot)</td>
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<tr>
<td>2401.521</td>
<td>Structure Excavation, Class ____</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2401.539</td>
<td>Reinforcement Bars Delivered</td>
<td>kilogram (pound)</td>
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<tr>
<td>2401.540</td>
<td>Reinforcement Bars Placed</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2401.541</td>
<td>Reinforcement Bars</td>
<td>kilogram (pound)</td>
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<tr>
<td>2401.542</td>
<td>Steel Fabric</td>
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<tr>
<td>2401.543</td>
<td>Spiral Reinforcement</td>
<td>kilogram (pound)</td>
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</tbody>
</table>
2402
Steel Bridge Construction

2402.1 DESCRIPTION
This work shall consist of the erection of those portions of bridges and structures that are made of structural steel and miscellaneous metals.

2402.2 MATERIALS
A  Structural Metals ......................................................  2471
B  High Strength Bolts, Direct Tension Indicators, and Pin Bolts .............................................................  3391
C  Elastomeric Bearing Pads ........................................  3741

2402.3 CONSTRUCTION REQUIREMENTS
A  General
A1  Structural Steel Components of Concrete Bridges .....  2401
A2  Steel Piling .................................................................  2452
A3  Assembly
   The Contractor shall assemble all bridge components according to the erection Plans and match markings. Assembly shall be in accordance with the procedures outlined in the Contract. Where no specific procedures are specified, assembly shall be in accordance with recognized practices and as indicated on the approved shop detail drawings.
B  Handling and Storage of Materials
   Girders and beams shall be stored in an upright position, and all materials shall be kept clean and properly drained. Members stored for longer than 3 months shall be covered or sheltered, with provisions for air circulation, in a manner that will protect them from the elements.
C  Straightening Bent Materials
   The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other damage. The metal shall be heated only when permitted by the Engineer, in which case the heating shall not be to a higher temperature than 650°C (1200°F).
   After heating and straightening, the metal shall be slowly cooled and be inspected for evidence of fracture or other damage. Galvanized and metallized coating shall be repaired as provided in 2471. The Engineer will reject any members not satisfactorily repaired.
D  Falsework Design and Construction
   At least six weeks before starting construction of the structural steel erection falsework, the Contractor shall supply the Engineer with three copies of the detailed Plans and Specifications and two copies of the associated calculations of the proposed system for constructing the falsework. Design of the falsework and forms shall be in accordance with AASHTO Guide Design Specifications for Bridge Temporary...
Works". The Plans and Specifications shall be prepared by an Engineer, thoroughly checked by a second Engineer for completeness and accuracy, and certified by a professional Engineer licensed in the State of Minnesota. The documents shall include sufficient details so that construction of the proposed system can be completed solely by reference to the Plans and Specifications. The design criteria shall be shown on the first sheet of the Plans.

As a minimum, falsework plans shall contain the following:

1. The size of all load-supporting members and all transverse and longitudinal bracing. Connection details for load-supporting members must be included.

2. All design-controlling dimensions must be shown, including beam length and spacing; post location and spacing; overall height of falsework bents; vertical distance between connectors in diagonal bracing; and similar dimensions that are critical to the design.

3. The location and method by which the falsework will be adjusted to final grade must be shown.

The Contractor will not be permitted to erect the structural steel until (1) Plans and Specifications meeting the above requirements have been provided to the Engineer; (2) the Engineer who has certified the plans and specifications for the falsework and forms has inspected the falsework after erection; and (3) the engineer inspecting the as-constructed falsework certifies in writing that all details are approved.

Timber used for falsework piles or members shall be of sound wood, straight, and in good condition. Steel members shall be straight and of adequate strength for the use intended.

Falsework shall remain in place until the field connections have been or bolted to the extent that release of falsework supports is approved by the Engineer that designed the falsework, and the removal of falsework shall be governed by the applicable provisions of 2401.

Except for attachment of screed rail support pipes, no welding will be permitted on primary stress-carrying members of the bridge structure for the purposes of fastening any appurtenances not shown in the Plans or on the approved detail drawings. Screed rail support pipes may be welded to the top flange with 6 mm (¼ inch) longitudinal fillet welds not exceeding 50 mm (2 inches) in length. No welding of any kind will be permitted in the negative moment area (designated in the Plans as Area "A") of the top flange of primary stress-carrying members of the bridge structure.

Base metal preparation and ambient weather conditions during welding shall conform to 2471.3F.
E  Preparation and Erection

Before bearing plates and shoes are placed, the concrete surfaces upon which they will rest shall be prepared by methods acceptable to the Engineer, so as to provide uniform bearing surface.

Immediately before assembly, all temporary protective coatings shall be removed from pins and pin holes, and the contact surfaces at connections shall be cleaned of all foreign matter. Where pin holes are provided with bronze bushings, the areas of contact between the pins and bushings shall be cleaned to bare metal before assembly.

The required painting on surfaces that will be inaccessible after erection shall be completed before fit-up.

F  Field Fit-up

Structural steel members shall be erected in a manner that will provide safety to the workers, inspectors, and the public at all times, as well as reasonable assurance against damage to the members. The primary members, such as beams and girders, shall be temporarily anchored and braced as they are erected, so as to preclude movement or creep in any direction, and so as to prevent tipping and buckling. Struts, bracing, tie cables, and other devices used for temporary restraint shall be of a size and strength that will ensure their adequacy.

Simple spans shall be "fully assembled" before starting permanent bolting. On continuous spans, permanent bolting on a span in the continuous series shall not be started until the immediately adjacent spans in the same series have been "fully assembled". The term "fully assembled" means assembly of all transversely interconnected beams and girders, diaphragms, and floor beams, but not necessarily stringers, expansion devices, or other members that have no significant effect on the main structural members or that have independent means for adjustment. The Engineer may allow permanent bolting of field splices in beams for continuous spans on the ground prior to "full assembly" of adjacent spans, provided beams to be spliced are positioned on firm supports adjusted to provide the correct alignment, camber, grade, and skew shown in the Plans.

Splices in primary stress-carrying members shall have one-half of the holes filled with erection pins and bolts (half bolts and half pins with balanced distribution) prior to placing the permanent connectors. When live loads are to be carried by these members during erection, additional bolts and erection pins shall be used as required to compensate for the additional loads. Connections for diaphragms and other secondary members shall have a sufficient number of holes filled with erection pins and bolts so that the plates are drawn into full contact and so that the holes are properly matched prior to placing the permanent connectors.
Pins and pinholes, including pinholes having bronze bushings, shall be coated with an approved heavy duty grease prior to assembly.

Erection bolts shall be of the same diameter as the permanent connectors. Erection pins shall not be larger than the diameter of the hole and in no case shall they be smaller than the hole diameter minus 1 mm (1/32 inch). Erection washers shall generally be used with erection bolts.

Pin nuts shall be drawn tight, except those with cotter keys, and the exposed thread at the face of the nut shall be upset by centerpunching to prevent backoff. Pin nuts with cotter keys shall be tightened only to the extent that the cotter key can be freely inserted and the pin is free to turn without binding under the Lomas nut.

When the required section has been fully assembled, it shall be referred to the Engineer for approval before proceeding with placement of permanent connectors. Vertical adjustments shall be made at splice points as directed by the Engineer, based on elevations taken at these points. Shifting of the spans may be required to provide for proper anchorage and expansion device locations.

Bearing plates and assemblies shall be checked for contact prior to placement of the permanent connectors, and any deviations from full bearing between parts, or between the bridge seat and the bearing plates, shall be corrected in a manner satisfactory to the Engineer. Major deviations may require readjustment of diaphragms, cross frames, splice plates, recambering, or other refabrication procedures. Minor deviations may, with approval by the Engineer, be corrected by the use of properly shaped and sized fills or shims.

G Permanent Connections

Permanent field connections shall, unless otherwise specified in the Contract or permitted by the Engineer, be made using high strength bolts, or pin bolts, at the Contractor's option. The same type fastener shall be used throughout the structure except as otherwise permitted by the Engineer.

G1 Welded Connections

All field connections to be made by welding shall be performed in conformance with the quality requirements of 2471. All field welders are required to pass the Mn/DOT Welder Qualification Test.

G2 Connections Using High Strength Bolts

G2a General

Bolts shall be installed with their heads outward for the webs of fascia girders, and with their heads downward for the flanges of beams and girders spanning highways, streets, roadways, and walkways.
Bolted Parts

The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled, and shall not be separated by gaskets or any other interposed compressible material.

When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of dirt, loose scale, burrs, other foreign material, and other defects that would prevent solid seating of the parts. In addition, contact surfaces of friction-type joints shall also be free of coating materials such as oil, galvanizing, and rust inhibitors.

Installation

Bolt Tension

At the time of installation, threaded portions of bolts and nuts shall be free of dirt and corrosion, lubricated and dyed as per 3391. If dirty or corroded, threads shall be cleaned prior to installation.

Threaded bolts shall be tightened by the turn-of-nut or direct tension indicator methods. If required because of bolt entering and wrench operation clearances, tightening by either procedure may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in the following tabulation for the size of fastener used:

<table>
<thead>
<tr>
<th>TABLE 2402-1</th>
<th>BOLT TENSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt Size mm (inches)</td>
<td>Minimum Tension (A) KN (Kips)</td>
</tr>
<tr>
<td>19 (¾)</td>
<td>125 (28)</td>
</tr>
<tr>
<td>22 (7/8)</td>
<td>173 (39)</td>
</tr>
<tr>
<td>25 (1)</td>
<td>227 (51)</td>
</tr>
<tr>
<td>29 (1-1/8)</td>
<td>249 (56)</td>
</tr>
<tr>
<td>32 (1 ¼)</td>
<td>316 (71)</td>
</tr>
</tbody>
</table>

(A) Equal to the proof load (length measurement method) given in ASTM A 325.

Washers

All fasteners shall have a hardened washer under the element (nut or bolt head) that is turned during tightening.
High strength bolts used in conjunction with full sized punched holes shall have one hardened washer under both the bolt head and the nut.

Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

G2c(3) Direct Tension Indicator (DTI) Tightening.

When direct tension indicators are used to provide the required bolt tension, installation of the indicators, including snug tight fit-up, shall be in accordance with the manufacturer's recommendations except that the DTI should be placed under the non-turned end of the fastener. Compressible washer-type indicators shall meet the requirements of ASTM F 959. Inspection shall be in accordance with manufacturer's recommendations, except that a device that can accurately measure deformation of the direct tension indicator shall be able to be inserted into at least one space between the protrusions.

G2c(4) Turn-of-Nut Tightening

There shall first be enough bolts brought to a "snug tight" condition to ensure that all parts of the joint are brought into full contact with each other. "Snug tight" is defined as plates in firm contact achieved by a few impacts of an impact wrench or the full effort of an adult using an ordinary spud wrench. Following the initial operation as specified in 2402.3F, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All nuts and bolts shall be match marked and then be tightened additionally by the applicable amount of nut rotation specified herein after, with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

For coarse thread heavy hexagon structural bolts and heavy hexagon semi-finished nuts, nut rotation from snug-tight condition shall be in accordance with the following:

(a) When both faces are normal to bolt axis (with or without use of beveled washers), nut rotation shall be one-third turn for bolt lengths equal to 4 diameters or less, one-half turn for bolt lengths greater than 4 diameters but not exceeding 8 diameters, and 2/3 turn for bolt lengths exceeding 8 diameters but not exceeding 12 diameters.

(b) When one face is normal and the other is sloped not more than 1:20 (beveled washers not used), nut rotation shall be one-half turn for bolt lengths equal to 4 diameters or less, two-thirds turn for bolt lengths greater than 4 diameters but not exceeding 8 diameters, and
5/6 turn for bolt lengths exceeding 8 diameters but not exceeding 12 diameters.

c) When both faces are sloped not more than 1:20 (beveled washers not used), nut rotation shall be two-thirds turn for bolt lengths equal to 4 diameters or less, five-sixths turn for bolt diameters greater than 4 diameters, but not exceeding 8 diameters and, one turn for bolt lengths exceeding 8 diameters but not exceeding than 12 diameters.

Bolt length shall be measured from underside of head to extreme end of the bolt. Nut rotation is rotation relative to bolt regardless of the element (nut or bolt) being turned. Allowable tolerance in nut rotation shall be one-sixth turn over and nothing under.

G2d  Inspection

The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are tightened to the specified tension. The following inspection procedure will be used in testing bolt tension unless a more extensive or different procedure is specified.

G2d(1) Calibration of Inspection Wrench

The inspection wrench shall be a manual wrench that shall be accurately calibrated as follows:

Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly. Frequency of testing shall be three assemblies per combination. Bolts of the same grade, size, and condition, as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. There shall be a washer under the part turned in tightening each bolt. Test bolts shall be the same length as the bolts used in the structure.

Each test bolt shall be tightened in the calibration device by any convenient means to an initial condition equal to approximately 15 percent of the specified bolt tension and then to the minimum tension specified for its size as given in Table 2402.1. The inspecting wrench shall then be applied to the tightened bolt and the torque necessary to turn the nut or head five degrees (approximately 25 mm at 300 mm (1 inch at 12 inch) radius) in tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the "job-inspecting torque" to be used in the manner specified in 2402.3G2d(3).

The Contractor shall furnish the inspection wrench and the bolt tension-indicating device required by these Specifications. The Engineer shall have full opportunity to witness the prescribed calibration tests.
2402.3

During the calibration procedure specified in 2402.3G2d(1), the bolt and nut shall withstand rotation to two times the required number of turns required by 2402.3G2c(4) without visible stripping of threads or failure of either bolt or nut.

G2d(2) Inspection Procedure for Calibrated Wrench

Either the Engineer, or the Contractor in the presence of the Engineer, at the Engineer's option, shall operate the inspecting wrench as follows:

(a) The tightened bolts in the structure shall be inspected by applying, in the tightened direction, the inspecting wrench and its job-inspecting torque to 10 percent of the bolts, but not less than two bolts, selected at random in each connection.

(b) If no nut or bolt head is turned by this application of the job-inspecting torque, the connection shall be accepted as properly tightened. If any nut or bolt head is turned by the application of the job-inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job-inspecting torque shall be tightened and reinspected; or alternatively, the Contractor may retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

G2d(3) Inspection Procedure for Direct Tension Indicators (DTI)

The performance of the DTIs should be checked in the field before the start of bolting.

The gap is used to indicate the tension in the bolt.

Either the Engineer, or the Contractor in the presence of the Engineer, at the Engineer's option, shall operate the tapered leaf thickness (feeler) gage as follows:

(a) An initial visual inspection of the DTIs should occur after all the bolts have been brought to a snug tight condition. No DTI should be completely crushed during snugging. If this occurs the DTI should be removed and replaced.

(b) The tightened bolts in the structure shall be inspected by placing a feeler gage into 10% of the DTIs, but not less than two DTIs, selected at random in each connection. The gap between the washer and the bolt head is measured in the spaces between the protrusions. The bolt is tightened to 1.05 times the required installation tension and the gap is measured using a tapered leaf thickness (feeler) gage. The average gap should equal or exceed 0.125 mm (0.005 inches) for coated DTIs. Tightening beyond crushing of the protrusion should not be allowed.
G3 Connections Using Pin Bolts

Pin bolts shall be installed in conformance with 2402.3G2a and 2402.3G2b, together with the following requirements:

The driving of the pin bolts shall be done by the use of a special driving tool capable of partial swaging of the collars to allow for some adjustment during erection when the pinning and bolting work is performed. The tool shall be capable of producing the required tension in the bolt, and shall be capable of swaging the collar into the annular locking grooves, forming the collar into the proper size and shape as recommended by the manufacturer, before the pin tail breaks.

The pin bolts will be tested prior to use in a device (furnished by the Contractor) capable of indicating actual bolt tension. Not less than three typical bolts of each size and length shall be furnished for tests from the supply of bolts that will subsequently be used in the work. Other bolts may be tested during the bolting operation as directed by the Engineer. The same installation tool that will subsequently be used for tightening and swaging the bolts for the field connections shall also be used for applying tension in the bolts during the testing procedure.

The expendable pin tails shall be recovered from the driving tool as it breaks from the bolt, and shall not be permitted to drop in such a manner as to create a hazard.

The procedure for testing and the installation of pin bolts shall meet with the approval of the Engineer.

H Setting Anchor Bolts

Holes for anchor bolts shall be drilled, except when the Contract specifies otherwise. The bolts shall be accurately set and fixed with Portland cement grout completely filling the holes, except that during freezing weather other products approved by the Engineer may be used.

Nuts for anchor bolts shall be set as indicated in the Plans, providing for clearance where required. The bolt thread at the face of the nuts shall be upset by center punching to prevent back-off.

Anchor bolts that are cast in the concrete shall be accurately set to proper location and elevation with templates.

I Blank

J Bearing Assemblies and Hangers

Rocker bearings and hangers shall be plumb at 7°C (45°F). Elongation resulting from total load deflection shall be considered when setting these devices.
2402.3

K Expansion Joint Devices

Expansion joint devices will be designated by type as given in the item name. The type number denotes the minimum movement capability, in millimeters (inches), required of the device to be installed at a given location. Maximum movement capability may range up to 50 percent greater than the minimum specified.

Shop detail drawings shall be furnished for all expansion joint devices in accordance with 2471.3B. The drawings shall include detailed instructions for installation and tabulated joint openings for various temperatures.

Joint devices having movement capability exceeding 50 percent of the specified minimum, may be approved for use, provided that the functional requirements are met and the shop drawings indicate the sizes being proposed.

Steel components of expansion devices shall be furnished in lengths that will facilitate installation under roadway and traffic conditions existing at the time of placement. Splices in the gland will not be permitted except where necessary at "tee" intersections where vulcanized splices are required. Welded gutter sections shall be smooth faced at the grip surface.

All structural steel surfaces of the expansion devices, including anchorages, shall be galvanized after fabrication in accordance with 3394. Bolts for roadway sections of the expansion devices shall meet the requirements of 3391.2E, Type 316. Bolts for curb, sidewalk, median, and barrier cover plates shall be stainless steel conforming to 3391.2E, Type 316, or shall be galvanized in accordance with 3392. Steel extrusions and roadway plates shall be straightened after galvanizing to meet a tolerance of 3 mm in 3 m (1/8 inch in 10 feet).

Expansion devices shall be installed in accordance with the details and instructions provided by the shop drawings and as directed by the Engineer. All joint-forming material shall be removed from the joint opening.

The complete expansion joint installation shall be watertight at all points and shall be so tested by filling the joint opening, or portions thereof, as designated by the Engineer, with water and observing the results over a period of not less than 1 hour.

L Field Painting

After all erection work has been completed, structural metals shall be cleaned and painted in accordance with 2478 or 2479, whichever is applicable.

2402.4 METHOD OF MEASUREMENT

Structural metals placed in bridges or other structures will be measured by mass, length, area, or unit complete in place.
A  Mass
The mass of all structural steel shapes and plates and of all steel sheets and bars will be computed on the basis of the net finished dimensions shown in the Plans using the theoretical density of 7849 kg/m³ (490 pounds per cubic foot). No allowance will be made for the fabrication of girder cambers, haunches, and sweeps, nor for the machining of surfaces. No deductions will be made for open holes and incidental bevels or chamfers. The summation of these masses, exclusive of steel piling, will be increased by 1.5 percent to compensate for incidental metal items such as: permanent bolts 150 mm (6 inches) or less in length, shop or field high strength bolts, field shims, weld metal deposits, extra material used to make weld procedure tests, shop galvanizing, metallizing, overruns, etc., for which no direct mass measurements are made.

The mass of bolts over 150 mm (6 inches) long and tie rods that are used for connecting structural steel parts, including nuts and washers, will be computed from the nominal mass as given in the AISC Manual of Steel Construction and will be included in the mass of structural steel.

The mass of non-incidental metals other than steel will be computed from the theoretical densities as given in the AISC Manual of Steel Construction using the above measurement limitations, except that no measurement will be made of any bolts, nuts, rivets, washers, or shims used in the fabrication and erection, and that a percentage increase in mass therefore shall not apply.

B  Length
B1  Metal Railing
Unless other limits are shown in the Plans, the length will be the summation of the lengths of the various sections shown in the Plans, measured at the base of the rail.
B2  Pipe
Unless other limits are shown in the Plans, the length will be the summation of the lengths of all the runs, measured on the centerline of the pipe and fittings.
B3  Expansion Joint Devices
Expansion joint devices of each type will be measured separately by length based on the out-to-out distance along the centerline of each expansion device.
B4  Other Items
Linear measurement of other items not specifically covered herein will be made between the limits shown in the Plans.
2402.4

C Area

Unless other limits are shown in the Plans, the area will be computed on the basis of net finished dimensions. No deduction will be made for open holes.

D Complete Unit

The unit will be construed to be the complete assembly of all its component parts.

2402.5 BASIS OF PAYMENT

The cost of providing temporary support and restraint, as specified in 2402.3F, shall be included in the Contract unit price bid for the particular structural steel item.

Payment for structural metals at the Contract price per unit of measure will include the mass of all structural metals in a single total.

Payment for item 2402.532, Furnishing Structural Steel, (Spec. No.) at the Contract price therefore, will be compensation in full for all costs of: (a) furnishing and fabricating, in accordance with 2471; (b) surface preparation and shop coat painting, unless otherwise specified in the Contract, in accordance with 2478, or 2479, whichever is applicable; and (c) delivering, in accordance with the Contract, the materials included in this item.

Payment for item 2402.533, Erecting Structural Metals, at the Contract price therefore, will be compensation in full for all costs of erecting the structural metals complete in place as specified, and for all required field coat painting in the absence of a Contract item therefor.

Payment for item 2402.521, Structural Steel (and other ferrous metals included therein), at the Contract price therefore, will be compensation in full for all costs of: (a) furnishing and fabricating, in accordance with 2471; (b) surface preparation and shop coat painting, unless otherwise specified in the Contract, in accordance with 2478 or 2479, whichever is applicable; and (c) delivering and erecting, in accordance with the provisions herein, all materials included in this item.

Payment for metal railings at the Contract price per unit of measure will be considered to include compensation for coating, metal posts, fittings, castings, anchor bolts, and all other accessories required for the erection.

Payment for expansion joint devices of each type at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing the devices complete in place as specified, including curb, sidewalk, median, and barrier sections, together with all required coverplates and any waterproof glands.
Payment for elastomeric bearing pads or assemblies of each type specified at the Contract prices therefore will be compensation in full for all costs of furnishing and installing the pads or assemblies complete in place.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
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<tr>
<td>2402.521</td>
<td>Structural Steel, (Spec. No.)</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2402.532</td>
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<td>Floor Drain, Type ___</td>
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<tr>
<td>2402.555</td>
<td>Rigid Steel Conduit</td>
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<tr>
<td>2402.560</td>
<td>Metal Pipe (Spec. No.)</td>
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<tr>
<td>2402.584</td>
<td>Structural Tube Railing Design</td>
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</tr>
<tr>
<td>2402.585</td>
<td>Pipe Railing</td>
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<td>Plate Railing</td>
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<td>Elastomeric Bearing Pad, Type ___</td>
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<td>2402.591</td>
<td>Expansion Joint Devices, Type ___</td>
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<tr>
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<td>Elastomeric Bearing Assembly, Type ___</td>
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<td>Bearing Assembly</td>
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<tr>
<td>2402.599</td>
<td>Structural Metals</td>
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</tbody>
</table>

2403

Timber Bridge Construction

2403.1 DESCRIPTION

This work shall consist of the construction of those portions of bridge structures that are made of timber.

2403.2 MATERIALS

A Timber

A1 Stress-rated Timber and Lumber

The Contractor shall use stress-rated timber and lumber meeting 3426 for the grade specified.

The Contractor shall use lumber for laminating that is graded according to 3426 with allowable working stress values and/or base resistance values as shown in the Contract, and which conforms to ANSI/AITC A190.1

A2 Timber Piling | 3471
A3 Other Lumber | 3457

B Preservative Treatment

All timber shall be preservative treated in accordance with 3491 unless untreated timber is specified in the Contract.
2403.2

C  Adhesives
   The Contractor shall use adhesives that meet the requirements for
   wet-use (waterproof) according to ANSI/AITC A 190.1.

D  Dowels
   The Contractor shall use hot rolled 3306 steel that is galvanized
   according to 3394.

E  Blank

F  Plank for Laminated Floors
   The strips shall be surfaced on one side (S1S) to a uniform
   thickness of not more than 75 mm (3 inches). Unless so specified in the
   Plans, surfacing to uniform width will not be required.
   At least 50 percent of the strips shall be 5 m (16 feet) or more in
   length. No strips, except as may be necessary to fill skews, shall be less
   than 2 m (6 feet) long. Other lengths shall be such that no joints will
   occur over any one stringer closer than each third strip.

G  Blank

H  Railings
   Timber and lumber for railings shall be especially selected to secure
   material free from blemishes that detract from the appearance of the
   finished work, and shall be surfaced on 4 sides (S4S).

I  Blank

J  Hardware
   All hardware, including nails, spikes, and timber connectors, shall
   be galvanized after fabrication in accordance with 3392.
   Bolts shall conform to 3391.2C unless otherwise shown or noted in
   the Plans.
   Driftbolts, lag screws, and rods shall conform to 3306 for incidental
   items. Driftbolts shall have counter-sunk heads and chisel points.
   Plate washers shall be properly proportioned to develop the full
   strength of the bolt. Unless otherwise shown in the Plans, the diameter
   of the washer or the minimum side dimension of a square washer shall
   be at least 3.5 times the diameter of the bolt, and its minimum thickness
   shall be equal to 0.5 of the diameter of the bolt. Washers for bolts less
   than 12 mm (½ inch) in diameter may be cut from medium steel plate.
   Timber connectors shall be standard manufactured products, of the
   size and type specified in the Plans.

2403.3  CONSTRUCTION REQUIREMENTS

A  General
A1  Cutting and Framing
   All cutting, framing, and boring of treated timber shall, so far as
   possible, be done before treatment.
Nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep or frequent hammer marks in exposed wood surfaces shall be considered evidence of poor work quality and may be cause for rejection of the piece or member.

B  Blank
C  Handling and Storage

Timber shall be handled, transported, and stored by methods that will not be detrimental to any portion that will remain in the completed structure. Care shall be exercised to avoid splitting or damaging the surfaces and edges, and in the case of treated timber, to avoid puncturing the treated surface by the use of pointed tools, temporary bolts, or spikes.

D  Framing

D1  General

Lumber and timber shall be accurately cut and framed, true and exact to a close fit, in such a manner that the joints will have even bearing over the entire contact surfaces. No shimming will be permitted in making joints, nor will open joints be accepted.

D2  Holes in Untreated Timber

Holes for the following types of hardware shall be bored and shall have the diameters specified below:

- For round driftbolts and dowels, 2 mm (1/16 inch) less than the diameter of the bolt or dowel; for square driftbolts or dowels, equal to the least dimension of the bolt or dowel; for machine bolts, the same diameter as the bolt; for rods, 2 mm (1/16 inch) greater than the diameter of the rod; for lag screws, not larger than the body of the screw at the root of the thread.

D3  Holes in Treated Timber

All holes bored in timber after treatment shall be 2 mm (1/16 inch) larger than specified above for holes in untreated timber.

E  Field Treatment

All field cuts (except pile cut-offs), daps, field bored holes, and abrasions in treated piles and timbers shall be carefully trimmed and coated with at least two applications of copper naphthenate or another compatible preservative material meeting AWPA Standard M4, with a minimum time lapse of 2 hours between application.

After cut-off, the tops of all treated timber piles used in timber bridge construction shall be treated in accordance with 2452.3F.

F  Piling

Concrete pedestals, where required for the support of framed bents, shall be carefully finished so that the sills or posts will take even bearing on them. Dowels for anchoring the sills shall project not less
than 225 mm (9 inches) above the tops of pedestals and shall be set during the casting of pedestals.

Sills shall have true and even bearing on piles or pedestals. They shall be drift-bolted to the piles, with the bolts extending into the piles not less than 225 mm (9 inches). When possible, all earth shall be removed from around the sills so that there will be free air circulation around them.

Posts shall be fastened to sills by dowels extending not less than 150 mm (6 inches) into the posts and sills.

**H Caps**

Timber caps shall be placed so as to obtain an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps, except wing pile caps, shall be secured by driftbolts extending not less than 225 mm (9 inches) into the posts or piles. The driftbolts shall be located approximately in the center of each post or pile.

**I Blank**

**J Bracing**

The bracing shall be fastened to the pile or post and cap using bolts of not less than 20 mm (¾ inch) diameter in tandem with split or tooth ring connectors. Intermediate intersections shall be bolted and spiked with wire spikes, boat spikes, or spike grid connectors, as indicated in the Plans.

**K Stringers and Bridging**

Stringers shall be sized at bearings. Stringers that are one panel in length shall be so placed that knots near the edges will be in the top portion of the stringers. Stringers that are two panels in length shall be so placed that knots near the edges will be in the compression edges and that lapped joints will be staggered over the supports.

Outside stringers shall have butt joints, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. Toenailing or bolting, as specified, shall securely fasten the lapped ends of stringers.

Cross bridging members shall be neatly and accurately framed with bevel cut ends. When placed, they shall have full bearing at each end against the sides of stringers and shall be securely held by at least two nails at each end. The cross bridging shall be set before placing the floor. The top ends shall be tightly set and the nails driven "home", the lower ends being nailed only enough to hold the bridging in place. After all the floor and wearing surface is in place, the lower ends of cross bridging shall be readjusted, drawn tight to the face of the stringers, and fully nailed as required.
Block or header bridging shall be placed before laying the subfloor. The blocks shall be fully nailed at the top and only temporarily nailed at the bottom. After the entire floor is in place, the nailing of the bridging shall be completed. When the Plans require bolts or lag screws to fasten block bridging, the final tightening of the bolts or lag screws shall be deferred until the entire floor is placed. Block bridging shall be cut square and to accurate length to avoid need for shims. If end shims are necessary, they shall be of zinc or galvanized sheet steel. Shims shall be of the size of the end of the block, with sufficient additional width to permit nailing along one side of block. Shims shall be held in place by means of galvanized roofing nails.

Unless otherwise indicated in the Plans, cross bridging shall be placed at the center of each span.

N  Prefabricated Timber Panels

The Contractor shall ensure that nail or glue laminated timber panels for use in bridge superstructures are fabricated and installed in accordance with the following:

N1  Nail Laminated Panels

The Contractor shall ensure that the following sequence is followed:

1. Cut individual timber members for use in the panels to proper length and drill all dowel holes.
2. Treat members with preservative.
3. Fabricate members into panels.

The Contractor shall have the panels fabricated according to Plan details and fully assembled at the fabrication plant before delivery to the Project. The panels shall be match-marked before shipment. Tolerance on panel length shall be 3 mm (1/8 inch) and on width shall be such that when installed the overall deck width is within 6 mm (\(\frac{1}{4}\) inch) of Panels Plan dimension.

N2  Glued Laminated Deck Panels

The Contractor shall ensure that glued laminated deck panels are fabricated and installed in accordance to these requirements, the Plans, and ANSI/AITC A 190.1, American National Standards for Wood Products - Structural Glued Laminated Timber. Shop details shall be furnished and approved in conformance to 2471.3B before fabrication work is begun.

N2a Appearance Grades

The panels shall be surface finished to the AITC Industrial Appearance Grade except that the roadway surface of the panels need not be finished. Individual planks shall be placed in a manner that will achieve the maximum corrugation on the roadway surface.
2403.3

N2b Dowel Holes
All dowel holes shall be drilled 2 mm (1/16 inch) greater in diameter than the dowel and 12 mm (½ inch) deeper than necessary to provide the planned dowel projection before the preservative treatment process.

N2c Marking and Protection
The panels shall be match-marked before shipment. The panels shall not be end sealed, surface sealed, or wrapped.

N2d Preservative Treatment
The Contractor shall ensure that the following sequence is followed:
(1) Fabricate the panels.
(2) Thoroughly remove all excess glue from all surfaces of the panels, except on the roadway surfaces.
(3) Treat with preservative.

N2e Inspection ................................................................. 3491.3
The Contractor shall have the independent commercial inspection agency verify conformance with the above requirements by providing an approval certification mark on each panel and a Certificate of Compliance including the test results.

N2f Assembly
The Contractor shall verify dowel projection and conformance with plan dimensions at the project site prior to assembly.

O Blank
P Blank
Q Blank
R Railings
Railings shall be accurately framed in accordance with the Plans, and special care shall be used in erection to secure true lines.

S Hardware
Driftbolts shall be placed in the structure with the chisel point at right angles to the grain of the unbored section of the timbers connected.

Plate washers shall be used for all bolts 12 mm (½ inch) in diameter or larger, unless special bolt heads and nuts that provide equivalent bearing surface and strength are used.

Timber connectors shall be of the type specified in the Plans. The split ring and the shear plate shall be installed in precut grooves of the dimensions as shown in the Plans or as recommended by the manufacturer. The toothed ring and the spike grid shall be forced into the contact surfaces of the timber joint by means of pressure equipment. All connectors of this type at a joint shall be imbedded simultaneously and uniformly. The claw plate shall be installed by a combination of both methods, partially by precut grooving and partially by pressure.
2403.4 METHOD OF MEASUREMENT
A Treated or Untreated Timber
The Department will measure treated timber and lumber and untreated timber and lumber separately by the unit of measure based on nominal sizes and lengths incorporated in the structure. No allowance will be made for waste except beveled ends.

The Department will measure panels by the number of acceptable units of each type furnished and installed. Panel hardware is included in this item.

B Hardware
The Department will measure hardware by mass only if a pay item for hardware is included in the Contract. The Department will not include the mass of nails, dowels, or panel hardware in quantities for payment.

2403.5 BASIS OF PAYMENT
The Department will make payment for each item at the Contract price per unit of measure as full compensation for all costs of manufacturing, transporting, and installing the item.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2403.501</td>
<td>Untreated Timber</td>
<td>cubic meter (Mbm*)</td>
</tr>
<tr>
<td>2403.502</td>
<td>Treated Timber</td>
<td>cubic meter (Mbm*)</td>
</tr>
<tr>
<td>2403.506</td>
<td>Hardware</td>
<td>kilogram (pound)</td>
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<tr>
<td>2403.508</td>
<td>Prefabricated Timber Panels, Type ___</td>
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</tr>
<tr>
<td>2403.510</td>
<td>Glued Laminated Deck Panels, Type ___</td>
<td>each</td>
</tr>
</tbody>
</table>

* Means 1,000 Board-Feet Measure
Concrete Wearing Course for Bridges

2404.1 DESCRIPTION
The work shall consist of constructing a Portland cement concrete wearing course on a bridge structural slab or approach panel.

2404.2 MATERIALS
The wearing course shall be composed of a 50 mm (2 inch) minimum depth low slump concrete course produced in accordance with the following unless the plan requires or allows a latex modified concrete wearing course:

A  Latex Modified Concrete
A1  Portland Cement, Type I or Type IA ......................... 3101
   The Portland cement shall be of recent manufacture and free of lumps. When mixed with the other ingredients, the mixture shall have between 3.5 and 6.5 percent entrained air as determined in accordance with AASHTO T 152.
A2  Fine Aggregate .................................................... 3126
A3  Coarse Aggregate, Class A, Gradation CA70 ............. 3137
A4  Formulated Latex Modifier
   The formulated latex modifier shall be a nontoxic, film forming, polymeric emulsion to which all stabilizers have been added at the point of manufacture, and shall be homogeneous and uniform in composition. The latex modifier shall be of approved manufacture as listed in the Special Provisions.
   The latex modifier shall conform to the following requirements:
   Polymer Type .......................................................... Styrene Butadiene
   Stabilizers, Latex .................................................. Nonionic Surfactants
   Portland Cement Composition ................................. Poly Dimethyl Siloxane
   Percent Solids ......................................................... 46.0 - 49.0
   Density at -4°C (25°F) .................. 1.0 kg/L (8.4 pounds per gallon)
   Shelf Life ............................................................... 2 years minimum
   Color ........................................................................ White
   Suitable precautions shall be taken to protect latex modifier from extreme heat or cold. Latex modifier shall be stored in suitable enclosures that will protect it from prolonged exposure to temperatures above 29°C (85°F). Drums of latex modifier may be stored at the bridge site in direct sunlight for a period not to exceed 10 days if covered on top and all sides with a suitable insulating blanket material.

A5  Mixing Requirements
   Latex modified concrete shall be mixed according to the following proportions:
   Portland Cement ....392 kg/m³ (658 pounds/cubic yards) of concrete
   Latex Modifier .................. 0.3 L/kg (22.4 ounce/pound) of cement
Water ................................................... As required for slump control

Slump: 140 mm with a tolerance of 25 mm (5 ½ inch ±1 inch) when tested 4 to 5 minutes after discharge from the mixer. A minimum quantity of water shall be used sufficient to provide a mixture that can be placed and finished in accordance with these Specifications.

Approximate Ratio of Dry Ingredients by Mass:
  Cement - 1 part;
  Fine aggregate - 2.5 parts;
  Coarse aggregate 2.0 parts; based on 2.65 specific gravity aggregates.

B Low Slump Concrete

Low slump concrete shall be produced in accordance with 2461 as modified by the following:

B1 Mix Requirements

The substitution of Ground Granulated Blast Furnace Slag (GGBFS) or Fly Ash Cement is not permitted regardless of any other provision of the Contract.

The concrete mix shall be No. 3U17A, using the maximum quantity of water-reducer permitted by the Mn/DOT Concrete Manual.

Concrete slump shall be maintained at 20 mm (¾ inch) within a tolerance of 6 mm (¼ inch).

Air content shall be maintained within the range of 6 to 7 percent whenever possible, and it shall not be less than 5 percent nor more than 8 percent of the measured volume of freshly mixed concrete.

B2 Air Content Provisions

Low slump concrete (Mix No. 3U17A) having air content less than 4.8 percent or more than 8.2 percent, when tested in accordance with the prescribed procedures and excluding permissible deviations, will not be accepted for payment at Contract prices, but shall be subject to the following:

(a) Concrete having air content of more than 8.2 percent will be paid for at an adjusted unit price equal to 95 percent of the Contract bid price for the item involved.

(b) Concrete having air content less than 4.8 percent but not less than 4.0 percent will be paid for at an adjusted unit price equal to 75 percent of the Contract bid price for the item involved.

(c) Concrete having air content less than 4.0 percent but not less than 3.5 percent may be left in place without any payment being made therefor.

(d) Concrete having air content less than 3.5 percent shall be removed and replaced.
When air-entraining cement is used and it is found that the air content of the concrete is less than 6 percent or more than 7 percent, the use of that particular brand of cement shall be discontinued as provided in 2461.4.

C  Bonding Grout
Grout for bonding the new concrete to the structural slab shall consist of equal parts, by mass, of Portland cement and sand mixed with sufficient water to form a slurry having the consistency of thick cream. The grout shall not be self-leveling but should require brushing or scrubbing with stiff bristle brooms. Completely coat the in-place concrete immediately before placing the concrete wearing course. For sealing vertical joints, this grout shall be thinned with additional water to a paint-like consistency.

D  Membrane Curing Compound, Type 2, Class B

2404.3 CONSTRUCTION REQUIREMENTS
A  General
All equipment used for proportioning, mixing, placing, and finishing the concrete shall be subject to the approval of the Engineer. This approval will be contingent upon satisfactory performance and will be rescinded in the event that such performance is not being achieved.
Concrete shall be mixed in accordance with the specified requirements for the equipment used. The concrete, as discharged from the mixer, shall be uniform in composition and consistency. Mixing capacity shall be such that finishing operations can proceed at a steady pace, with final finishing being completed within the times specified herein. Placing and finishing equipment shall include adequate hand tools for placement of the concrete and for working the concrete down to approximately the correct level for strike-off.

An approved power-operated finishing machine shall be used. The finishing machine shall be so designed that, under normal operating conditions, the elapsed time between depositing the concrete on the bridge deck and the final screeding shall be minimal but in no case exceed 15 minutes.
Design of the finishing machine, together with appurtenant equipment, shall be such that positive machine screeding of the plastic concrete will be obtained. The length of the screed shall be sufficient to extend at least 150 mm (6 inches) beyond the edge of a subsequently placed section, and to overlap the edge of a previously placed section at least 150 mm (6 inches). The finishing machine shall be capable of forward and reverse motion under positive control. Provisions shall be made for raising the screeds to clear the screeded surface for traveling in reverse.
Unless otherwise directed by the Engineer, the Contractor will be required to demonstrate that the finishing machine proposed for use will produce the required results (placement rate, concrete density, surface finish, etc.) under the conditions to be encountered.

Rails will be required for the finishing machine to travel on and they shall be placed outside of the wearing course area. Rail anchorages shall provide horizontal and vertical stability and shall not be ballistically shot into concrete that will not be overlaid.

After the rails have been set to proper grade and elevation, and prior to starting the concrete placement, the clear distance from the bottom of the screed to the top of the prepared concrete surface shall be checked by the Contractor in the presence of the inspector. A fill strip or other approved device shall be attached to the bottom of the screed during this check as a means of detecting any areas encroaching on the required wearing course thickness. Sufficient screed rails shall be set to allow the clearance check to be made in one continuous run for a complete day's placement. Corrections shall be made as directed by the Engineer so as to obtain the specified thickness.

The location of longitudinal joints shall be subject to the approval of the Engineer and shall be located at the edges of traffic lanes.

Immediately before placing the concrete wearing course, the slab surface shall be thoroughly cleaned, and the entire bridge surface and designated approaches shall be sandblasted. The sandblasting shall be of sufficient force and duration to remove all surface film, laitance, fractured concrete particles, and other materials that may impede the bond of the subsequent overlay. Use of steel shot for sandblasting is permitted provided that materials that may impede the bond of the overlay are removed. After sandblasting, the resulting debris shall be removed by sweeping or other approved method, after which surface dust shall be removed by airblasting. The air supply system must be provided with a suitable oil trap between the storage tank and air nozzle.

All sandblasting, sweeping, and cleaning of the bridge structural slab shall be completed prior to placing the concrete so that surface inspection can be accomplished during the daylight hours when natural light is sufficient for visual inspection.

Concrete placement and finishing shall proceed at a linear rate, measured parallel to the centerline of the bridge, of not less than 12 m (40 feet) per hour under normal working conditions. Concrete wearing course placement widths exceeding 7.3 m (24 feet) will not be authorized unless other dimensions are designated in the Special Provisions.
Joints shall be made in the concrete wearing course in accordance with the applicable requirements of 2401.3E, and shall be located directly above the original joints constructed in the bridge deck slab. Saw cuts shall be made as soon as the concrete can be cut without raveling. This work shall be performed in a manner that will expose the uncured concrete to surface drying for the shortest time practicable. Saw cuts shall be sealed with joint sealer conforming to 3723.

After the concrete has been consolidated, screeded and floated, the Contractor shall texture the surface of the wearing course by drawing a carpet drag longitudinally along the pavement before the concrete has attained its initial set. The drag shall be mounted on a bridge. The dimensions of the drag shall be the width of the concrete placed by a longitudinal length of 1.2 m (4 feet). The carpet drag shall be adjusted as necessary to produce a texture satisfactory to the Engineer.

The carpeting for the drag shall be an artificial grass type having a molded polyethylene pile face with a blade length of 16 to 25 mm (5/8 to 1 inch) and a total minimum mass of 2.35 kg (70 ounces) per square meter (yard). The backing shall be of a strong, durable material not subject to rot, which shall be adequately bonded to the facing to withstand use as specified. In lieu of the carpet drag texturing, a coarse broom texturing may be used subject to approval by the Engineer.

In addition to and immediately following the carpet drag, the bridge slab shall be given a transverse metal-tine texture. The device used for this operation shall be equipped with 100 to 150 mm (4 to 6 inch) steel tines approximately 1 by 2 mm (1/12 by 1/8 inch) thick (cross section) arranged so as to obtain randomized grooves approximately 3 to 8 mm (1/8 to 5/16 inch) deep with a variable spacing of 15 to 25 mm (5/8 to one inch). The Engineer may approve other texturing equipment provided an equivalent texture is obtained. Tining shall not extend into areas within 0.3 m (1 foot) of curbs.

The final surface shall not vary more than 3 mm (1/8 inch) from a 3 m (10 foot) straightedge laid longitudinally thereon. Special care shall be taken in the areas of expansion devices and other breaks in the continuity of the wearing course to ensure that this tolerance is met.

Surface areas not meeting the specified tolerances shall be corrected by removal and replacement or by grinding the high spots to the extent directed by the Engineer. Nonconforming areas that are not satisfactorily corrected shall be subject to 1503 and 1512.

The provisions of 2401.3J shall be complied with in performing the sealing operations.

If the daytime temperature for a scheduled concrete placement is predicted by the National Weather Service to reach or exceed 27°C (80°F), the placement shall either be rescheduled or it shall be started
between the hours of 7:00 p.m. and 5:00 a.m. Pours started after 7:00 p.m. but not completed by 5:00 a.m. shall be terminated at 5:00 a.m. if the air temperature is at or above 27ºC (80ºF). If the air temperature is below 27ºC (80ºF) at 5:00 a.m., the pour may continue until such time as the temperature reaches 27ºC (80ºF). No concrete wearing course shall be placed when the air temperature is below 5ºC (40ºF) nor when the slab surface shows signs of frost.

The Contractor shall notify the Engineer a reasonable length of time in advance of scheduling a night operation, and shall provide artificial lighting as necessary for quality workmanship and adequate inspection.

Concrete for wearing courses shall not be placed before April 15th, or after September 15th, north of the 46th parallel, or after October 1st, south of the 46th parallel, unless the deck is heated and housed in accordance with the following:

(1) The Contractor shall submit, for the Engineer's approval, a plan and proposed time schedule for cold weather protection and maintenance of acceptable curing temperatures. No work shall be commenced until all necessary provisions have been made to the satisfaction of the Engineer.

(2) The concrete shall be provided with suitable housing immediately after placement, such as will provide free air circulation above the surface and protect against freezing rain or snow.

(3) Pre-heating of the structural slab may be required prior to concrete placement. Insulation blankets or heating facilities shall be provided as necessary to maintain the specified curing temperatures.

(4) For the first 96 hours after concrete placement, the concrete surface or enclosure temperature shall be maintained at a minimum temperature of 16ºC (60ºF) for low slump concrete and 13ºC (55ºF) for latex modified concrete. Thereafter, for the next 26 calendar days, insulation or heating shall be provided as necessary to ensure that the concrete will not be exposed to temperatures below 5ºC (40ºF).

(5) The housing enclosure shall not be removed until the cold weather protection needs have been fulfilled, as determined by the Engineer.

B Latex Modified Concrete

B1 Mixer Requirements

Proportioning and mixing equipment shall be of an approved stationary batch or self-contained mobile type. Conventional ready-mix truck mixers shall not be used.

Self-contained mobile type mixers shall comply with the following requirements:

(a) The mixer shall be self-propelled and be capable of carrying sufficient unmixed materials for the latex composition.
(b) The mixer shall be capable of positive measurement of the cement being introduced into the mix. A recording device, visible at all times, and equipped with ticket print-out shall indicate this quantity.

(c) The mixer shall provide positive control of the flow rate of water and latex emulsion into the mixing chamber. Water flow shall be indicated by a flow measuring device and be readily adjustable to compensate for minor variations in aggregate moisture.

(d) The mixer shall be capable of being calibrated to automatically proportion and blend all components of the indicated composition on a continuous or intermittent basis, as required by the finishing operations, and shall discharge the mixed material through a conventional chute directly in front of the finishing machine.

(e) The mixer shall be capable of adequately blending the latex composition so that the freshly consolidated material contains no more than 6.5 percent entrained air.

Stationary batch type mixers shall be capable of producing a latex composition that is equal in all respects to that produced by the mobile mixer unit.

B2 Concrete Placement

Bulkheads shall be installed to the required grade and profile and they shall not be treated with a parting compound to facilitate removal.

The surface to be overlaid shall be dampened with water immediately prior to placement of the latex composition. No puddles or standing water will be permitted on the surface at the time of placing the latex composition.

Latex composition shall not be placed at air temperatures lower than 7ºC (45ºF) and may be placed at 7ºC (45ºF) only when rising temperature is predicted.

Properly mixed latex composition shall be promptly delivered to and be deposited on the dampened surface, where it shall be brushed out carefully to ensure uniform coating of all vertical as well as horizontal surfaces. Spent aggregate from the brushing operations shall be disposed of in an approved manner. The rate of progress in placing the latex composition shall be so controlled that it does not become dry before being covered with the wearing course.

A surplus of mortar shall be maintained in front of the leading edge of the finishing machine screed during all operations. Hand finishing with a wood or magnesium float will be required as necessary to produce a dense, uniform surface.

Bulkheads shall be separated from the newly placed concrete by passing a pointing trowel along the inside face. Care shall be exercised to ensure that the trowel cut is made for the entire depth and length of the bulkheads after the concrete has set sufficiently so it will not flow.
B3  Curing Requirements

A single layer of wet burlap or approved equal shall be placed on the surface as soon as the concrete has set sufficiently to support it without deformation. Care shall be exercised to ensure that the burlap is well drained. It is the nature of the latex modifier to form a plastic film at the surface upon drying, usually within 25 minutes in hot dry weather. The burlap covering must be placed prior to formation of this film, to ensure against premature drying and cracking.

A layer of polyethylene film shall be placed on the wet burlap and remain in place for a period of not less than 48 hours. If the ambient temperature falls below 13°C (55°F) during this period, the duration of the wet cure shall be extended as directed by the Engineer.

No traffic shall be permitted on the concrete wearing course until it has had 72 hours of drying time after removal of the curing media.

C  Low Slump Concrete

C1  Mixer Requirements

Mixing equipment shall conform to 2461, modified to the extent that a continuous mixer used in conjunction with metered proportioning will be required. This mixer shall be calibrated by the Department for the specific materials to be used. A minimum of 7 days lead time will be required to establish mix settings. All concrete shall be mixed at the job site.

The finishing machine shall have at least one oscillating screed and be designed to consolidate the concrete to 98 percent of rodded density by vibration. Either a sufficient number of identical vibrators, or pillow blocks with eccentric cams, shall be installed so that effectively at least one vibrator (or source of vibration) is provided for each 1.5 m (5 feet) of screed length. If only one screed is vibrated, it shall be the front screed. The bottom face of this screed shall be at least 125 mm (5 inches) wide and have a turned-up or rounded leading edge to minimize surface tearing. Each screed shall produce a pressure of at least 366 kg/m² (75 pounds per square foot) of screed area of bottom face. Each screed shall be provided with positive control of the vertical position, angle of tilt, and shape of the crown. The finishing machine shall be equipped with an adjustable power-operated paddle or auger to strike off concrete in front of the first screed.

C2  Concrete Placement

The prepared deck surface shall not be presaturated, but shall be dry so as to allow absorption of bonding grout. The bonding grout shall be thoroughly scrubbed into the deck surface at a rigidly controlled rate as will not allow the bonding grout to become dry before it is covered with the concrete wearing course.
The concrete shall be mechanically struck off slightly above final grade before being consolidated and screeded to final grade.

At transverse and longitudinal joints, the course previously placed shall be sawn to a straight, vertical edge, and the trimmings shall be completely removed before the adjacent course is placed. No impact equipment shall be operated in the adjacent lane during the first 72 hours after concrete placement without specific authorization from the Engineer. As soon as finishing and texturing have been completed, all vertical joints with adjacent concrete shall be sealed by painting with thinned bonding grout.

C3 Curing Requirements

The concrete shall be coated with membrane curing compound (Mn/DOT 3754) within 30 minutes after depositing the concrete on a given area. The compound shall be applied by an approved airless spraying machine at the approximate rate of 1 liter per 4 m² (1 gallon per 150 square feet) of curing area.

The spraying machine shall have as essential elements:
(a) A recirculating bypass system that provides for continuous agitation of the reservoir material.
(b) Separate hose and nozzle filters.
(c) A multiple or adjustable nozzle system that will provide for variable spray patterns.

Before application, the curing compound as received in the shipping containers shall be agitated until a homogeneous mixture is obtained. Application shall be such that a uniform coating is obtained. Any areas that appear to have too light a coating shall be resprayed immediately. Also, should the membrane film become damaged at any time prior to placement of the wet cure, the damaged areas shall be repaired immediately by respraying.

Failure to apply membrane curing in a given area within 30 minutes after depositing concrete thereon shall be subject to 1512. However, if the Engineer determines that vibration of the concrete is necessary, this time limit will be extended 15 minutes. Concrete in areas not coated with membrane curing compound within the stated time limits shall be removed and replaced at no additional cost to the Department.

As soon as the concrete can be walked on without damage, conventional curing media (wet burlap or curing blankets) shall be placed in accordance with 2401.3G for a minimum curing period of 96 hours.

No vehicular traffic shall be permitted on the concrete wearing course during the 96 hour curing period. If the daily mean temperatures
have been below 16°C (60°F) during this 96 hour period, additional
curing time will be required by the Engineer before traffic will be
permitted.

2404.4 METHOD OF MEASUREMENT
The concrete wearing course will be measured by surface area as
computed from specified dimensions. No deduction will be made for
the surface area of expansion devices or other miscellaneous
appurtenances.

2404.5 BASIS OF PAYMENT
Payment for the concrete wearing course at the Contract price per
unit of measure will be compensation in full for all costs of constructing
the wearing course complete as specified, except for those costs that the
Contract specifically designates as having been included for payment
under separate items for which the Proposal contains specific unit
prices.

Payment for concrete wearing course will be made on the basis of
the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2404.501</td>
<td>Concrete Wearing Course</td>
<td>square meter</td>
</tr>
</tbody>
</table>
<pre><code>              |                                        | (square foot) |
</code></pre>

2405 Prestressed Concrete Beams

2405.1 DESCRIPTION
This work shall consist of the fabrication and installation of
prestressed concrete I-beams and double Tee-beams for use in bridge
superstructures.

2405.2 MATERIALS
A Concrete
The concrete shall be produced in a central-mix plant meeting
2461.4D4. Generally, Portland cement, Types I, II, or III may be used
at the Contractor’s option.

Concrete for prestressed I-beams shall be Mix No. 1W36 or 3W36.
When the minimum required concrete strength for I-beams, as shown in
the Plans, is greater than 35 Mpa (5,000 psi) but does not exceed
42 Mpa (6,000 psi), the concrete shall be concrete Mix No. 1W36 and
an approved water reducing admixture shall be added. The quantity of
admixture shall be sufficient to reduce the water content of the concrete
by not less than 5 percent when compared with concrete that does not
contain the admixture. When the minimum required concrete strength
for concrete I-beams, as shown in the Plans, is greater than 42 MPa
(6,000 psi), the concrete shall be Mix No. 1W36 modified to give the
required concrete strength or an approved alternate mix. This may
2405.2

require the use of a super water reducer under procedures approved by the Concrete Engineer.

Concrete for double Tee-beams shall be Concrete Mix No. 3W36.

B Reinforcement Bars .................................................... 3301
C Structural Steel ........................................................... 3306
D Corrosion-Resistant High Strength Steel .................. 3307
E Prestressing Tendons Seven Wire Strand............... 3348
F Structural Steel Pipe ................................................... 3362
G Galvanized Structural Shapes ................................. 3394
H Curing Paper ............................................................... 3752
I Blank
J Plastic Curing Blankets .............................................. 3756

2405.3 CONSTRUCTION REQUIREMENTS

The Contractor shall fabricate the beams in a precast/prestressed concrete fabrication plant that has been granted Certification by the Precast/Prestressed Concrete Institute, or by an organization approved by the Materials Engineer.

The prestressed concrete beams shall be fabricated in accordance with the applicable sections of 2401, 2471, and 2472, and the PCI Manual for Quality Control: Precast and Prestressed Concrete except as modified hereinafter.

A General

The State Materials Engineer is the Engineer with authority concerning all matters of plant fabrication and inspection prior to delivery of the material to the Project. The Project Engineer is the Engineer with authority concerning all matters of fabrication at the Project site.

The Contractor shall notify the Department, in writing, immediately after placing orders for prestressed concrete beams. This notification shall be directed to the Engineer, with a copy to the Project Engineer, and shall include the name and address of the supplier and the location at which the beams will be manufactured. This information is required so that proper arrangements can be made for inspection at the place of manufacture.

The Fabricator shall notify the Engineer at least 7 days prior to starting manufacturing operations, except that if the beams are cast at the site of the bridge, the Engineer shall be notified a sufficient time in advance of casting to permit inspection of the forms and reinforcement.

When the beams are cast at a plant away from the bridge site, an office meeting the requirements of 2031.3A shall be provided. In addition, air conditioning and convenient access to sanitary facilities shall also be provided. Laboratory space will not be required.
When the beams are cast at a plant away from the bridge site, and if, on any day on which the services of the Department inspector are required, less than 2 beams are cast, the Department will deduct from any moneys due or becoming due to the Contractor the total cost of such inspection for that day. This policy may be modified by the Materials Engineer to suit the particular circumstances. However, in any case, after informing the Fabricator, inspection costs deemed excessive by the Engineer will be deducted from the total cost for the product paid to the Contractor.

The Fabricator shall have a PCI Level II, Certified Technician, on site at the start of fabrication and throughout fabrication of the prestressed beams. All technician's performing quality control functions will be Mn/DOT - PCI Level I Certified. The supervisor of the quality control staff will be PCI Level II Certified.

The Fabricator shall take adequate precautions to prevent contamination of the prestressing steel with oil, dirt, or other deleterious substances and to prevent damage to prestressing steel that may result in weakening the prestressing steel or that may result in its failure under stress. Nicking or kinking of the prestressing steel may result in rejection of the material. Sparks or pieces of molten metal from welding or burning equipment shall not be permitted to contact any prestressing steel, and the use of prestressing steel as a ground for welding equipment will not be permitted. The cutting off of surplus tendon ends by burning will be permitted, provided the burning is done rapidly and neatly.

During the tensioning of the tendons, and until such time as the stress has been transferred from the jacks to permanent anchors or temporary grips, special precautions shall be taken by the Fabricator to prevent accidents that may result from failure of the equipment or materials.

Shop drawings for all structural metals shall be prepared in accordance with 2471.3B.

B Forms

Forms shall be designed to withstand the pressure due to concrete, vibration, and impact without distortion. They shall be set and maintained mortar tight, free of warp, and on a rigid foundation. The soffit form shall be at right angles to the vertical axis of the beams, with the plane of bearing surfaces flat and true. Side and soffit forms shall be true to Plan dimensions and shall be so set and maintained during casting and until the concrete has set. Joints in sectional forms shall have a tight fit without offset.

Forms for prestressed concrete beams shall be so set that the dimensions of the beam after prestress transfer will conform to the Plan
dimensions within the tolerances specified in 2405.31.

The face of the forms in contact with the concrete shall be treated with form coating material meeting 3902 before the form is set in position. Forms shall be thoroughly cleaned of accumulations of oil or other substances prior to use.

When beam end blocks are required, the length of the end block shown in the Plans is a minimum and may be increased as much as 300 mm (12 inches) to accommodate sectional forms. The length of the end blocks for all beams of the same length in any one span shall be the same.

C Steel Units

Reinforcement bars for prestressed concrete beams shall be placed, supported, and tied in accordance with the applicable provisions of 2472, except that welded ties will be permitted at bar intersections that are to be contained within the top flange of the beams, provided that no welding is performed in the vicinity of the prestressing strands. This is the only exception to the requirements for using wire ties.

When the top flange transverse stirrup reinforcement bars are tack welded to the vertical web reinforcement bars in fabricating the reinforcement bars into cages, additional U-shaped No. 13 vertical reinforcement bars will be required at the top flange. The bar details shall be the same as the vertical web reinforcement bars, except that the length of the bars from the top of the curve to the ends of the legs shall be 450 mm (18 inches). These bars shall be located at the vertical web reinforcement bars at each end of the beam and at the intermittent bars at a spacing that does not exceed 600 mm (24 inches). The bars shall be placed to match the projection of the vertical web reinforcement bars from the top of the beam and shall be held in place with wire ties. Tack welding will not be permitted. Where two vertical web reinforcement bars are used in end blocks, and where half vertical web reinforcement bars are used in end block tapers, one bar is required and may be located with either bar or half bar.

The concrete cover on reinforcement bars shall not be less than 25 mm (1 inch) at any point.

Sole plates for prestressed beams shall be so set that after prestress transfer, the location of the sole plates will conform to the Plans within the tolerance specified for the length of pretensioned beams. The sole plates shall be in close contact with the soffit forms and shall be so maintained during placement of concrete.

Floor drains shall be placed in the position shown in the Plans and securely fastened to the forms in such a manner that the placing of the concrete will not alter their alignment or location.

All loose rust and all dirt, oil, and other foreign substances shall be
removed from prestressing tendons before the side forms are erected for the beams.

The construction of hold-down devices for deflected strands may be such that the device can be removed for a distance of 25 mm (1 inch) or more from the face of the concrete and the hole plugged with mortar, or the device may rest on the bottom form and remain in-place, in which case that part in contact with and for a distance of at least 25 mm (1 inch) from the form shall be galvanized.

D  Placement of Concrete

The beams shall be cast in an upright position and the concrete in each beam shall be placed without interruption, except that for prestressed I-beams, the concrete shall be placed in continuous lifts of approximately 35 percent of the beam depth. The casting procedure shall be modified when the length of the beams and placement conditions are such that a cold joint may result if each lift is continued full length before another lift is placed.

The concrete in each beam shall be vibrated internally, externally, or both, as required to produce uniformly dense concrete, and in such a manner as to avoid displacement of enclosures or steel units. Internal vibration shall conform with 2401.3D, except that internal vibrators shall have a vibrating head not greater than 32 mm (1 ¼ inch) in diameter and shall operate at a frequency of not less than 100 Hz (100 cps).

After the top surface of the beams has been struck off to the required level, it shall be worked and hand floated sufficiently to seal open tears in the surface and depress all coarse aggregate, and the surface shall then be roughened by transverse brooming.

E  Blank

F  Concrete Curing

F1  General

The curing operations shall begin immediately after the concrete has taken its initial set and shall be continued until the concrete, as evidenced by the strength of control test cylinders cured with the beams, has reached a compressive strength not less than the minimum required for prestress transfer.

When cold weather protection is required, the temperature inside the housing shall, after the expiration of the curing period, be reduced at a rate not exceeding 22°C (40°F) per hour until the temperatures inside and outside the housing are equal.

F2  Curing Methods

The beams shall be cured by any of the following methods or combinations thereof:
(a) A covering of burlap or canvas kept continuously wet,
(b) A continuous water spray or mist,
(c) A complete airtight seal using curing paper or plastic curing blankets,
(d) Submersion of the unit in water, or
(e) The moist air or steam method of curing, subject to the requirements set forth below. This will include any method where an external source of heat is used.

**F3 Steam Curing**

The introduction of steam into the curing chamber, for curing purposes, shall be delayed until the concrete has taken its initial set and in any event until at least 3 hours after the concrete is placed. During the delay period, the minimum temperature within the curing chamber shall be not less than 10°C (50°F), and the maximum temperature shall not exceed the temperature of the concrete at the time of placement by more than 5°C (9°F). Steam may be used only to maintain the curing chamber temperature within these limits.

Steam jets shall not impinge directly on the concrete or on the forms. The rate of rise in temperature adjacent to the concrete shall not exceed 15°C (27°F) per hour. There shall be free circulation around the top, sides, and ends of the concrete units. The temperature adjacent to the concrete shall not exceed 70°C (158°F) at any time. The steam within the curing chamber shall be thoroughly saturated at all times. The temperature of the concrete unit shall be kept above 10°C (50°F) during the entire curing period. The difference in temperature adjacent to the concrete at different locations within the chamber shall not exceed 5°C (9°F) at any one time.

After the expiration of the steam curing period, the temperature inside the chamber shall be reduced at a rate of not more than 22°C (40°F) per hour until the temperature inside and outside of the chamber are equal; and, after being removed from the chamber, the beams shall be protected as may be necessary to avoid cooling at a rate greater than 22°C (40°F) per hour until the air temperature at the storage site is reached.

When side forms are removed from the curing chamber before the steam curing cycle (including temperature taper off process) is completed, only the minimum area of the curing chamber enclosure that is necessary to remove each individual form section shall be removed and remain uncovered at any one time. The open area in the enclosure shall be immediately closed as each form section is removed, and in any event, within 15 minutes of the time the area was first uncovered.

When the Fabricator elects to remove the beams from the casting bed during the cooling-off process, the Fabricator shall take appropriate measures to keep the beams warm during the moving operations, and
shall immediately resume the cooling-off process at the storage area.

Two continuous recording thermometers shall be provided for each casting chamber having a casting bed length of 30 m (100 feet) or less and, for each additional 30 m (100 feet) or fraction thereof in the length of the casting bed within each chamber, one additional thermometer shall be provided. Thermometers shall be located in each enclosure or curing chamber as directed by the Engineer. Complete temperature recording charts for all cures shall be submitted to the Engineer for review.

When the records indicate that the temperature and time element Specifications pertaining to the steam curing are not being complied with, the use of steam curing shall be discontinued and other approved cured methods shall be used.

G  Tensioning

G1  Equipment

Prestressing tendons shall be tensioned with hydraulic jacks or dynamometers and hydraulic jacks. Each jack pump shall be equipped with a hydraulic pressure gauge. Jacks, gauges, and pumps shall be calibrated as a unit under conditions as nearly similar to operating conditions as practicable, and a dated, certified calibration curve shall be furnished for each combination used. Recalibration will be required for equipment that gives erratic results during tensioning operations.

The sensitivity and accuracy of hydraulic pressure gauges shall be such that at final elongation of the prestressing tendons, the actual stress on the jacks can be accurately determined within a tolerance of 2 percent of the total indicated stress at that time.

The dynamometer that is used to measure an initial tension shall be calibrated, and the sensitivity and accuracy of the dynamometer shall be such that the initial tension can be accurately determined within a tolerance of 5 percent.

G2  General Procedures

The tensioning procedure shall be so conducted that the indicated stress on the tendons based on gauge pressures and the indicated stress based on the corresponding elongation of the tendons may be measured and compared at any time. When the two indicated stresses, corrected for friction loss, differ by 5 percent or less, the tendons shall be so stressed that the lower of the two indicated stresses is equal to the required tension in the tendon, except that in no case shall any tendon be tensioned to an indicated stress in excess of 85 percent of its specified yield point strength. If the difference exceeds 5 percent, tensioning operations shall cease until the source of the discrepancy has been determined and corrected.

Tensioning of prestressing strands in the bundled position with
direct contact between adjacent strands will not be permitted. A minimum of 6 mm (¼ inch) clear space shall be maintained between adjacent strands during tensioning. However, tensioned strands may be depressed into a bundled position with contact between adjacent strands after all tensioning has been completed.

The Contractor shall keep a record of gauge pressures, indicated stresses, and elongations and shall submit the record to the Engineer.

Each strand shall be given an initial tension of such magnitude and be supported at such intervals that the strand is straightened and the slack partially removed before jacking is started. Strands tensioned as a group shall have the same initial tension, and all strands in the group shall be from the same manufacturer. When the required initial tension is 650 N (150 pounds) per strand or less, it shall be considered zero tension. When the required initial tension exceeds 650 N (150 pounds) per strand, it shall be measured with a dynamometer or an equally accurate device, and the elongation due to the initial tension applied shall be added to the final elongation measurement.

The tensioning of deflected strands shall be done in a manner that the final tension in all parts of the strand is uniform, and freely turning rollers shall be provided to reduce frictional forces at the bend points to a minimum.

Tension-elongation measurements shall be corrected for losses, as determined by the Engineer in the field, due to slippage of grips or anchorages, and friction, to obtain the required prestress force in the strands after anchorages are set.

When there will be an appreciable change in elongation of the strands due to a temperature differential in the strands at the time of tensioning and time of concrete placement, the change shall be considered in the final elongation measurements to obtain the required prestress force at the time of casting. The change in elongation due to temperature shall be based on 1 mm per 10 m (1/8 inch per 100 feet) of strand length for each 8ºC (15ºF) variation in temperature. Tensioning of prestressing tendons shall only be allowed if the ambient air temperature is above 0ºC (32ºF) and rising.

**Prestress Transfer**

Beams shall not be removed from their casting beds until the prestressed transfer has been made. When not otherwise noted in the Plans, the prestress transfer shall not be made until the control cylinders indicate the concrete has reached a compressive strength of at least 31 Mpa (4500 psi) when a steam cure is used, the prestress transfer shall be made while the concrete is still warm and moist.

Prestress transfer sequence shall be such as to keep the lateral eccentricity of the prestress to a minimum and prevent cracking in the
top flange of the beams. The prestress transfer may be made by the gradual release of hydraulic jacks, by heating exposed portions of individual strands to failure, or by a combination of these two methods. When heating of individual strands is employed, it shall be subject to the following:

1. Heating of each individual strand shall be done simultaneously on the strand at a minimum of two locations along the casting bed. The sequence of heating each strand along the bed and the sequence of prestress transfer between individual strands shall be such that no detrimental effect will result.

2. Heating shall be done with a large, low oxygen flame played along the strand for a minimum distance of 125 mm (5 inches). The application of heat shall be so controlled that failure of the first wire in the strand does not occur for at least 5 seconds after heat is applied, followed by gradual elongation and failure of the remaining wires. Prestress transfer shall not begin until the forms are completely stripped from the beams.

I  Blank
J  Tolerances

The dimensions of the prestressed concrete beam after prestress transfer shall conform to the Plan dimensions within the tolerances specified in the "Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products" prepared by the Prestressed Concrete Institute except as modified by the appropriate Mn/DOT Prestressed Concrete Beam Inspection form. Tolerances for double Tee-beams shall be in accordance with Section 5.5.2. Tolerances for I-beams shall be in accordance with Section 5.5.8.

Differential camber between adjacent members of the same design, if applicable, will be measured with the beams erected to their final position.

Any member that does not conform to the plan dimensions within the specified tolerances shall be subject to 1503.

K  Rejection

Beams shall be subject to rejection because of failure to meet any of the requirements specified above, or if, upon removal of the forms, there is evidence of honeycombing, stone pockets, sand streaks, or imperfect mixing and casting.

Minor surface cavities or irregularities that do not impair the service value of the beams and that are satisfactorily repaired shall not constitute cause for rejection. Repairs shall not be made until the Engineer has inspected the extent of the irregularities and has determined whether or not the beam will be rejected. All grout used
shall meet the approval of the Engineer.

L  **Marking, Handling, Storage, and Transportation**

Beams may be moved from the casting bed to a nearby storage area upon attaining the minimum compressive strength for prestress transfer; however, no beam shall be transported or installed until the minimum compressive strength specified for transportation has been attained, as evidenced by control cylinders. If not otherwise specified, the minimum strength for transportation shall be 35 Mpa (5000 psi).

Each beam shall be marked showing casting date and piecemark. Beams cast away from the bridge site shall bear the name or trademark of the manufacturer and the bridge number. Prior to shipment, the beams will be stamped with the official mark of the Department.

All markings shall be placed in such a manner as to remain in evidence after erection, but not readily visible in the completed structure. No beam shall be transported or installed unless it bears all of the required markings.

Prestressed beams shall remain in an upright position at all times and shall be supported during storage, lifting, and transportation at two points only. The location of the support points shall be determined by the Contractor in accordance with standard Prestressed Concrete Institute methods and shall include consideration of beam stresses and stability, subject to final approval by the Engineer.

Permits may be required from road authorities.

**M  Installation**

After each prestressed beam has been erected, it shall be temporarily braced and tied in a manner satisfactory to the Project Engineer so as to preclude sliding, tipping, or other movement that may otherwise occur prior to placement of the diaphragms and the slab. The Contractor shall arrange the work schedule so that at least two adjacent I-beams will be erected and braced in any one span before operations are suspended.

The prestressed concrete beams shall be installed and permanently fastened in accordance with the details shown in the Plans.

Intermediate diaphragms for prestressed concrete I-beams shall be in accordance with the Plans.

All structural steel shapes and plates for the steel intermediate diaphragm option shall comply with either 3306 or 3309. Steel plates
and shapes complying with 3306 or 3309 shall be galvanized in accordance with 3394.

Fasteners, including washers, for the intermediate steel option shall be in accordance with 3391. Fasteners for use with galvanized structural steel shall meet the requirements of ASTM A 325, Type 1 or 3, and shall be galvanized in accordance with 3392.

Cast-in-place anchorages shall be used to connect the steel intermediate diaphragms to the fascia beams. The anchorages shall provide an ultimate pull-out strength of at least 65 kN (15 kips) per anchorage.

Material used to form holes in beam webs for connection bolts for steel intermediate diaphragms shall be either plastic or galvanized steel.

In addition to the ordinary surface finish, a special surface finish conforming to 2401.3F will be required on the outer face of the exterior beams of a bridge. The special surface finish shall be done with the beams in place and in conjunction with the final finish of the remainder of the structure.

2405.4 METHOD OF MEASUREMENT

Item 2405.501, Prestressed Concrete Beams Type ___, will be measured separately as individual units regardless of minor variations in Plan details between beams of the same type.

Item 2405.502, Prestressed Concrete Beams ___, will be measured by summation of the individual lengths, out to out, along the centerlines of beams.

Intermediate diaphragms for prestressed concrete I-beams will be measured by length based on the horizontal distance from centerline to centerline of beam along the axis of the diaphragms.

2405.5 BASIS OF PAYMENT

Payment for prestressed concrete beams, at the Contract price per unit of measure, will be compensation in full for all costs of manufacturing, transporting, and erecting the beams in their final position, including the placement of temporary bracing as specified in 2405.3M.

Payment for intermediate diaphragms for prestressed concrete I-beams will be made at the Contract price per unit of measure, which price will be compensation in full for all costs of constructing the intermediate diaphragms complete in place, including all structural steel or concrete and reinforcement bars required.

Payment for prestressed concrete beams and appurtenances will be made on the basis of the following schedule:
2405.5

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2405.501</td>
<td>Prestressed Concrete Beams Type ____</td>
<td>each</td>
</tr>
<tr>
<td>2405.502</td>
<td>Prestressed Concrete Beams ____mm (____inch)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2405.505</td>
<td>Prestressed Concrete Double Tee-Beam Type ____</td>
<td>each</td>
</tr>
<tr>
<td>2405.511</td>
<td>Diaphragms for Type ____ Prestressed Beams</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>

2411

Minor Concrete Structures

2411.1 DESCRIPTION

This work shall consist of constructing concrete structures of miscellaneous types and varied designs, either with or without metal reinforcement, and including box culverts, retaining walls, culvert headwalls, open flumes, and other cast-in-place items not covered by other Specifications.

2411.2 MATERIALS

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

Mix designations shall be as indicated in the Plans for the specific items of work.

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

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

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

E Geotextile Filter .................................................. 3733

2411.3 CONSTRUCTION REQUIREMENTS

Construction requirements shall be the same as those specified in 2401.3, except as modified by the following provisions:

A General

The structure locations shown in the Plans will be considered as being approximate only, and the exact locations shall be determined in the field by the Engineer. Each structure shall conform to the planned design, but the Engineer may change the dimensions to fit on-site conditions. Materials shall not be ordered until the exact locations and dimensions have been established.

All details and notes shown on the Mn/DOT Standard Box Culvert Plans, pertaining to construction joints, reinforcement bar splicing and computation of quantities, shall apply except as modified by the following:

1 Transverse construction joints, if used, shall be staggered at least 1200 mm (4 feet) in relation to any other joint that would result in a plane of weakness through the culvert structure.

2 Where long culverts result in lengths of reinforcement bars that are impractical for use, but are less than 18.3 m (60 feet) long,
additional splices will be permitted. The extra bar material used in making these additional splices will not be included in the pay quantity.

(3) Pay quantities for concrete and reinforcement bars shall be as determined from the formulas given on the box culvert Plans, except that such formula quantities will be adjusted to account for any additional materials due to design modifications made by the Engineer or to provide a completed structure in conformance with the Plans and Special Provisions.

B Falsework and Forms

Form lining shall be used on all vertical faces that will be exposed to view in the completed work. Detailed falsework or forming plans will not have to be furnished unless specifically required by the Special Provisions.

C Concrete Curing and Protection

All concrete structures shall have curing protection in accordance with the applicable requirements of 2401.3G, until the concrete has attained a strength gain of not less than 45 percent.

D Geotextile Filter

Geotextile shall be furnished and installed as shown in the Plans. Furnishing and installing the fabric shall be incidental work with no direct compensation being made therefor.

2411.4 METHOD OF MEASUREMENT

Measurement of structural concrete will be based on Plan dimensions, with each Grade or Mix being measured separately, and with no allowance being made for excess quantity beyond the minimum dimensions specified. No deductions will be made for volumes displaced by metal reinforcement, chamfer strips, or other incidentals.

Measurement of metal reinforcement items will be in accordance with 2472.4A.

When separate items are provided in the Proposal for structure excavation or granular backfill material, quantities will be measured in accordance with 2451, but only for those structures where the Plans show an estimated quantity.

2411.5 BASIS OF PAYMENT

Payment for structural concrete of each Grade or Mix designated at the Contract prices per unit of measure will be compensation in full for all costs of constructing the structures complete in-place as specified, except that separate payment will be made for metal reinforcement, structure excavation, and backfill materials when the Proposal contains specific unit prices therefor.

Payment for concrete structures of each Design or Type designated at the Contract prices per unit of measure will be compensation in full
for all costs of constructing the structures complete in-place as specified, except that when payment is made in surface area units the concrete incorporated therein will be paid for separately under the provisions of 2461.5.

Separate payment will be provided for structure excavation and special backfill materials only when the structures are paid for by volume, and then only when the Plans show an estimated quantity for the specific structure, but not when the structures are paid for as individual units.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2411.501</td>
<td>Structural Concrete (Mix No.)</td>
<td>cubic meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(cubic yard)</td>
</tr>
<tr>
<td>2411.503</td>
<td>Concrete (Type of Structure)</td>
<td>square meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(square yard)</td>
</tr>
<tr>
<td>2411.505</td>
<td>Concrete Structure, Design</td>
<td>each</td>
</tr>
<tr>
<td>2411.507</td>
<td>Concrete (Type of Structure)</td>
<td>each</td>
</tr>
<tr>
<td>2411.511</td>
<td>Structure Excavation, Class</td>
<td>cubic meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(cubic yard)</td>
</tr>
<tr>
<td>2411.521</td>
<td>Granular Backfill (1)</td>
<td>cubic meter</td>
</tr>
<tr>
<td>2411.523</td>
<td>Aggregate Backfill (1)</td>
<td>cubic meter</td>
</tr>
<tr>
<td>2411.541</td>
<td>Reinforcement Bars</td>
<td>kilogram</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(pound)</td>
</tr>
</tbody>
</table>

NOTE: (1) Specify the basis of measure (LV or CV) after the item name. See 2451.4B.

2412

Precast Concrete Box Culverts

2412.1 DESCRIPTION

This work shall consist of the installation of precast concrete box culverts.

2412.2 MATERIALS

A  Concrete ................................................................. 2461
B  Reinforcement Bars .................................................. 3301
C  Steel Fabric ........................................................... 3303
D  Joint Sealer Materials
   D1  Preformed, Type A or B ..................................... 3726
   D2  Bituminous Mastic ............................................. 3728
E  Granular Materials ................................................. 3149
F  Geotextile, Type II ................................................ 3733
G  Precast Concrete Box Culverts ................................. 3238
2412.3 Construction Requirements

Construction requirements shall be subject to 2411, 2451, and 3236 and the following additional requirements.

A Foundations

Foundation preparation shall be in accordance with 2451.3C, except that a minimum 150 mm (6 inch) thickness of granular bedding conforming to 3149.2F shall be provided. The bedding shall be shaped to a flat base using a template. Compaction adjacent to the bottom corner radii shall be accomplished with a mechanical hand compactor.

B Laying Precast Concrete Box Culvert

Precast concrete box culvert sections shall be laid with the groove end of each section up-grade, and the sections shall be tightly joined. The individual sections shall be tied together with concrete pipe ties. The joint on the bottom of the culvert shall be sealed with preformed mastic. A strip of geotextile material extending 300 mm (12 inches) or more on each section shall be placed over the joints on the top and sides in a manner that will prevent displacement during backfilling operations.

When so required by the Contract, the joints in the precast concrete box culvert shall be effectively sealed to provide a flexible watertight joint using an approved joint sealer material (preformed rubber, preformed plastic, or bituminous mastic).

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

2412.4 Method of Measurement

A Culvert Excavation

When the Proposal contains separate items for culvert excavation under the payment provisions of this Specification, the excavation for concrete box culverts will be classified and measured in accordance with the applicable provisions of 2451.4A.

B Precast Concrete Box Culverts

Precast concrete box culverts will be measured by length, as determined by the summation of the nominal laying lengths of the individual sections incorporated into each structure. Measurements will be separated as to size indicated in the item name.

Transition sections between two different sizes will be measured for payment as the larger (or more costly) size, except for such special sections as may be designated for measurement as a unit. Any cast-in-place concrete work for extending an existing box culvert will be included for payment with the adjacent precast box culvert.
2412.4

C   End Sections and Other Appurtenant Items

End sections and other appurtenant items such as flap gates and other specially identified units designated for payment on a per each basis, will be measured separately by the number of complete units of each type and size incorporated into the box culvert structures.

Any cast-in-place concrete work, other than end sections, required in connection with the construction of precast concrete box culverts will be measured for payment under 2411.

D   Granular Materials

The 150 mm (6 inches) granular bedding is incidental and no direct payment will be made. When the Proposal calls for any other special backfill or bedding, such material will be measured in accordance with 2451.4B.

2412.5 BASIS OF PAYMENT

Payment for precast concrete box culverts and end sections will be made on the basis of the following schedule; this payment in each instance will be compensation in full for all costs of furnishing and installing the culverts and end sections complete in place as specified and will include, but not be limited to, the necessary excavations, drop-wall, foundation preparation, granular bedding material, and backfill, unless payment for any of these items is shown in the Plans and provided for by separate Contract pay items.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2412.511</td>
<td>___ x ___ Precast Concrete Box Culvert</td>
<td>.......................................................... meter (linear foot)</td>
</tr>
<tr>
<td>2412.512</td>
<td>___ x ___ Precast Concrete Box Culvert End Section</td>
<td>.......................................................... each</td>
</tr>
</tbody>
</table>
2422
Crib Walls

2422.1 DESCRIPTION
This work shall consist of constructing retaining walls of the crib type, using preformed galvanized metal units or precast concrete units.

2422.2 MATERIALS
A Metal Cribbing............................................................ 3351
B Concrete Cribbing ...................................................... 3661
C Hardware
Hardware shall be of the type and size shown in the Plans, and shall be galvanized as specified in 3392.

2422.3 CONSTRUCTION REQUIREMENTS
A Preparation of Foundation ...................................... 2451.3
B Erection
Crib walls shall be erected in accordance with the Plans for the type being constructed. The planned length of the structure will be adjusted during construction so that only units of standard length will be required.
C Backfilling
Backfilling shall mean the placement of excavated material within the limits of the excavation, whether inside or outside the crib. If the material is suitable for that purpose, it shall be used for crib filling as hereinafter described. Backfilling outside of the crib shall progress with the crib filling, and the material shall be placed in layers not more than 200 mm (8 inches) thick, with each layer being thoroughly compacted before the succeeding layer is placed.
Any excavated material that is not used for backfilling shall be disposed of as directed by the Engineer. If the excavated material is not suitable for use as backfill, the backfill shall be made with the same material as provided for crib filling, and it will be paid for as such.
D Crib Filling
The material to be used for filling the interior of the crib shall be approved prior to its use, and the filling shall progress with the erection of the cribbing units.
Approved earth material shall be used to fill the interior of the cribs when the cribbing is to be used principally for the retention of an embankment where there is no wave action against the face of the wall. It shall be placed in layers not more than 200 mm (8 inches) thick, with each layer being thoroughly compacted before the succeeding layer is placed.
When the wall is to be subjected to wave or current action, boulders or quarry run rock shall be used to fill the interior of bar type cribs, and pit run gravel or quarry run rock shall be used for the bin type. The
2422.3

minimum size of the rock for filling bar type cribs shall be larger than
the vertical distance between bars, and the material shall be so placed
that no damage is caused to the cribbing units and that the void content
is reduced to a minimum.

2422.4 METHOD OF MEASUREMENT

A  Excavation

When separate items are provided in the Proposal for structure
excavation under this Specification, the excavation will be classified
and measured in accordance with 2451.

B  Crib Walls

Crib walls of each type will be measured separately by the overall
area of the front face of the wall, based on actual completed dimensions.

C  Crib Filling

Crib filling will be measured for payment only when separate items
are provided therefore, and then the material used will be measured by
volume, vehicular measure.

2422.5 BASIS OF PAYMENT

Payment for constructing crib walls of each type at the Contract
prices per unit of measure will be compensation in full for all costs of
constructing the walls complete in place, except for any crib filling
provided for under separate items.

If the crib is constructed in conjunction with the construction of an
adjacent embankment and if no special crib filling material is required,
the crib filling will be considered as embankment construction and no
separate payment will be made therefore.

If the crib is not constructed in conjunction with the construction of
an adjacent embankment or if special crib filling material is required,
the crib filling will be paid for as Extra Work in the absence of a
Contract item therefore.

Payment for structure excavation will be made in accordance with
2451, whenever an item therefore is provided in the Proposal.
Otherwise any excavation work involved shall be performed without
direct compensation.

Payment for crib wall construction will be made on the basis of the
following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2422.501</td>
<td>Structure Excavation, Class</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2422.506</td>
<td>Metal Crib Walls</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2422.507</td>
<td>Concrete Crib Walls</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2422.511</td>
<td>Earth Crib Filling</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2422.512</td>
<td>Gravel Crib Filling</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2422.513</td>
<td>Rock Crib Filling</td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>
2433

Structure Renovation

2433.1 DESCRIPTION
This work shall consist of renovating existing structures, by widening, rebuilding, or restoring, as indicated in the Plans and Special Provisions, including necessary removals to accomplish the improvements.

2433.2 MATERIALS
Except when otherwise specified all materials used in this work shall conform to the requirements of Division III.

2433.3 CONSTRUCTION REQUIREMENTS
A General
Traffic provisions shall be as defined in the Special Provisions. In addition to the requirements set forth in 1710 and unless otherwise specified in the Contract, the Contractor will furnish flaggers, and erect and maintain temporary curbs, rails, extra warning lights, special signs, or other protective devices, as may be required by the Engineer for the protection of all traffic and workers at no expense to the Department.
When the Contract specifies the construction of temporary sidewalks for the use of pedestrians, the sidewalks shall be constructed entirely outside of the vehicular traffic lanes. They shall be provided with suitable handrails and shall be not less than 1200 mm (4 feet) wide.
A2 Explosives
Explosives shall not be used to remove any portion of a structure that is to be widened or reconstructed. The restricted use of explosives to remove any material not directly connected to the structure will be permitted only upon written authorization of the Engineer and subject to 1711.
A3 Field Measurements
The dimensions of the old structure as shown in the Plans shall be considered as being approximate. Before any shop detail drawings are made or any fabrication is performed, the Contractor shall take sufficient measurements of the old structure to ensure that the old and new work will be properly joined, and furnish these measurements to the Engineer. Field measurements shall be shown on the shop detail drawings as specified in the detailed Specification for the type of work involved.

B Removal and Disposal Requirements
The removal and disposal of materials encountered in the renovation of existing structures shall be in accordance with 2442
insofar as they are applicable, together with the following additions and modifications.

The removal of old concrete or stone masonry shall not extend beyond the limits shown in the Plans and shall be accomplished in such a manner as not to damage any portion of the remaining structure. Saw cuts to a depth of about 25 mm (1 inch), or more if necessary, shall be made on faces that will be exposed to view, in order to produce neat appearing joints.

Where shown in the Plans, keyways shall be cut into the concrete that remains in place, without damage to the remainder of the structure.

The removal of piling located within the new footing area shall be accomplished in a manner that will not impair the supporting power of the foundation soil or damage any part of the remaining structure.

When old piles interfere with the planned spacing of new piles the Engineer may require the Contractor to drive the old piling sufficiently to determine their bearing capacity and suitability for use in the new construction. Unless otherwise provided in the Contract, such extra pile driving will be paid for as Extra Work.

C  Concrete Construction

Concrete construction shall be in accordance with 2401 together with the following additions:

Bolt anchors and other fasteners shall be placed and secured as specified.

When no surface finishing of old concrete is specified, at least 600 mm (2 feet) of the adjoining portion of the old concrete shall be given a surface finish in a manner that will blend the finish of the new with the old work.

Unless otherwise shown in the Plans the size and depth of the drilled holes and the installation of bolt anchorages shall conform to the recommendation of the manufacturer.

D  Reinforcement Steel

Reinforcement steel shall be placed in accordance with 2472 together with the following additions:

Unless otherwise shown in the Plans or required by the Special Provisions, reinforcement bars that extend through the cut line shall not be cut nearer than 40 diameters to the cut line.

When the strength of any bar has become impaired due to careless operation of removing old concrete, an approved bolt anchor or clamp, capable of developing the strength of such bar, shall be installed at no expense to the Department and as directed by the Engineer.

E  Structural Steel Construction

Structural steel shall be fabricated as provided in 2471 and erected as provided in 2402, together with the following additions:
(1) So far as practicable, holes for field connections between new and old steel shall be subpunched in the shop and reamed to proper size in the field after assembly. When the holes for these connections are made in the field, the parts shall be firmly clamped together and the holes drilled, using the holes in the old steel as a template. The use of a flame-cutting torch for making holes will not be permitted.

(2) The tops of all steel stringers, floor beams, etc., that are to be in contact with timber or concrete shall be cleaned of rust, scale, and other foreign matter and then be given the required coats of field paint and allowed to dry for not less than 24 hours. Before new steel is permanently connected to old steel, the contact surfaces of the old steel shall be thoroughly cleaned of all foreign matter and be given a coating of the designated primer paint. Painting of the structure shall be in accordance with 2478.

F Masonry Construction
Masonry shall be constructed in accordance with the Plans. Connections to old stone masonry shall be made at the old mortar joints and such joints shall be stepped, as directed by the Engineer.

All mortar and all loose or fractured material shall be cleaned from old stone masonry at the juncture of old and new work before new work is joined thereto. Immediately before placing new concrete or stone masonry, the surface of the old masonry shall be thoroughly wetted.

G Timber Construction
Timber construction shall conform to 2403 and the following:

(1) New nails, spikes and hardware shall be used throughout the work.

(2) Before placing either new or old timber on any part of a structure, the contact surfaces of the timber shall be thoroughly cleaned. Contact surfaces, except new treated timber and those that constitute parts of the structure to be treated with oil paint, shall be given at least two applications of copper naphthenate or another compatible preservative material meeting the requirements of AWPA Standard M4, with a minimum time lapse of 2 hours between applications.

2433.4 METHOD OF MEASUREMENT
A Structure Removals
The item of structure removals will be measured by lump sum.

B Item Removals
Removal of specified items such as concrete, masonry, structural steel, timber, etc., will be made by the unit of measure as indicated in the pay item and in accordance with the following:

B1 Lump Sum
Lump sum measurement will include the entire item as designated in the Contract or authorized by the Engineer.
B2  Mass
When measurement of structural steel is specified by mass, the mass will be computed in accordance with 2402.4A.

B3  Length
Length will be measured longitudinally along the center of the unit and as limited by the Plans or removal limits designated by the Engineer.

B4  Area
Area will be computed on the basis of actual width and length measurements and as limited by the Plans or removal limits designated by the Engineer.

B5  Blank

B6  Volume
Volume measurements, except for timber, will be computed on the basis of actual dimensions of the unit as removed. Timber will be measured based on nominal sizes and actual length measurements.

B7  Each
When the unit of measurement is designated as each, the Department will count each complete item needed for performing the required work.

C  Anchorages
Furnishing and placing anchorages of each type specified will be measured separately by the number of units complete in place.

D  Placing Used Materials
Placing used materials such as structural steel, timber, etc., will be measured separately by unit of measure as prescribed for removal items.

2433.5  BASIS OF PAYMENT
Payment for structural removals will include the removal of all specified portions of the existing structure as necessary to accomplish the renovation work and will include disposal of the materials removed and such other work as may be necessary to properly prepare the structure for the new work.

Payment for structure renovation work will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2433.501</td>
<td>Structure Removals</td>
<td>lump sum</td>
</tr>
<tr>
<td>2433.502</td>
<td>Remove (1)</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2433.503</td>
<td>Remove (1)</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2433.505</td>
<td>Remove (1)</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2433.506</td>
<td>Remove (1)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2433.507</td>
<td>Remove (1)</td>
<td>lump sum</td>
</tr>
<tr>
<td>2433.509</td>
<td>Remove (1)</td>
<td>each</td>
</tr>
<tr>
<td>2433.510</td>
<td>Place Used (1)</td>
<td>each</td>
</tr>
</tbody>
</table>
2433.511 Place Used (1) ........................................... kilogram (pound)
2433.512 Place Used (1) ........................................... lump sum
2433.513 Place Used (1) ........................................... cubic meter (Mbm*)
2433.515 Place Used (1) ........................................... meter (linear foot)
2433.516 Anchorages, Type ........................................... each

* Mbm = 1,000 Board-feet measure
(1) Specify item name such as structural steel, concrete, timber, masonry, etc.

2442
Removal of Existing Bridges

2442.1 DESCRIPTION
This work shall consist of the removal and disposal of existing bridges, or portions thereof, as indicated in the Contract.

2442.2 USE OF EXPLOSIVES
In addition to the requirements of 1711, the use of explosives in conjunction with the removal of existing bridges shall be subject to approval of the Engineer.

2442.3 REMOVAL AND DISPOSAL REQUIREMENTS
A General
Except as otherwise provided in the Plans or Special Provisions, the Contractor will not be required to salvage any materials during bridge removal. Materials that are not to be salvaged for the Department may be removed by any means the Contractor may desire, provided adequate precautions are taken to avoid damage to members that are to be salvaged.

All materials salvaged for the Department shall be placed in stockpiles at locations convenient for loading as directed by the Engineer. When the Contract specifies that certain materials are to be hauled to a storage yard, or some other designated location, those materials shall be neatly placed on suitable skids furnished by the Contractor. The Contractor in accordance with 1506 and 2104.3C shall dispose of all materials not required to be salvaged for the Department.

All portions of substructures, including piling and minor obstructions, shall be completely removed when they interfere with the new structure. Existing piles under new footings shall be removed to the bottom of the new footings. Existing substructure units located outside the limits of the new structures shall be removed to the elevation of the stream bed or to an elevation not less than 600 mm (2 feet) below the final ground surface, except that, in established navigation channels, they shall be removed to an elevation not less than 600 mm (2 feet) below the established bottom of the channel. Substructure units and piles that are located within the roadbed shall be removed to an
2442.3

elevation not less than 1200 mm (4 feet) below subgrade. When located on a railroad grade, such substructure units and piles shall be removed to an elevation 1200 mm (4 feet) below base of rail, unless otherwise directed.

Piles, portions of drift material, sheet piling and other minor construction within the limits of the Right of Way that are not a part of the existing bridge but that constitute obstructions to the stream channel or that present an unsightly appearance shall be removed as incidental to the removal of the existing bridge. This provision is intended to apply to minor items of work that may not be shown in the Plans but that are readily discernible upon inspecting the site of the work. Items such as ice breakers, portions of existing piers, and similar units, will be designated for removal in the Contract. The removal of items that are not included in the Contract and that are not visible on inspection of the site of the work will be paid for as Extra Work, except when the removal is solely for the Contractor's convenience.

Pits or trenches resulting from the removal operations shall be filled with suitable earth material. Backfill placed above water level shall be placed in layers not more than 300 mm (1 foot) in thickness, and each layer shall be thoroughly compacted.

When a bridge designated for removal is located elsewhere than at the site of the new structure, the removal of the existing bridge shall include the excavation and disposal of the embankments adjoining the abutments, as directed by the Engineer, to slopes conforming to the natural ground surface or to a 1 vertical to 2 horizontal slope beginning at the intersection of the front face of the abutment and the natural ground surface. In no case shall the stream channel be constricted except as provided for in the Contract, or as specifically permitted by the Engineer.

When it is necessary to remove part of an existing concrete pavement, the pavement shall be removed to an existing joint or cut on a straight line at right angles to the centerline of the road. When cutting is to be performed the top surface shall be cut for a depth of at least 25 mm (1 inch) with a saw, and care shall be taken to prevent damage to any portion of the pavement that is to remain in place. Precautions shall be taken during excavation operations to prevent undermining or disturbing the foundation material under pavement that will not be removed.

B Structural Steel

Structural steel that is to be salvaged shall be dismantled in sections, individual members, or parts as indicated in the Plans, or if not indicated in the Plans, then as directed by the Engineer. Unless
otherwise specified in the Contract, the removal shall conform to the original erection in reverse sequence. The manner and method of removal shall be one that will preclude damage to the members. Only field driven rivets shall be cut. Pins shall be drawn by means of pilot nuts wherever possible.

The Contractor shall match-mark all members with approved paint, in accordance with a diagram furnished by the Department. All pins, pin nuts, loose plates, ring fills, etc., shall be similarly marked to indicate their proper location. All loose parts shall be securely wired or bolted to adjacent members, or packed in boxes, properly identified.

All pins, pin-holes and machined surfaces shall be coated with an approved grease.

Rivets shall be removed with an approved pneumatic or hand tool. The use of torches will not be permitted unless specifically permitted in the Contract.

Structural steel shall be stockpiled on suitable skids and the material so arranged that dissimilar parts be in separate piles. This material shall be piled in order to preclude damage to the members.

2442.4 METHOD OF MEASUREMENT

Each bridge removed will be measured as a single lump sum with no separate measurement being made of any portions of the work. Salvage materials will be measured as a single lump sum for each bridge with no separate measurement if more than one type of material is salvaged.

2442.5 BASIS OF PAYMENT

Except as otherwise provided in the Contract, payment of the lump sum amount will be compensation in full for all operations necessary or incidental to bridge removal, including excavation, removal, disposal, backfill and grading of the work area.

Payment for the removal of existing bridges or material salvage will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2442.501</td>
<td>Remove Existing Bridge</td>
<td>lump sum</td>
</tr>
<tr>
<td>2442.502</td>
<td>Salvage and Haul Material (Bridge)</td>
<td>lump sum</td>
</tr>
</tbody>
</table>
Structure Excavations and Backfills

2451.1 DESCRIPTION
This work shall consist of excavating, preparing foundations and placing backfill for bridges and miscellaneous structures. It shall also include the construction and removal of cofferdams, making soil bearing tests, and the disposal of surplus excavated materials.

For the purpose of this Specification, the various types of structures shall be considered as being either the "cast-in-place" type or the "prefabricated" type. "Cast-in-place" structures shall be construed to be such structures as bridge substructures, concrete box culverts, concrete retaining walls, structural plate arch footings, etc. "Prefabricated" structures shall be construed to be such precast concrete or prefabricated metal structures as pipe culverts and sewers, cattle passes, subsurface drains, etc. The detailed Specification for a particular class of work will generally designate the applicable provisions of this Specification for each type of structure.

2451.2 MATERIALS
A  Granular Materials .................................................... 3149
Granular materials for special backfill, bedding, drain or filter purposes shall meet the requirements for the item of work as specified.

2451.3 CONSTRUCTION REQUIREMENTS
The following construction requirements are subject to any specific requirements or modifications that may be provided in the detailed Specifications for a particular class of work.

A  General Requirements
All foundations shall be prepared to the designated elevations and grades, and the structure or substructure placed in open excavations in the dry, by use of temporary construction adequate to accomplish this purpose.

A1  Site Preparations
All necessary clearing and grubbing shall be performed in accordance with 2101. The entire area bounded by straight lines between the structure extremities shall be cleared and grubbed. In the case of bridge construction, the clearing and grubbing shall extend to the Right of Way between the bridge extremities. Any tree branches that overhang the structure to the detriment of its function shall be neatly removed.

When the Proposal does not contain an estimated quantity for clearing and grubbing, any clearing and grubbing required for construction of the structure shall be considered to be Extra Work and paid for accordingly.
Any necessary preliminary embankment construction shall be performed in accordance with 2105 and will be paid for as provided therein.

A2 Elevations and Dimensions
The elevations shown in the Plans for the bottom of footings for bridges shall be considered as approximate only and the Engineer may order, in writing, such changes in elevations and dimensions of footings as may be necessary to secure a satisfactory footing.

The location and orientation of all box culverts and pipe structures, as shown in the Plans, shall be considered as approximate only. The Engineer will make whatever adjustments necessary to provide the most satisfactory placement.

A3 Temporary Construction
The Contractor shall provide temporary construction necessary to properly prosecute the work without unnecessary hazard or disruption, at no expense to the Department. Proper and adequate sheeting, shoring, bulkheads, dikes, channels, drainage pipes, sluiceways, cofferdams, warning signs and fencing shall be provided as may be necessary.

When specified in the Contract, the Contractor shall obtain the Engineer's approval of detailed construction Plans and methods prior to their execution.

A3a Cofferdams
Cofferdams shall be sufficient in size and construction to allow safe and adequate construction work to be performed therein, and to permit pumping and waterways outside of the forms. Provisions shall be made that will allow for lowering the foundation elevation to 1 m (3 feet) below that shown in the Plans.

No cofferdam bracing shall bear against the concrete forms or the structure. Steel bracing may extend through the poured concrete, if located below the final ground elevation. Boxing out of braces or struts will not be permitted except upon written approval of the Engineer.

Cofferdams located within roadbed embankments shall, when no longer needed, be removed to an elevation at least 1.2 m (4 feet) below the subgrade elevation. Those located in a stream or lake and within the limits of low water shall be removed to the elevation of the stream or lakebed except that, in established navigation channels, they shall be removed to an elevation at least 0.6 m (2 feet) below the established bottom of the channel. Those located outside the above defined limits shall be removed to an elevation at least 0.6 m (2 feet) below grade.

A3b Concrete Foundation Seal
When not indicated in the Plans, the Contractor may, at no expense to the Department and with the Engineer's prior approval, install a
concrete seal within a cofferdam. A written notice shall be delivered to the Engineer that indicates the planned seal thickness, sources of materials, and other pertinent facts. If the Engineer approves the use of the proposed seal, the Engineer will also furnish the Contractor with a mix design for the concrete to be used.

The seal shall be entirely below the planned foundation elevation. Excavation below the planned foundation elevation will be incidental to the seal construction. The seal placement shall be in accordance with 2401.3C insofar as it applies.

A.3c Pumping

Pumping from within any foundation enclosure shall be conducted in a manner that will preserve the foundation materials intact and not draw water through or over the fresh concrete. Pumping will be permitted during concrete placement, or within 24 hours thereafter, only if done from a suitable sump that is separated from the work by a watertight wall or other effective means of preserving the foundation.

Pumping to dewater a cofferdam sealed with concrete shall not be started until the seal has cured for a minimum period of:

1. Three days when the temperature of the water within the cofferdam has been maintained at or above 20°C (70°F);
2. Four days when the temperature of water has been maintained between 7°C (45°F) and 20°C (70°F); or
3. Five days when the temperature of the water within the cofferdam has been 7°C (45°F) or below during the curing period.

A.4 Restoration Work

Where the function and general features of the former surface at the excavation site will continue after the work is completed the Contractor shall satisfactorily restore the site to a like or better condition, for the intended function, as it was previous to the construction. Payment for necessary special materials in the restoration will be made only when the Contract specifically provides for payment under separate items.

A.5 Cold Weather Protection

The Contractor shall protect foundation soils against hard freezing and related heaving actions after a bridge substructure footing has been cast or foundation pilings have been driven. Protection may be obtained by placing permanent or temporary backfill materials or by using other insulating materials acceptable to the Engineer.

When, at the time of freezing conditions, the only pile driven within the foundation area is test piling, the aforementioned foundation protection requirements will not apply. However, if there is evidence of frost heaving, the Engineer may require that the test pile be further driven at the time the remainder of the piles are installed.
Excavating

B1 General
The Contractor shall excavate sufficiently to permit erection of all necessary forms, temporary construction, and proper compaction of the backfill materials, unless otherwise restricted in the Contract or allowed by the Engineer.

B2 Types
Classification of excavation type, as signified by the letters U, E, WE, or WR, shall be in accordance with the following designations:

- **U** --- All materials within the excavation unclassified as to the materials encountered or the conditions of removal.
- **E** --- All materials within the excavation except for those materials that are as described for Class R below.
- **R** --- Ledge rock, and boulders, detached rock, or concrete pieces, each having a volume of 0.4 m³ (½ cubic yard) or more.
- **W** --- The upper limit of any excavation so designated will be the elevation of low water, assumed or actual, as specifically shown in the Plans for waterway bridges.

The volume of structures, to be removed from within the excavation limits as a separate removal item, will not be considered as part of the excavation.

B3 Cast-In-Place Structures
Accumulation of water within the excavation, to the detriment of the structure or the stability of the backfill, may be considered as grounds for rejection of the work.

Excavation in streams or lake beds shall generally be confined within caissons or cofferdams. Any disturbance of a stream or lake bed shall be satisfactorily repaired using materials approved by the Engineer.

Special attention should be directed to completing excavation operations within sealed cofferdams before other operations are started, particularly in those areas that are not readily accessible to the excavating equipment, such as under waler, struts and other framework members.

B3a Earth Excavations
When the Plans call for concrete to be placed on a natural soil foundation without piling, the bottom of the excavation shall be accurately shaped to the required dimensions and elevations. The foundations shall be compacted by vibratory methods, where and to the extent determined by the Engineer. Unsuitable foundation soils shall be replaced with acceptable material, firmly compacted. Materials from below the foundation area that are removed unnecessarily by the Contractor, shall be replaced at no expense to the Department.
Excavation shall be nearly completed in advance of pile driving operations for a unit. After the piles have been driven, the bottom of the excavation shall be accurately shaped to the required elevation. Any excavation below the established elevation of the foundation shall, as directed, be backfilled with sand, gravel, or concrete at no expense to the Department.

B3b Rock Excavation
Class R and WR materials encountered in the excavation shall not be removed, unless the excavation is classified as Class U, before necessary measurements or other data have been obtained for pay quantity determination purposes by the Engineer.

Where the foundation for a footing is in solid rock, the rock shall be carefully removed to the elevation shown in the Plans for the entire area bounded by vertical planes through the neat lines of the footing. If no elevation is shown in the Plans, the rock shall be removed to an elevation no higher than the established elevation for the bottom of the footing or to the elevation designated by the Engineer.

Rock shall be removed in a manner that will not impair the quality of the foundation.

B4 Prefabricated Structures
B4a Earth Excavations
Where no special foundation construction is required, the excavation shall be completed in a manner that will provide uniform support under the entire structure, permit the satisfactory placement of the structure to the staked grade and line, and allow for the proper installation of backfill materials.

When special foundation treatment is required, the excavation shall be made to the extent necessary to provide the proper foundation thickness and uniform structure support.

B4b Rock Excavations
When materials are encountered during Class E or Class WE excavation that will be removed under the classification of Class R or Class WR excavation, these materials shall be sufficiently exposed before removal so that any necessary data for determination of pay quantities may be obtained by the Engineer.

Any unyielding materials such as bedrock, boulders or concrete located within 300 mm (1 foot) from the sides or the bottom of the structure shall be removed and replaced with “selected materials” as defined in 2451.3D, to the extent that a satisfactory foundation may be constructed in accordance with 2451.3C.
C  Foundation Preparations

The structure foundations shall be prepared according to the following provisions, except as modified by the applicable structure Specification and the Plans.

The Contractor shall, at no expense to the Department, provide temporary construction, pumping or other means to the extent necessary to permit structure construction in a dry excavation.

C1  Cast-In-Place Structures

All rock foundations shall be cleaned of all disintegrated and loose material or thin strata rock, after which all seams shall be cleaned out and filled with concrete, cement mortar or grout as directed. Unless otherwise provided in the Contract, the cleaning and filling of seams in rock foundations will be paid for as Extra Work.

Where the character of the natural foundation soil is unsuitable, additional excavation may be ordered below the planned footing elevation as the Engineer considers necessary to provide a satisfactory foundation. Limits of the excavation and the placement of special backfill shall be as the Engineer directs.

C2  Prefabricated Structures

Where a structure has its foundation in new embankment, the embankment shall first be constructed to an elevation 300 mm (1 foot) above the low point of the structure in accordance with the applicable provisions of 2105. Natural topsoil beneath the structure site shall be removed when the height of embankment to the bottom of the structure is 1 m (3 feet) or less.

Unsuitable foundation materials, when encountered at or below the foundation elevation, shall be removed and suitable replacement materials shall be installed as directed. The subfoundation excavation shall have near vertical sides and a bottom width equal to the structure width plus twice the depth of excavation. Unless otherwise provided, the replacement material shall conform to “selected material” as defined in 2451.3D, and shall be installed in 150 mm (6 inch) layers, each compacted to uniform density.

Before the structure is installed, the foundation shall be shaped to closely fit the bottom of the structure and provide uniform support. For lines of pipe the foundation shall be prepared according to the following requirements for Class C bedding, unless otherwise indicated in the Plans or Specifications.

Class C bedding shall consist of shaping the foundation material to closely fit the lower part of the pipe to a depth of: (a) at least 15 percent of the outside diameter for circular pipes; and (b) at least 50 percent of the height at the point of maximum span above the bottom of the arch for pipe-arch structures.
Class B bedding where specifically called for in the Plans, shall consist of bedding the culvert on a minimum 150 mm (6 inch) thickness of granular bedding material shaped by means of a template to accurately fit the lower part of the pipe exterior to at least 60 percent of the pipe width for round pipe and at least 80 percent for pipe-arches. After excavating the trench to an elevation that is approximately 15 percent of the outside diameter or rise of the pipe above the established grade for the bottom of the pipe, the foundation for the bedding shall be prepared by carefully excavating to the required depth and shape of the bedding.

All granular materials used for Class B bedding and foundation backfill at pipe installations shall be compacted as required for embankment materials under 2105 with the exception that, within the 150 mm (6 inch) layer immediately below and parallel to the bottom surface of the pipe, consolidation need only be sufficient to produce uniform pipe support. Compaction and any subsequent scarification of the bedding layer shall be such that only a layer of uniform and minimal thickness will remain uncompacted to facilitate template shaping.

**D Backfilling Excavations**

Excavations for structure construction shall be backfilled to the required extent and at the appropriate time. Suitable backfill materials shall be uniformly distributed in layers 200 mm (8 inches) or less in thickness (loose measurement) and thoroughly compacted to the required density before successive layers are placed.

Compaction of the backfill shall be in accordance with 2105 when Specified Density is required by the Plans for adjacent and overlying embankment construction. In all other cases, compaction of each layer shall continue until the density of the backfill and the adjacent material at the same elevation is considered by the Engineer to be acceptably equivalent.

Where special backfill materials are not specified, the backfill material within 450 mm (18 inches) of the sides and 300 mm (12 inches) above the top of the structure shall be "selected material" and the remainder of the backfill shall be acceptable embankment material as provided under 2105; or when outside the roadbed construction, any suitable material found in the excavation.

"Selected material" shall be an acceptable mineral soil that is free of clods, stones over 75 mm (3 inches) in greatest dimension, sod, and roots.

Backfill material shall not be placed on a foundation that is frozen deeper than 75 mm (3 inches), or when the material will freeze during the placement or compaction work.
2451.4

Sides of the excavation that are steeper than 1 vertical to 4 horizontal shall be stepped in every case where potential wedging action of the backfill is considered detrimental to the structure; except that the Contractor, at no expense to the Department, may enlarge an excavation and flatten the side slopes for backfill and compaction reasons when no specific maximum dimensions are required of the excavation.

To the extent that it will apply, backfilling shall progress uniformly in horizontal layers throughout the excavation area to be filled. Removal of any shoring or bracing from within the excavation shall proceed in a manner that will maintain the sides of the excavation intact and prevent voids in the backfilling.

E Surplus Materials

The Contractor shall dispose of excavated materials not needed for backfilling excavations at no expense to the Department and in accordance with 2105.3D.

2451.4 METHOD OF MEASUREMENT

The Department will determine quantities of excavation and embankment according to 1901, except as modified by these provisions. The Contractor shall provide sufficient time for the Engineer to determine quantities.

A Structure Excavation

The Engineer will not adjust (P) designated quantities except as provided for in 1901 or when certain excavation materials have been reclassified.

When the Contractor disputes an excavation quantity and the Engineer agrees to consider the dispute, the Engineer will recomputed the excavation quantity for the entire structure. However, if the excavation has been completed prior to a change ordered by the Engineer no deduction will be made for any resulting decrease in volume, nor will any addition be made for any increase in volume when no enlargement of the excavation is required.

For bridge excavations, any additional quantities disclosed in the recomputation will be considered separate from the quantities in the bid schedule.

When rock is encountered in the excavation, the volume of excavation under each classification will be recomputed using measurements of the rock quantity obtained when the rock is exposed. An increase or decrease in the volume of rock will result in a proportional decrease or increase in the other excavation classes to provide the total excavation quantity.
No adjustments will be made in the low water elevations shown neither in the Plan nor for safety concerns, working clearances, or stability of soils, regardless of existing conditions.

The Department will calculate structure excavation in accordance with the following except as modified for the type of structure, or as specified elsewhere in the Contract. The volume of structure excavation will be contained within the following limits:

(1) Vertical planes that encompass the structure, located 450 mm (1 ½ feet) beyond the outermost limits of the structure or its projections within the excavation.

(2) A top elevation that is either the natural ground surface or the designated elevation, in embankment or excavation, from which the structure excavation will begin.

(3) The bottom of the structure and its projections.

When an old structure is removed as a separate Contract item from within the excavation limits of the new structure, structural excavation will be reduced by a quantity equal to the space taken by the old structure.

Excavation quantities will not include material removed by the Contractor to expedite the work when that material is planned for removal by others or as a different Contract item.

A1  Cast-In-Place Structures

In ledge rock, the horizontal limits of excavations for footings will be the Plan footing limits.

Excavation for timber pile abutments and timber bents will be measured to the limits shown in the Plan. If no limits are indicated, the excavation will be incidental to the construction.

A2  Prefabricated Structures

Where foundation construction is required to a greater surface dimension than that provided above, the excavation will be measured using the greater dimension.

A2a  Induced Trench

Where the induced trench method (2501.3E) of structure installation is required, the additional excavation required to accommodate the loose backfill over the structure will be measured as the volume:

(1) Within the planned grading section,

(2) Between vertical planes separated by a distance equal to the outside width of the structure, and

(3) A depth equal to the outside height of the structure.
B  Granular Materials
The Engineer will measure granular materials for special backfill, bedding, or filter purposes by volume in accordance with 1901 and as specified in the Contract:
(1) Loose volume (LV), or
(2) Compacted volume (CV).

2451.5 BASIS OF PAYMENT
Except as specifically modified, the payment at the Contract unit price for the classes of structure excavation listed in the Proposal will be considered as compensation in full for all costs incurred in performing the required structure excavation and preparing the foundation for the subsequent construction.

When the Contract does not provide a unit price for Class R and Class WR excavation and the materials in this category are encountered during Class E or Class WE excavation, payment will be made separately for this work at a unit price determined as follows:
(a) Class R at 5 times the unit price of Class E.
(b) Class WR at 3 times the unit price of Class WE.

The unit bid prices for excavation for cast-in-place structures will be subject to adjustment as follows:
(a) Additional required excavation depth. The unit price will be increased 25 percent for additional excavation to 1 m (3 feet) below the planned excavation. When excavation is required to a depth greater than 1 m (3 feet) below the planned elevation, this portion of the additional excavation will be measured separately and will be paid for as Extra Work unless the unit price increased by 25 percent, or a lower price, is mutually acceptable to both the Contractor and the Engineer.
(b) Changed structure dimensions. When additional excavation is required because of changes in the dimensions, and the Contractor objects to payment therefore at the Contract prices, the additional excavation will be measured and paid for as Extra Work.
(c) Disputes of the Plan quantities. Any additional structure excavation disclosed for a bridge structure, when the quantities are recomputed at the Contractor's request, will be paid for separately at 50 percent of the Contract bid price per unit of measure.

Payment on the basis described above will be construed to include compensation in full for the work of making all removals and disposals necessary to the excavation; providing all necessary safeguards for the maintenance of drainage and proper prosecution of the work; and making whatever restoration or improvement that is required over, around, or because of the structure; all that is not otherwise paid for under separate Contract items.
Payment for granular material items at the appropriate Contract prices therefore will be compensation in full for all costs of furnishing the materials, placing and compacting the materials as specified, including the excavation required therefore in cases where Structure Excavation is not paid for as separate items.

Granular materials used for bedding, backfill, or filter purposes as required by the Plans, these Specifications, or by order of the Engineer, will be paid for as Extra Work in the absence of an appropriate pay item therefore.

Structure excavation will be paid for as a separate item only when so provided for in the detailed Specification for the type of structure involved, and then payment will generally be made under the items provided therein.

Payment for work performed under this Specification will be made in accordance with the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2451.501</td>
<td>Structure Excavation, Class ___</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2451.503</td>
<td>Granular Backfill ____ (1) .......</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2451.505</td>
<td>Aggregate Backfill ____ (1) .......</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2451.507</td>
<td>Granular Bedding ____ (1) .......</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2451.509</td>
<td>Aggregate Bedding ____ (1) .......</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2451.511</td>
<td>Coarse Filter Aggregate ____ (1)</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2451.513</td>
<td>Fine Filter Aggregate ____ (1)</td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>

NOTE (1): For all granular material items, specify the basis of measure (LV or CV) after the item name. See 2451.4B.
2452.3

2452

Piling

2452.1 DESCRIPTION
This work shall consist of the furnishing and driving of piling for the purposes indicated in the Contract.

2452.2 MATERIALS
A  Timber Piling .............................................................. 3471
B  Preservative Treatment .............................................. 3491
C  Steel H-Piles ................................................................. 3372
D  Cast-in-place Concrete Piles
   D1  Steel Pile Shells ............................................................ 3371
   D2  Concrete, Mix No. 1C62............................................... 2461
E  Reinforcement Bars.................................................... 3301

2452.3 CONSTRUCTION REQUIREMENTS
A  Delivery and Inspection of Piling
When test piles are specified in the Contract, the number of piles and lengths shown in the Plans are subject to change. The Engineer may designate that piles authorized for one unit of a structure be driven in another unit of the same structure or any unit of an adjacent structure constructed under the same Contract. When test piles are not specified in the Contract, the number and lengths of piles to be delivered will be shown in the Contract.

Prior to delivery, the Contractor shall establish the quality of the material in steel H-piles and in steel shells for cast-in-place concrete piles. The Contractor shall submit to the Engineer the Mill Test Reports and Mill Shipping Papers as specified in 3371 and 3372.

The use of small quantities of piling from the Contractor's surplus of cut-offs and overruns may be submitted for use and approved by the Engineer. These materials shall be certified by the Contractor to be remaining quantities of materials previously submitted with accompanying Mill Test Reports and subsequently approved for use on other projects. Pile splices used to make up authorized pile lengths shall be considered to have been made at the Contractor's convenience and shall not be considered eligible for extra compensation under 2452.4B.

Piling shall not be driven until the material has been accepted on the basis of mill test reports.

All piling will be given a visual inspection at the site before driving, to ascertain the quality of welding done in manufacture or splicing, and to determine that the pile lengths contain no physical defects such as kinks or buckles that would cause the pile to fail in driving or not perform as intended.
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B  Handling, Transportation and Storage
Piling shall be handled, transported, and stored by methods that will not be detrimental to any portion of the piles that will remain in the completed structure.

C  Equipment for Driving

C1  Requirements for Pile Hammers
In addition to conformance with the minimum ram mass and energy requirements shown in Table 2452-1, the pile hammer selected for a particular job shall be one that will yield a computed bearing at least equal to that which is defined as substantial refusal under 2452.3E1, as determined in 2452.3E2, at a penetration rate of not less than 3.8 mm (0.15 inches) per blow for gravity hammers and not less than 1.3 mm (0.05 inches) per blow for power-driven hammers. In lieu of the above requirements, hammer approval may be based on the satisfactory results of a wave equation analysis.

At least 30 days prior to the start of pile driving operations, the Contractor shall submit a completed pile and driving equipment data form (available from the Engineer) for each hammer proposed for the project and a wave equation analysis in accordance with GRL WEAP or similar program for each pile type and hammer.

The mass of the driving cap shall be included with the pile mass when it receives the hammer blow, but it should not be included when the ram delivers the blow directly to the pile.

When requested by the Engineer, the Contractor shall furnish the necessary statistical information concerning the pile hammer to be used. The same pile hammer, or a similar hammer, shall be used for driving the test piles as will be used for driving the piles authorized as a result of the test pile driving, except as may otherwise be indicated by driving conditions or substantial differences in pile sizes.

Gravity hammers shall not be used for driving cast-in-place concrete pile shells except when specifically permitted by the Special Provisions.

C2  Pile Driving Caps
When necessary to protect the pile against damage during driving, the top of the pile shall be equipped with a driving cap of a size and type that will serve the purpose. A shock block of approved type and size shall also be used on the upper side of the driving cap, when necessary. Generally, the recommendations of the pile hammer manufacturer shall be followed with respect to driving caps and shock blocks.
# TABLE 2452-1
MINIMUM REQUIREMENTS FOR PILE HAMMERS

<table>
<thead>
<tr>
<th>Pile Type</th>
<th>Hammer Type</th>
<th>Gravity Hammers</th>
<th>Power Driven Hammers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mass kg (lbs)</td>
<td>Required Ram Mass kg (lbs)</td>
<td>Energy Joules (ft - lbs)</td>
</tr>
<tr>
<td>Timber &amp; Steel H-Pile</td>
<td>1,090 (2,400)</td>
<td>680 (1,500)</td>
<td>9,490 (7,000)</td>
</tr>
<tr>
<td>Less than 15.24 m (50 feet) long</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.24 m (50 feet) or longer</td>
<td>1,360 (3,000)</td>
<td>815 (1,800)</td>
<td>16,950 (12,500)</td>
</tr>
<tr>
<td>Steel Shells for Cast-In-Place Pile</td>
<td>Not permitted</td>
<td>815 (1,800)</td>
<td>16,950 (12,500)</td>
</tr>
<tr>
<td>All lengths</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## C3  Pile Driver Leads
Pile driver leads shall be of a type that will hold the pile and the pile hammer in proper alignment during driving operations, and shall be long enough to preclude the necessity for the use of punches or chasers. Leads for drop hammers shall be steel or steel shod. Generally, the recommendations of the pile hammer manufacturer shall be followed with respect to pile driver leads.

## C4  Water Jets
When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 690 kPa (100 psi) pressure at two 19 mm (¾ inch) jet nozzles.

## D  Pile Driving
The Contractor shall notify the Engineer at least 24 hours before beginning any pile driving operations. The Engineer will reestablish the working points for each substructure unit after the excavation has been completed for that unit, but staking the pile locations shall be the responsibility of the Contractor.

Before any foundation piles or test piles, are driven in any unit, the excavation shall be completed to approximately the planned bottom of footing elevation. During pile driving operations, the water level in the excavation shall be kept below the top of the pile. Under-water pile driving will not be permitted unless a concrete foundation seal is required.
For each foundation pile, pile driving operations shall be as continuous as practicable unless otherwise directed by the Engineer.

In general, timber piles shall be sharpened to a minimum square point of 127 mm (5 inches) at the tip unless the subsoil is unusually soft or the piles will have point bearing on hard stratum. In such cases the pile shall remain blunt.

When the Contract provides for the construction of a concrete foundation seal, the piling may be driven by means of a power-driven hammer equipped to drive when submerged. The use of punches or chasers for pile driving will not be permitted. When the top of the hammer is submerged during the driving it shall be equipped with accurate detachable measuring rods for the purpose of recording pile penetration. Special care shall be given to obtain accurate location and spacing of the piling.

The pile material and all appurtenances shall be capable of withstanding driving to substantial refusal, as defined in 2452.3E1, without failure. Failure shall mean any buckling, bending, kinking, splitting, or rupture that will impair the strength of the pile, or that will reduce the effectiveness of the energy delivered by the pile hammer, as determined by the Engineer.

In the event that the piling material and appurtenances furnished for the work cannot satisfactorily withstand driving to substantial refusal, the Contractor shall discontinue pile driving until changes or corrections can be made in the pile driving operations and equipment, or until pile material with satisfactory strength is furnished. Only when failure of the pile occurs subsequent to issuance of an order by the Engineer to continue driving after substantial refusal has been obtained will the damage be considered to be the responsibility of the Department.

Jetting and Preboring

Water jetting may be used, or may be required, as an aid to driving timber or other displacement type piles, when driving to satisfactory penetration might otherwise be impractical or might be detrimental to the piles. Jetting shall not be used in embankments, or other areas where it may cause damage to the existing soils. Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration.

Preboring will be required for displacement type piles that are to be driven through embankments, when the depth of the embankment, measured below the bottom of the footing, is more than 2.4 m (8 feet). The depth to which preboring will be required shall be approximately the depth of the embankment, except that in the case of a shallow, dense crust at the surface of the original ground, preboring shall be continued through this crust when directed by the Engineer.
The Engineer may require pre boring through embankments less than 2.4 m (8 feet) in depth when the character and density of the material is likely to cause damage to the piles during driving. The Engineer may also require pre boring for displacement type piles when the character and density of the material below the bottom of a footing is of a nature that precludes driving to a penetration of approximately 3.0 m (10 feet) below the bottom of the footing without causing damage to the piles. A penetration of less than 0.75 mm (0.03 inch) per blow for each 1356 J (1000 foot pounds) of rated energy will be considered, for this purpose, as an indication of probable damage, due consideration being given to the mass of the ram and to the type and size of the piles.

The diameter of the prebored holes shall be sufficiently large to admit the largest section of the pile without creating friction between the faces of the pile and the prebored hole.

Sawing or cutting the body of a pile to assist in springing it to proper location will not be permitted. If a pile vibrates excessively, or shows signs of buckling during driving, it shall be braced or guyed as directed by the Engineer.

D2 Test Piles

Test piles shall be furnished as required by the Contract, and shall be driven at the locations shown in the Plans except when otherwise permitted or directed by the Engineer.

Except when otherwise permitted by the Engineer, test piles shall be full length when placed in the leads, and driving shall be as continuous as practicable. When the Engineer determines, from information shown on the survey sheet or from previous pile driving in the area, that test piles can be driven in sections without the danger of "set-up" during the period required for splicing, sectional driving will be permitted.

The Contractor shall cooperate with and assist the Engineer in obtaining data for bearing for the full length of the driving. When driving in soft or plastic soils or when conditions are favorable for obtaining pile "set-up", the Engineer may require the redriving of test piles. In such cases, the driving will be stopped at a point when the top of the pile is from 0.6 to 1.5 m (2 to 5 feet) above cut-off and resumed after a minimum delay of 24 hours in accordance with 2452.3D7.

In the event the Engineer determines that steel test piles or steel shells for cast-in-place test piles of specified length have not developed adequate bearing capacity, the Engineer may order additional lengths spliced thereon.
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D3  Pile Load Tests
D3a  General

Pile load tests, when required by the Contract, shall be made at the indicated locations or as directed by the Engineer. Concrete for cast-in-place concrete piles shall have been cast at least 7 days prior to starting the load test; this requirement may be reduced to 5 days when high-early strength concrete is used. Unless piles are driven to end bearing on rock or other similar hard strata, load testing shall not start until at least 5 days have elapsed since driving.

Pile load tests shall be accomplished by means that will provide accurate information and not be detrimental to the work or hazardous to the workers or inspectors. The Contractor shall submit details of the method and equipment proposed for use for the load test to the Engineer at least 10 days in advance of the scheduled test.

Pile load tests shall be completed and sufficient time allowed for analysis before proceeding with any further pile driving upon which the results of the load test may have an influence. Piles that are to be used as reaction piles, if driven at proper locations, may later be included as foundation piles. Reaction piles shall not be driven within 2.1 m (7 feet) of the pile to be load tested unless authorized by the Engineer. Final determination regarding the use of permanent piles as reaction piles will be subject to approval of the Engineer, and redriving of these piles may be required if there is evidence that uplift has occurred.

When a hydraulic jack is used as a means of applying load on the pile in specified increments, it shall be equipped with a pressure gauge. The jack and the gauge shall be calibrated as a unit to the satisfaction of the Engineer. The jack shall be capable of maintaining specified loads within a tolerance of plus or minus 5 percent for loads up to 45 metric tons (50 tons) and 3 percent for loads in excess of 45 metric tons (50 tons). A certified calibration chart shall be available to the Engineer for each jack and gauge combination to be used.

Ames dials for measurement of settlement will be furnished, placed and read by the Engineer, but the Contractor shall provide and install posts and cross frames as required for proper support of these dials. The support system for the Ames dials shall be independent of the other loading apparatus and shall have the support beams perpendicular to the reaction beam.

The Contractor shall provide a suitable temporary shelter at the location of each load test to protect the workmen, inspectors, and equipment during the time the load test is being conducted. Heat and lights shall be provided if deemed necessary by the Engineer.
D3b  Pile Load Tests, Type 1

Test loads shall be applied in increments up to a total of not less than 200 percent of the minimum pile bearing required by the Plans for the unit in which the load test is required, unless failure results at a lesser load. Failure, for this purpose, shall be considered to have occurred when the total settlement of the pile being load tested is in excess of 50 mm (2 inches). The load increments, defined as a percent of the total load, shall be applied as shown in the following tabulation, and shall be held for the indicated time after all measurable settlement has ceased.

Reading to determine cessation of measurable settlement will be taken every 15 minutes, and measurable settlement shall be considered as having ceased when the average of two or more dials indicates a settlement of less than 250 µm (0.01 inch) during a 15 minute period. Readings thereafter will be taken at 1-hour intervals, until the required time has elapsed for that increment, except when the Engineer determines that readings should be taken at closer intervals.

The load test increments shall be removed in reverse order from that in which they were applied, except that the time interval to be held for each increment will be limited to one 15 minute period. The final reading will be taken 2 hours after all load has been removed.

<table>
<thead>
<tr>
<th>Percent of Total Load</th>
<th>Holding Time After Measurable Settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>1 hour</td>
</tr>
<tr>
<td>50</td>
<td>2 hours</td>
</tr>
<tr>
<td>60</td>
<td>3 hours</td>
</tr>
<tr>
<td>70</td>
<td>4 hours</td>
</tr>
<tr>
<td>80</td>
<td>5 hours</td>
</tr>
<tr>
<td>90</td>
<td>6 hours</td>
</tr>
<tr>
<td>100</td>
<td>12 hours</td>
</tr>
</tbody>
</table>

D3c  Pile Load Tests, Type 2

The total load to be applied for each Type 2 pile load test shall be 400 percent of the minimum pile bearing required by the Plans for the unit in which the load test is required, unless failure results at a lesser load. Failure is considered to have occurred whenever continuous
pumping of the hydraulic jack is required to maintain load or when the settlement becomes disproportionate to the load being applied.

In addition to satisfying the requirements for hydraulic jacks in 2452.3D3a, the device for increasing jacking load shall be located in the immediate vicinity of the load test such that the person reading the pile deflection gauges and the person applying the jacking pressure can readily communicate necessary information. The jack shall have a minimum ram travel of 150 mm (6 inches).

The load shall be applied in increments of 4.5 metric tons (5 tons) at 2.5 minute intervals. Once failure has occurred or the required load has been reached, all loading shall be quickly and smoothly removed.

D4  Foundation Piles

Piles shall be guided during driving so as to terminate with the indicated batter, or plumbness, within a tolerance of 40 mm/m (\(\frac{1}{2}\) inch per foot), and so that the pile will be properly positioned within the footing area. Improperly positioned piles may be rejected, or payment reduced, when the Engineer determines that their function is impaired.

When there is evidence or probability that some piles in a unit have heaved while driving subsequent piles, the Engineer may require that these piles be redriven, and the pile driving will not be considered to be complete until these piles have been redriven.

D5  Trestle Piles

Trestle piling refers to any types of piles that are driven in single rows and that are capped with timber, steel or concrete caps, requiring that the piles be driven to closer tolerances than those generally associated with pile driving.

Piles shall be guided during driving so as to terminate with the indicated batter, or plumbness, within a tolerance of 20 mm/m (\(\frac{1}{4}\) inch per foot), and so that the pile will be properly positioned in the bent. Improperly positioned piles may be rejected, or payment reduced, when the Engineer determines that their function is impaired. Timber trestle piles shall be so selected that all piles in a bent will be of reasonably uniform diameter.

D6  Cast-in-Place Concrete Piles

The bottom of each pile shell shall be equipped with a driving shoe that shall be made watertight by welding and that shall not extend more than 6 mm (\(\frac{1}{4}\) inch) outside the periphery of the shell.

The Contractor and the Inspector shall inspect each pile jointly as soon as practicable after driving, for depth to the driving shoe and for condition of the shell. Any observable impairment or damage shall be called to the attention of the Engineer who will determine the acceptability of the pile, taking into consideration the bearing
requirements and driving conditions. Suitable light shall be provided for the inspection.

Reinforcement bars will not be required unless indicated in the Plans.

Vibration of the concrete will be required only when reinforcement cages are used within the shells, and then only for that portion of the pile containing the reinforcement cages.

Pile driving and other operations that may be detrimental to concrete during setting shall not be conducted so near to the concrete-filled piles as to cause noticeable vibrations thereof until the concrete has been in place for at least 3 days.

Concrete for footings and caps shall not be placed until the day following concrete placement for the piles.

Concrete in the piles shall be protected against freezing temperatures for not less than 3 days after placement. Concrete in that portion of the pile that is above a location 3 m (10 feet) below the groundline or waterline shall have 30 percent additional cement if the concrete is placed during freezing weather.

D7 Pile Redriving

If so directed by the Engineer, the Contractor shall redrive the test piles to determine the capacity that can be obtained by including pile "set-up". Subsequently, an additional number of foundation piles may be designated for redriving to verify that adequate bearing capacity has been achieved.

Piles designated by the Engineer to be redriven shall have a required minimum time delay of 24 hours, or as otherwise specified in the Proposal, between the initial driving and the redriving. During this time delay, no other piles shall be driven, unless authorized by the Engineer. All redriving shall be performed using a "warm" pile hammer. Generally, applying at least 20 blows to a previously driven pile or timber mats will warm up the hammer. Redrive hammer strikes shall not exceed 20 blows for each pile. Piles shall not be trimmed to the Plan cut-off elevation until the Engineer has determined the need for redriving.

No pile in any one substructure unit shall be filled with concrete until the Engineer decides that all piles in the unit have been driven to adequate bearing capacity and the pile shells have been trimmed to the cut-off elevation.

The Engineer may require that extensions be welded to piles that have been authorized and subsequently driven, or may require that additional foundation piles be driven at specified locations. In either case, the Contractor shall be compensated for furnishing and driving the additional pile lengths at the Contract prices per meter (linear foot).
E Penetration and Bearing

E1 General

The pile bearing requirements shown in the Plans are based on design loadings and indicate the loads that the piles may be required to support. The pile bearings computed using the dynamic formulas defined under Determination of Bearing Capacity are approximations only, and driving shall continue beyond these bearings until the required penetration is reached, or until the pile has been driven to substantial refusal or to a penetration and bearing satisfactory to the Engineer.

The following definition for "substantial refusal" is provided as a guide, and is based on normal conditions, normal pile lengths and sizes, and for pile hammers with a ram mass not less than the mass of the pile plus the driving cap. The Engineer will make such modifications as necessary to compensate for conditions less favorable than those defined above.

Except for conditions less favorable than those defined above, substantial refusal for drop hammers will be considered to have been attained when the penetration per blow produces a computed bearing that is not less than 130 percent of the design load. For power driven hammers substantial refusal will be considered as 160 percent of the design load. Bearing computations are based on formulas and conditions specified under Determination of Bearing Capacity. Design loads are those shown in the Plans after reduction factors have been applied.

E2 Determination of Bearing Capacity

The bearing capacity of piles will be determined by dynamic formulas, as follows:

All types of piles driven with gravity hammers.

\[ P_{\text{metric}} = \frac{2.5WH}{S + 13} \times \frac{W + 0.1M}{W + M} \]
\[ P_{\text{english}} = \frac{3WH}{S + 0.5} \times \frac{W + 0.1M}{W + M} \]

Timber, concrete, and shell type piles driven with power-driven hammers.

\[ P_{\text{metric}} = \frac{289E}{S + 5} \times \frac{W + 0.1M}{W + M} \]
\[ P_{\text{english}} = \frac{3.5E}{S + 0.2} \times \frac{W + 0.1M}{W + M} \]

Steel H-piling driven with power-driven hammers.

\[ P_{\text{metric}} = \frac{289E}{S + 5} \times \frac{W + 0.2M}{W + M} \]
\[ P_{\text{english}} = \frac{3.5E}{S + 0.2} \times \frac{W + 0.2M}{W + M} \]

WHERE:

\[ E = \text{Applicable modulus of subgrade reaction} \]
\[ W = \text{Weight of pile} \]
\[ M = \text{Mass of driving cap} \]
\[ S = \text{Pile penetration} \]
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\[ P = \text{Safe bearing capacity in Newtons (pounds).} \]
\[ W = \text{Mass of the striking part of the hammer in kilograms (pounds).} \]
\[ H = \text{Height of fall in millimeters (feet).} \]
\[ S = \text{Average penetration in millimeters (inches) per blow for the last 5 blows for gravity (drop) hammers and for the last 10 or 20 blows for power-driven hammers, except in cases where the pile may be damaged by this number of blows.} \]
\[ M = \text{Total mass of pile plus mass of the driving cap in kilograms (pounds).} \]

*The following definition is for Metric units; see English units below:

\[ E = WH \times 0.00981 \text{ for single acting power-driven hammers.} \]

\[ E = \text{is equal to the joules or newton-meters (joule = newton-meter) of energy per blow for each full stroke of either single acting or double acting hammers as given by the manufacturer's rating for the speed at which the hammer operates.} \]

*The following definition is for English units:

\[ E = WH \text{ for single acting power-driven hammers.} \]

\[ E = \text{is equal to the foot pounds of energy per blow for each stroke of either single acting or double acting hammers as given by the manufacturer's rating for the speed at which the hammer operates.} \]

NOTES:

When provisions are not made available for field determination of the energy output on a power-driven hammer, such as measurement of the drop for single-acting hammers, or such as pressure gauges or determination of energy on the basis of the frequency of the blows (cycles per minute) for double-acting hammers, computed bearings based on dynamic formulas shall be reduced by 25 percent. This reduction is not intended to apply when determining the required hammer size. Double-acting hammers, for the purpose of these requirements, will include all hammers for which a power source is utilized for acceleration of the down-stroke of the ram. The dynamic formulas specified herein-before are applicable only when:

(a) The gravity hammer has a free fall.
(b) The height of the fall of a gravity hammer will produce an energy blow between 37,950 and 48,800 J (28,000 and 36,000 foot pounds).
(c) The head of the pile is free from broomed or crushed fibre.
(d) The penetration of the pile is at a reasonably uniform rate.
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(e) There is no noticeable bounce after the blow. When there is a noticeable bounce, twice its height shall be deducted from $H$ to determine the value of $H$ in the formula.

F  Pile Cutoff

F1  Piles

Timber piles shall be cut off in the manner and at the elevation shown in the Plans, within a tolerance of plus 13 mm (½ inch) and minus 25 mm (1 inch). The head of the pile, after cut-off has been made, shall be sound, undamaged wood.

Steel piles shall be cut off by an approved method at the established elevation, except that when they are driven approximately to cut-off elevation without damage to the pile head, a tolerance of 25 mm (1 inch) above or below cut-off elevation will be permitted.

F2  Pile Bents

After the pile bent has been aligned and securely braced, the tops of timber piles shall be accurately cut off at the established elevation, so as to provide uniform bearing for the cap without the use of shims or fills.

Steel piles shall be cut off by an approved method at the established elevation when the type of construction is such as to require accurate framing of the members.

F3  Field Treatment of Tops of Timber Piles

After being cut off, the tops of all treated piles shall be treated with three coats of copper naphthenate or another compatible preservative conforming to AWPA Standard M4, with a minimum time lapse of 2 hours between applications.

G  Disposal of Pile Cut-offs

The Engineer shall have the right to require that pile cut-offs belonging to the Department be used in substructure units for which piling lengths have not been authorized for the same structure or for adjacent structures under the same Contract.

In the event that the Engineer directs the Contractor to make up a steel shell pile entirely from Department-owned cut-offs, furnishing and attaching the end plate will be considered to be equivalent to making an additional splice and the payment will be made accordingly.

All remaining steel H-pile and steel shell pile cut-offs, together with any timber cut-offs designated by the Engineer for salvage, shall be stockpiled by the Contractor on skids at a location convenient for truck loading. Cut-offs not designated for salvage shall be disposed of by the Contractor in a manner satisfactory to the Engineer.
H  Extensions and Splices

Splices for steel H-piles and steel shell piles shall be made in accordance with the details shown in the Plans, except that splices for cold rolled fluted steel shells shall be made as recommended by the manufacturer, subject to approval of the Engineer.

Welding shall be governed by 2471.3C, and the welders shall have been qualified as prescribed therein.

Splices made on piles that are to be driven in pile bents, shall be made at points that will not be exposed to view, unless otherwise specifically directed or authorized by the Engineer, in which case they shall be finished to present a neat appearance.

Commercial drive-fit splices may be permitted on a performance basis, subject to approval of the Engineer. However, such splices shall not be used in pile bent-type piers or abutments, where foundation soils are soft or unstable, in foundations where uplift is anticipated, or within 3 m (10 feet) of the pile cut-off.

J  Painting Steel H-Piles and Steel Pile Shells

The paint and painting shall be in accordance with 2478. Steel pile shells shall conform to the requirements for painted surfaces in 3371.

Steel H-piles and steel pile shells that will extend above ground surface or water surface shall be protected by epoxy zinc-rich primer on the outside of the piles for the entire length, except for those sections below splices that will be at least 600 mm (2 feet) below the final ground surface or low water elevation. Primer shall be applied at least 2 days before the piles are driven, and preferably before shipment.

After driving, the piles shall be painted with intermediate and finish coats on those exposed portions that are above the level of the water, as it exists at the time the paint is applied, or above an elevation 150 mm (6 inches) below the final ground surface. The color of the finish coat shall match Federal Standard 595 B No. 37200 (lusterless aluminum) where the superstructure is concrete and the topcoat color when the superstructure is painted steel. When superstructure is unpainted 3309 steel or timber, finish coat shall match 595 B No. 10075 (brown) but have a semi gloss finish.

2452.4  METHOD OF MEASUREMENT

A  Test Piles

When the Proposal contains specific Contract items for test piles, measurement will be by the number of test piles furnished in accordance with the Contract and driven as directed by the Engineer. Test piles will not be eliminated from the Contract, unless all piles for the unit in which they are to be driven are eliminated, or unless mutually agreed upon by the Contractor and the Engineer. When test
piles are not a separate item, measurement will be made as piling delivered and piling driven.

In the event the Engineer determines that steel H-test piles or steel shells for cast-in-place concrete test piles, furnished in accordance with the lengths specified in the Contract, do not develop sufficient bearing capacity or do not provide adequate information for ordering foundation piles, the Engineer may order that extensions be spliced onto these test piles, or that longer piles be delivered in their place. Additional quantities of piling so ordered and driven will be measured and paid for under 2452.4B, 2452.4C, 2452.5B and 2452.5C.

B  Piling Delivered

Piling delivered will be measured, as indicated in the Proposal, for acceptable piling delivered at the site of the work, and furnished in accordance with the lengths and sizes specified in the Contract when test piles are not required, or the lengths authorized by the Engineer when test piles are required.

C  Piling Driven

Piling driven will be measured by the length of acceptable piling below cut-off.

D  Pile Load Tests

Pile load tests will be measured by the number of piles load tested in accordance with the Contract and as directed by the Engineer.

E  Reinforcement Bars

Reinforcement bars used in cast-in-place concrete piles will be measured by mass, in accordance with 2472.

F  Pile Redriving

Pile redriving will be measured by the number of piles redriven in accordance with the Contract and as directed by the Engineer. The estimated plan quantity will be recomputed to agree with the actual number of piles redriven at the project site. The Department anticipates that not more than 25% of the total number of piles shown in the Plan will require redriving.

2452.5  BASIS OF PAYMENT

The fixed costs of all piling delivered and all piling driven are included in the compensation for the test piles when test piles are a separate item in the Contract. When test piles are not a separate item in the Contract and when no other provisions are made for fixed costs, fixed costs are included in the compensation for mobilization.

A  Test Piles

Payment for test piles of each kind and length, as a separate item at the Contract price per pile, will be compensation in full for all costs of furnishing and driving the piles in accordance with the requirements of the Contract, including the costs of furnishing and placing driving caps
and concrete for cast-in-place concrete piles and painting steel H-piles and steel shell piles.

B Piling Delivered

Payment for piling delivered at the Contract price per unit of measure for each kind will be compensation in full for all costs of furnishing the piling in the required lengths at the job site, in accordance with the requirements of the Contract and as authorized by the Engineer, except as otherwise provided for hereinafter.

Steel H-piles and steel shells for cast-in-place concrete piles delivered to the job site in stock lengths, prior to authorization of final lengths based on test pile driving, shall be entirely the Contractor's responsibility. Partial payments may include the actual cost of piles so delivered, but payment at the Contract bid prices for piling delivered will be made only for piles that have been furnished by authorization of the Engineer. Final payment for piling delivered will only be for authorized lengths, and any remaining unauthorized piles delivered shall be the property of the Contractor and shall be removed from the Project by the Contractor.

Piles, or portions of piles, that become damaged during handling will not be eligible for payment. Piles that become damaged during driving, so as to cause their rejection as structural members, may be eligible for payment if the Engineer determines that the damage was not due to the Contractor's carelessness or negligence. Piles rejected due to the use of an excessively heavy hammer will not be eligible for payment.

Splicing of steel H-piles and steel shell piles will be eligible for extra compensation when the splice is actually made and:

(a) Changes were ordered by the Engineer after the piles have been cut to lengths previously authorized;
(b) Lengths longer than the length of the longest test pile of a specific kind shown in the Plan were authorized by the Engineer for a particular unit, and then only for any extra splices required;
(c) The Engineer ordered cut-offs, belonging to the Department, to be spliced together or onto other sections, except when this is done solely for the Contractor's convenience.

Unless otherwise provided for in the Contract, each splice eligible for payment under conditions enumerated above will be paid for at the rate of two times for Metric or (six) times for English, the Contract unit bid price for piling delivered.

C Piling Driven

Payment for piling driven at the Contract price per unit of measure for each kind will be compensation in full for all costs of preparing the piles for driving, preboring, jetting, furnishing and placing the driving
shoes and concrete for cast-in-place piles, cutting and trimming, and painting steel H-piles and steel shell piles.

In the event foundation conditions are found to exist at the site of a structure, or a portion thereof, that are quite different from those upon which the foundation design was based, resulting in changes in foundation design or resulting in requirements for foundation pile lengths substantially different from those upon which the unit bid prices were established, the Engineer will, upon presentation of documentary evidence by the Contractor, enter into a Supplemental Agreement to reimburse the Contractor for any additional pile driving expense incurred as a result of those changes.

Payment for driving pile cut-offs from previously driven piles in the same Contract, which are the property of the Department, will be made at the following percentages of the Contract bid prices for piling driven:
1. Timber and Steel H-Piles ......................................................150%
2. Cast-in-Place Concrete Piles .................................................200%

Payment for driving pile cut-offs in accordance with the above provisions will include all costs incidental thereto, except making the required splices, the costs of which will be compensated for under the item for piling delivered.

D Pile Load Tests
Payment for pile load tests at the Contract price per pile tested will be compensation in full for all costs of the labor, material and equipment required to complete the test as specified, including the costs of furnishing and driving any reaction piles at locations that preclude their use in the structure as foundation piles.

E Pile Redriving
Payment for pile redriving at the Contract price per pile will be compensation in full for all costs associated with redriving the test piles and/or foundation piles in accordance with requirements of the Contract.

F Pay Items
Payment for piling will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2452.501</td>
<td>Untreated Timber Piling Delivered</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2452.502</td>
<td>Untreated Timber Piling Driven</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2452.503</td>
<td>Treated Timber Piling Delivered</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2452.504</td>
<td>Treated Timber Piling Driven</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2452.507</td>
<td>Cast-in-Place Concrete Piling Delivered</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2452.508</td>
<td>Cast-in-Place Concrete Piling Driven</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Unit</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>2452.5</td>
<td>Steel H-Piling Driven</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2452.511</td>
<td>Steel H-Piling Delivered</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2452.516</td>
<td>Untreated Timber Test Pile, ___ m (feet) long</td>
<td>each</td>
</tr>
<tr>
<td>2452.517</td>
<td>Treated Timber Test Pile, ___ m (feet) long</td>
<td>each</td>
</tr>
<tr>
<td>2452.519</td>
<td>Cast-in-Place Concrete Test Pile, ___ m (feet) long</td>
<td>each</td>
</tr>
<tr>
<td>2452.520</td>
<td>Steel H-Test Pile, ___ m (feet) long</td>
<td>each</td>
</tr>
<tr>
<td>2452.525</td>
<td>Reinforcement Bars</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2452.526</td>
<td>Pile Load Test, Type</td>
<td>each</td>
</tr>
<tr>
<td>2452.527</td>
<td>Pile Redriving</td>
<td>each</td>
</tr>
</tbody>
</table>

(1) Nominal size in mm (inches).
2461

Structural Concrete

2461.1 DESCRIPTION
This work shall consist of producing, furnishing, and placing portland cement concrete for placement in structures, pavements and incidental construction as specified.

Except when otherwise specified, the concrete shall be proportioned and mixed as provided for herein, so as to meet the requirements specified for the Mix Designation indicated in the Contract.

2461.2 MATERIALS

A Portland Cement ................................................................. 3101
The Contractor:
(1) Shall only use cementitious materials from certified sources. The Mn/DOT Concrete Engineer maintains the certification procedures and a list of certified sources is available on the Mn/DOT Concrete Engineering Unit Website.
(2) Shall use Type I non-air-entrained concrete produced by using Type I portland cement and Type 3 air-entrained concrete produced by using either Type IA air-entraining portland cement or Type I portland cement plus an approved air-entraining agent.
(3) May use a blend of the two cements (Type I and Type IA) provided they are both manufactured at the same mill and the blending ratio to be used is approved by the Concrete Engineer.
(4) Shall comply with exceptions noted elsewhere in the Contract for the class of work in which the concrete is to be used.

B Portland Pozzolan Cement, Type IP or IP-A ................................. 3103

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

D Coarse Aggregate ............................................................... 3137
The gradation of the coarse aggregate that will be required or permitted in the work shall be as specified in 2461.3B4, subject to any exceptions noted in the detailed Specifications for the item of work in which the concrete is to be used.

Class B aggregate or a mixture containing Class B aggregate will not be permitted in that portion of a bridge deck slab that is directly exposed to vehicular traffic.

Unless otherwise specified, the class of coarse aggregate, as defined in 3137.2B, shall be optional with the Contractor.

Optional use of Class R aggregates will only be permitted by written authorization of the Concrete Engineer.

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

F Concrete Admixtures ......................................................... 3113

G Fly Ash ............................................................................... 3115

H Ground Granulated Blast Furnace Slag, .......................... 3102
2461.3 MIX REQUIREMENTS

A Mix Designation and Control

Concrete mix design shall be governed by the gradation and void content of the job aggregates; the absolute volume relationships and basic mix proportions set forth herein for control of cement, water and air content; and the degree of workability necessary for placement conditions and finishing requirements.

B Classification of Concrete

Concrete will be classified by type, grade and mix designation as provided for hereinafter, and the mix requirements shall be as prescribed for and by the Mix Number given for each item of work in which the concrete is to be used.

The first digit in the Mix Number designates the type of concrete; the following letter designates the grade of concrete; and the two digits following the grade designation letter will indicate the maximum permissible slump and the coarse aggregate gradation range, respectively. A letter or letters following the last two digits designates a specific class of coarse aggregate or a special modified mix design. In case no Mix Number is given for a particular concrete unit, the concrete to be used shall meet the requirements for Type 3, Grade A, and shall have a slump and aggregate gradation that will give the desired workability properties.

Concrete produced in conformity with the requirements for an established job mix other than the Mix Number designated for use may be accepted as a substitute, with no additional compensation being made, provided the design strength is maintained or exceeded, Type 1 concrete is not substituted for Type 3, and the mix is capable of being acceptably placed and finished.

B1 Type Designation

Concrete will be classified as either Type 1 or Type 3, depending on whether or not an air-void system is desired in the cement paste. Type 3 concrete shall have entrained air meeting the specified percentages in 2461.4A4b, subject to any exceptions noted in the detailed specifications for the item of work in which the concrete is to be used. Type 1 concrete has no air entrainment requirements.

B2 Grade Designation

Concrete will be classified into strength grades established in terms of the cement-void ratio relationship to compressive strength.

The grade designations, cement-void ratios, and anticipated compressive strengths of the concrete are shown in the following tabulation:

The cement-void ratio is defined as the ratio of the absolute volume of cement in the mix to the sum of the absolute volumes of water (less water absorbed by the aggregates) and any air that may be entrained in the concrete.

The cement-void ratios shown shall control the cement contents of all concrete mixes with the following exceptions:
2461.3

(a) When the cement content is fixed by the minimum values provided for in 2461.3C.
(b) As otherwise authorized herein.
(c) For bridge deck concrete, the ratio of the mass (weight) of water to the mass (weight) of cement shall not exceed 0.44.

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>Cement-Void Ratio</th>
<th>Anticipated Compressive Strength Mpa (psi)</th>
<th>Cement-Void Ratio</th>
<th>Anticipated Compressive Strength Mpa (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>0.80</td>
<td>43 (6300)</td>
<td>0.70</td>
<td>39 (5600)</td>
</tr>
<tr>
<td>V</td>
<td>0.76</td>
<td>41 (6000)</td>
<td>0.66</td>
<td>37 (5300)</td>
</tr>
<tr>
<td>W</td>
<td>0.72</td>
<td>39 (5700)</td>
<td>0.62</td>
<td>34 (5000)</td>
</tr>
<tr>
<td>X</td>
<td>0.68</td>
<td>37 (5400)</td>
<td>0.58</td>
<td>32 (4700)</td>
</tr>
<tr>
<td>Y</td>
<td>0.62</td>
<td>34 (5000)</td>
<td>0.54</td>
<td>30 (4300)</td>
</tr>
<tr>
<td>A</td>
<td>0.56</td>
<td>31 (4500)</td>
<td>0.50</td>
<td>27 (3900)</td>
</tr>
<tr>
<td>B</td>
<td>0.52</td>
<td>28 (4100)</td>
<td>0.46</td>
<td>23 (3400)</td>
</tr>
<tr>
<td>C</td>
<td>0.44</td>
<td>22 (3200)</td>
<td>0.40</td>
<td>19 (2700)</td>
</tr>
</tbody>
</table>

The compressive strength listed above for each type and grade of concrete is the minimum strength that can be anticipated when the concrete is produced in accordance with this Specification in the laboratory and cured for 28 days under laboratory conditions. If the test cylinders show a strength less than the strength listed, the Department reserves the right to increase the cement content to the extent deemed necessary by the Concrete Engineer. The Contractor may be permitted to increase the cement content upon approval of the Concrete Engineer.

B3 Mix Designation

The first digit following the grade designation letter in the Mix Number designates the upper limit of a 25 mm (1 inch) slump range.

<table>
<thead>
<tr>
<th>Slump Designation</th>
<th>Maximum Slump</th>
<th>Slump Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25 mm (1 inch)</td>
<td>0-25 mm (0-1 inch)</td>
</tr>
<tr>
<td>2</td>
<td>50 mm (2 inches)</td>
<td>25-50 mm (1-2 inches)</td>
</tr>
<tr>
<td>3</td>
<td>75 mm (3 inches)</td>
<td>50-75 mm (2-3 inches)</td>
</tr>
<tr>
<td>4</td>
<td>100 mm (4 inches)</td>
<td>75-100 mm (3-4 inches)</td>
</tr>
<tr>
<td>5</td>
<td>125 mm (5 inches)</td>
<td>100-125 mm (4-5 inches)</td>
</tr>
<tr>
<td>6</td>
<td>150 mm (6 inches)</td>
<td>125-150 mm (5-6 inches)</td>
</tr>
</tbody>
</table>
Except for permissible deviations, the limits so defined shall be the minimum and maximum slump limit within which the concrete mix is to be maintained. If unusual placement conditions are encountered in the work that render the specified consistency unsuitable, the mix composition shall be altered to produce the desired change in consistency while maintaining the other specified properties of the concrete mix. The addition of water only, for the purpose of temporarily facilitating the placement of concrete under such unusual conditions, will not be permitted.

B4  Coarse Aggregate (CA) Designation

The second digit following the grade designation letter in the Mix Number shall be the range number that defines the optional coarse aggregate designations contained in Table 3137-2, that may be used in the mix, and those options shall be as indicated in the following schedule:

<table>
<thead>
<tr>
<th>Range</th>
<th>Optional CA Designations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>CA-00 Only</td>
</tr>
<tr>
<td>1</td>
<td>CA-15 to 50, Inclusive</td>
</tr>
<tr>
<td>2</td>
<td>CA-15 to 60, Inclusive</td>
</tr>
<tr>
<td>3</td>
<td>CA-35 to 50, Inclusive</td>
</tr>
<tr>
<td>4</td>
<td>CA-35 to 60, Inclusive</td>
</tr>
<tr>
<td>5</td>
<td>CA-45 to 60, Inclusive</td>
</tr>
<tr>
<td>6</td>
<td>CA-50 to 70, Inclusive</td>
</tr>
<tr>
<td>7</td>
<td>CA-70 Only</td>
</tr>
<tr>
<td>8</td>
<td>CA-80 Only</td>
</tr>
</tbody>
</table>

In any mix design where it is required that the coarse aggregate composition be of a specified Class as defined in 3137.2B, the Class designation will be identified by a letter following the last digit of the Mix Number. Special concrete mix designation may also be identified with other letters following the last digit such as HE (High Early), MS (Microsilica), or others.

Grout will be designated by Type and Grade, followed by "GROUT". Grout shall contain no coarse aggregate. If no type or grade is indicated, the designation shall be 3A GROUT and be so indicated on all reports.

C  Cementitious Content

In the mix design, the minimum quantity of cementitious material per cubic meter (yard) of the various grades and consistencies of concrete shall be as indicated in the following schedule:

The maximum cementitious content for a cubic meter (yard) of concrete shall not exceed 505 kg (850 pounds) unless the concrete is designed as high-early, in which case, the maximum shall be 535 kg (900 pounds). These maximums shall not apply to GROUT mixtures.
Unless the use of high-early strength portland cement (Types III or IIIA) is specifically permitted by the Specifications applying to the item of work in which the concrete is to be used, production of high-early strength concrete shall be accomplished by increasing the normal cement content of the concrete mix by 30 percent. The addition of calcium chloride may also be required to further accelerate the gain in strength, subject to the admixture restrictions of 2461.3E.

<table>
<thead>
<tr>
<th>Specified Slump Limit</th>
<th>U</th>
<th>V</th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 mm (1 inch)</td>
<td>475</td>
<td>435</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>50 mm (2 inches)</td>
<td>490</td>
<td>455</td>
<td>390</td>
<td>375</td>
<td>340</td>
<td>315</td>
<td>290</td>
<td>250</td>
</tr>
<tr>
<td>75 mm (3 inches)</td>
<td>505</td>
<td>475</td>
<td>410</td>
<td>395</td>
<td>360</td>
<td>335</td>
<td>305</td>
<td>265</td>
</tr>
<tr>
<td>&gt; 75 mm (3 inches)</td>
<td>--</td>
<td>--</td>
<td>435</td>
<td>415</td>
<td>380</td>
<td>350</td>
<td>320</td>
<td>280</td>
</tr>
</tbody>
</table>

**D** Cement Substitutions

Ternary mixes (portland cement, GGBFS, and fly ash) are not allowed unless approved by the Concrete Engineer.

**D1 Fly Ash**

At the Contractor’s option, fly ash or portland-pozzolan cement may be substituted for portland cement, except when recycled aggregates are used. When recycled aggregates are used, fly ash or portland-pozzolan cement shall be substituted for portland cement. The substitution is subject to the following restrictions:

(a) Class C and Class F Fly Ash substitutions shall not exceed 15 percent, on a one for one basis, by mass (weight) of the designed portland cement.

(b) When fly ash is used, the computed cement-voids ratio shall be based on a cementitious content equal to the originally designed cement content.

(c) Batch mass of coarse aggregates will be adjusted to compensate for volume changes due to substitution of fly ash or portland-pozzolan cement.

**D2 Ground Granulated Blast Furnace Slag**

Ground granulated blast furnace slag (GGBFS) may be substituted for Type I portland cement in concrete mixes according to the following restrictions:
a) The GGBFS may be incorporated as a separate product meeting the requirements of AASHTO M302 Grade 100 or Grade 120 or blended with Type I portland cement to meet the requirements of AASHTO M240.

b) The substitution of GGBFS in both of the above conditions shall be limited to 35 percent.

c) The GGBFS or blend shall be from a certified source and comply with the latest requirements for certified cement available from the Mn/DOT Concrete Engineering Unit website.

E Admixtures

An approved Type A water reducing admixture may be used at the discretion of the Producer/Contractor.

All admixtures shall be Mn/DOT approved. (Approved list available on the Mn/DOT Concrete Engineering Unit Website).

No substances other than cementitious materials, aggregate, water, air-entraining and Type A water reducing admixtures shall be used in the concrete except by permission from the Concrete Engineer or as otherwise required or permitted in the Specifications applying to the item of work in which the concrete is to be used. No reduction in the normal cementitious content of the concrete mix will be made when accelerators, retarders or water reducing admixtures are specified or permitted, except by written permission of the Concrete Engineer, and in no case will the cement content be reduced below the minimum specified in 2461.3C.

The use of calcium chloride in concrete will not be permitted between March 15 and September 15. After September 15, the Engineer may permit the use of calcium chloride for the purpose of accelerating the hardening of concrete. In any event, calcium chloride will not be permitted in units containing prestressing steel nor in bridge superstructure concrete.

F Tentative Proportions

As an aid to prospective bidders in estimating concrete production costs, estimated mix proportions and quantities per cubic meter (yard) will be furnished by the Department upon request. It shall be understood that, in furnishing this preliminary information, the Department does not, expressly or by implication, guarantee or agree that the estimated proportions and quantities will apply exactly to the materials actually furnished for the work. The estimated mix proportions issued for bidding purposes will not include any optional or required admixtures.

The Department will render all reasonable assistance in testing preliminary samples from proposed sources for the purpose of determining the general quality and suitability of the materials after the Project is awarded. The Engineer will establish the job mix proportions as provided below, after a sufficient quantity of satisfactory material has been produced.

Laboratory testing of the material to determine the properties upon which the mix proportions are to be based will require not less than 21 days after the samples have been delivered to the Materials Laboratory, and some testing may require a considerably longer time period. To avoid delays in starting the work, production of aggregates should be started sufficiently in
2461.3

advance of concrete production to permit preliminary testing of the aggregate to be completed.

G  Job Mix Proportions

A tentative job mix will be designed for use at the start of construction and until the required water content under existing job conditions can be accurately determined. This tentative mix will be based on water and air contents estimated on the basis of previous experience with the materials from the sources to be used; or, in the case of materials from sources not previously used, on the Department's established rules of design.

As soon as practicable after the required water content can be accurately determined, the Engineer will establish the job mix in accordance with the cement-voids ratio or minimum cementitious factor, whichever requires the greater quantity of cementitious material.

H  Concrete Yield

The yield of concrete as placed in the work is the ratio of the volume of mixed concrete, less accountable waste, to the planned volume of the work constructed. Since a large portion of the ingredients of the concrete mixture is naturally occurring and therefore not entirely homogeneous, the Department does not assume responsibility for the yield that will be obtained in terms of units of completed work from a given volume of mixed concrete.

J  Mix Adjustments

The Department reserves the right to require adjustments in the mix composition at any time as may be found necessary to maintain the specified consistency and cement void ratio of the concrete, without any adjustments in compensation being made either for or against the Contractor.

After the job mix has been established, the production of concrete shall be so controlled that the following tolerances are not exceeded:

1. The cement voids ratio of the concrete as actually produced shall not be more than 4 percent less than the minimum value given in 2461.3B2.

2. When the cementitious content of the concrete is not controlled by the minimum cementitious content specified, the water content as actually used shall not exceed the established value by more than 4 percent.

If, at any time, it is found impossible to maintain production of the established job mix within the above-specified tolerances because of changes in materials, equipment or placement conditions, the Engineer will establish a new job mix for subsequent production. However, the Engineer may accept on an occasional basis any concrete batch in which:

1. The total aggregate does not exceed the design mass (weight) by more than 5 percent,

2. The cementitious content is not deficient by more than 3 percent of the design mass (weight), or

3. The cementitious content does not exceed the design mass (weight) by more than 30 percent.
2461.4 PRODUCTION REQUIREMENTS

A Production Controls

A1 Batch Material Requirements

Unless authorized by the Engineer, no change in the source, kind or gradation of batch materials shall be made after the start of concrete production for the work. If any changes are authorized, the supply at hand shall be completely exhausted before using different material.

When freshly washed aggregates are delivered to the batching plant, they shall be drained for a period of at least 12 hours prior to being used in the batching operations. When freshly washed aggregates are to be drained at the site of the batching plant, provisions shall be made for complete separation of the drained material currently being used in the batching operations from the undrained materials, and adequate means shall be provided for the disposal of water that accumulates from the drainage of materials.

The sites of all stockpiles shall be smooth, firm, and well drained, and they shall be cleared of all vegetable and extraneous matter. Where the natural foundation is unsatisfactory, the Engineer may require that the stockpiles be constructed upon suitable platforms. In congested areas, suitable bulkheads or partitions shall be constructed to ensure separation of aggregate of different kind, gradation or water content.

Stockpiles shall be constructed by methods that hold segregation and degradation to a minimum. If evidence of segregation or degradation exists, the Engineer may designate that pile as being unacceptable for use.

A2 Concrete Mixing Restrictions

Concrete production shall not be started on any day until the Engineer has been given adequate notice to provide the necessary inspection forces and has approved all preparations for placement of concrete, nor until it has been determined that weather conditions will permit the placement, finishing and curing of concrete in accordance with the Specification requirements and restrictions.

Concrete production shall be commenced, suspended, or otherwise regulated so as to comply with the following provisions governing the placement, finishing and protection of concrete:

(a) Concrete shall not be placed in any unit or section of work until the Engineer has inspected and approved the required foundation preparations, form and falsework erection, placement of reinforcement steel, materials, equipment condition, and any provisions for cold weather protection that might be needed.

(b) Concrete shall not be placed on a frozen foundation or against any surface the temperature of which is below freezing.

(c) Unless provisions satisfactory to the Engineer have been made in advance for cold weather protection of concrete, concrete production shall not be commenced or continued when the air temperature at the construction site in the shade and away from artificial heat is below 2°C (36°F), except as authorized by the Engineer when the air temperature has reached 1°C (33°F) and is rising.
(d) Whenever weather conditions are such as to cause unusual or adverse placing and finishing conditions, the Contractor shall expedite the application of curing media or temporarily suspend the mixing and placing operations, as the conditions require.

(e) Except as otherwise specifically authorized by the Engineer, in the case of emergency or when adequate artificial lighting is provided, concrete shall not be produced for placement earlier than 60 to 90 minutes before official sunrise nor shall concrete be produced or dispatched from the mixing plant so early or late in the day that it cannot be finished and protected in accordance with the Specification requirements. Written permission from the Engineer will be required to conduct the placement and finishing operations under artificial lighting.

The Contractor shall assume full responsibility for the acceptable production, placement, finishing, and curing of concrete under the conditions prevailing, regardless of the restrictions imposed, and any artificial lighting and rain or cold weather protection provided shall be at no expense to the Department. Any defects in the concrete or concrete surfaces resulting from weather conditions, inadequate lighting, or other causes shall be subject to 1503 and 1512.

A3 Concrete Temperature Control

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

When mixed, all concrete shall have a temperature of not less than 10°C (50°F) nor more than 30°C (90°F), except that a temperature of not less than 5°C (45°F) will be acceptable with the use of an approved accelerator at the manufacturer's recommended dosage rate. The concrete shall be maintained within that temperature range until it is deposited in the work.

If necessary to obtain the specified temperature, either the water or the aggregate, or both, shall be heated prior to being introduced into the mixer. However, aggregates shall in no case be heated to a temperature of more than 55°C (130°F), and the cement shall not be heated in any case. Cementitious material shall not be permitted to come in contact with any other batch material when the aggregate temperature exceeds 55°C (130°F).

When heating of any batch materials is required, they shall be heated by means of an approved heating system operated in a manner satisfactory to the Engineer. Spot heating of the material by means of steam jets as the work progresses will not be permitted.

Mixer heaters intended for heating the batch materials within the mixer drum will not be permitted.

A4 Concrete Mixture Requirements

A4a Water Content

Water content of the concrete shall be the minimum that will produce the desired consistency. The water content shall consist of the free water carried by the aggregate plus the water added at the mixer, and may also include the water used in making extremely dilute admixture solutions.
The Engineer will test the concrete for consistency as often as may be necessary during the progress of the work. The Department reserves the right to reject any concrete batch the consistency of which is found to be outside of the permissible slump range. When any test shows the slump to be in excess of the upper limit by more than 25 percent or below the upper limit by more than 50 percent, the concrete represented by that test will be rejected unless adjustments satisfactory to the Engineer are made in the concrete prior to use.

If any mix composition is altered by the Engineer to effect a change in consistency, the permissible slump range shall be as established for the revised mix.

A4b Air Content

Except as otherwise specifically authorized, the air content of Type 3 concrete shall be maintained at 6.5 percent, plus or minus 1.5 percent, of the measured volume of the freshly mixed concrete. The quantity of air-entraining agent needed to obtain the desired air content shall be the responsibility of the Contractor. Any adjustments necessary to meet the desired air content range shall be made immediately.

Type 3 concrete not conforming to the above air content requirements will not be allowed in the work. Any nonconforming concrete inadvertently placed in the work will not be accepted for payment at Contract prices, but shall be subject to the following provisions governing acceptance and payment:

1. Concrete having an air content of more than 8.2 percent or less than 4.8 percent but not less than 3.8 percent will be paid for at an adjusted unit price equal to 95 percent of the Contract bid price for the item involved.
2. Concrete having an air content less than 3.8 percent but not less than 3.0 percent will be paid for at an adjusted unit price equal to 75 percent of the Contract bid price for the item involved, subject to items (5) and (6) below.
3. Concrete having an air content less than 3.0 percent but not less than 2.5 percent may be left in place without any payment being made therefor, subject to items (5) and (6) below.
4. Concrete having an air content less than 2.5 percent shall be removed and replaced, subject to item (5) below.
5. Concrete having an air content less than 3.8 percent, which is placed in any part of a retaining wall, box culvert, bridge abutment, or similar unit, such that it would not normally be exposed to salt-brine freeze-thaw cycling, will be accepted for payment at an adjusted unit price equal to 90 percent of the Contract bid price for the item involved.
6. Concrete having an air content less than 3.5 percent, which is left in place where its surface will be exposed to salt-brine freeze-thaw cycling, shall be coated with an approved epoxy penetrant sealer at the Contractor's expense.

All determinations regarding the disposition, payment, or removal of concrete not having the required air content shall be made by the Engineer.
Price adjustments will apply only to the Contract item under which the concrete is furnished.

For determination of compliance with cement-voids ratio requirements as described in Table 2461-1 for mix design and 2461.3J for mix adjustments, the air content shall be assumed to be 5.5 percent.

A5 Test Methods and Specimens

Concrete sampling and testing will be performed in accordance with the procedures described in the Mn/DOT Concrete Manual.

The forms for the test specimens and the testing equipment will be furnished by the Department.

When requested, the Contractor shall transport the test specimens from the site of the work to the Department’s field laboratory or office, in such manner as to protect them from damage. The Contractor shall also furnish facilities for curing the concrete specimens in a manner similar to the structure curing or as otherwise directed by the Engineer. No compensation in addition to the Contract prices will be made to the Contractor for any concrete, material, labor, equipment, or other assistance that the Contractor may be called upon to furnish in connection with handling and curing test specimens.

When the sequence of construction operations is dependent upon the rate of concrete strength developments this strength shall be determined by control cylinders. The Contractor (or Producer of precast units) shall:

(a) furnish 100 by 200 mm (4 x 8 inch) cylinder forms (Use 150 by 300 mm (6 x 12 inch) cylinder forms if the maximum aggregate size is greater than 31.5 mm (1 ¼ inch)),
(b) cast the control cylinders,
(c) cure the cylinders in the same location and under the same conditions as the concrete structure or unit involved.

A sufficient number of control cylinders shall be cast to accurately determine when the strength of the concrete for all desired control limitations has been attained. All control cylinders shall be cast in the presence of and under the direction of the Engineer and the cylinders shall be clearly marked for positive identification with the concrete unit or section of concrete represented.

The Contractor shall transport the control cylinders to the Materials Laboratory for testing in such quantity and at such times as it is agreeable with the Engineer. Upon completion of the testing procedure, the Engineer will be notified of the test results. In lieu of transporting the cylinders to the laboratory, the Contractor may perform the tests in the presence of the Engineer on a portable mechanical or hydraulic testing machine that has been checked and calibrated with a standard proving ring.

B Batch Requirements

B1 Proportioning Methods

Concrete batch materials shall be proportioned by mass (weight) except where volumetric proportioning is specifically authorized or required in accordance with the following provisions:

(a) Concrete for bridge deck overlays shall be proportioned by volume.
(b) Volumetric proportioning will be permitted when the concrete for any single item or group of items of work is produced at a single batching and mixing set-up and the quantity produced does not exceed 50 m$^3$ (cubic yards).

(c) Volumetric proportioning may be permitted on other items of work by written authorization of the Engineer, provided the mixer is calibrated for the specific batch materials to be used.

(d) The methods and equipment used in volumetric proportioning shall be subject to approval by the Engineer.

(e) Volume proportions will be determined on the basis of 100 kg (pounds) of cementitious material and the appropriate conversions for the other materials.

(f) Unless the mixer is calibrated for the specific materials being used, only sacked cement furnished in the original mill containers shall be used, and fractional sacks will not be permitted.

(g) Unless the mixer is calibrated for the specific materials being used, the cementitious content shall be increased by 10 percent in the computation of volume proportions.

### B2 Weighing Equipment

All concrete mixture ingredients shall be weighed or measured using load cells or meters.

Weighing equipment shall be subject to 1901 and such tests as the Engineer deems necessary to ensure continued accuracy and sensitivity.

### B3 Batching of Cement

When proportioning by mass (weight), the bulk cement shall be weighed independently of the aggregates, either on separate scales or in separate compartments.

Cement batched shall be within 1% of the targeted batch weight.

The use of sacked cement will be permitted only when the Engineer can accurately determine the quantity of cement proportioned into each batch.

### B4 Batching of Aggregates

For multiple weighing on a single dial scale, the delivery tolerance shall be 1 percent of the full scale for a total mass (weight) over 50 percent of scale capacity and 0.5 percent of the full scale for a total mass (weight) less than 50 percent of scale capacity. On individual weighing of aggregate fractions, the delivery tolerance shall be 0.5 percent of the full scale for each fraction.

Aggregates batched shall be within 1% of the targeted batch weights.

Aggregates shall meet the specified gradation requirements and have a stable and reasonably uniform moisture content at the time of being proportioned into the batches. Aggregates will be considered to have unstable moisture content if there is evidence of gravity drainage in the weighing hoppers or on the bottom of truck boxes, and they will be considered not to be reasonably uniform in moisture content if the variations in moisture carried by any one or more of the materials causes a marked variation in the consistency of successive batches of the mixed concrete.
Aggregates used by the Contractor in constructing runways for loading or hauling equipment shall not be used in concrete batches. The use of aggregate from the bottom 0.3 m (1 foot) of a stockpile placed on an earth foundation shall be avoided until necessary for final cleanup, unless there is to be a change in the kind or gradation of aggregate to be stockpiled at that location. Materials from the bottom layer of stockpiles shall only be used under the direct supervision of the Engineer, and then only if the material meets all requirements for quality, gradation and cleanliness.

B5 Admixture Proportioning

When two or more different types of admixtures are to be added to the concrete mix, each type shall be added in a manner that will prevent contact between or intermixing of the different admixtures prior to their being mixed with other batch materials.

Unless otherwise authorized, admixtures shall only be added to the batch mix in liquid or solution form. Admixture solutions shall be maintained at a uniform concentration at all times. When the use of calcium chloride is permitted or required, the concentration of solution and proportions to be used shall be as designated by the Manufacturer. Admixtures shall be measured within 3% of the target.

When concrete is mixed at the site of the work in mixers having a rated capacity of 0.45 m³ (16 cubic feet) or more, air-entraining admixtures shall be measured and added to the concrete batch by a mechanical dispenser that discharges the air-entraining agent into the discharge pipe of the mixer water system. When a mechanical dispenser is used for proportioning Class I or II admixtures, it shall either be a transparent device or an approved meter connected in such a manner that the quantity discharged can be verified. Any dispenser used shall be checked periodically to determine its accuracy and ensure unobstructed flow.

B6 Batching of Other Cementitious Materials

Other cementitious materials shall be proportioned by mass (weight) unless volume proportioning is specifically authorized by the Engineer. The bulk material shall be weighed independently of the aggregates either in separate compartments or on separate scales. Other cementitious materials batched shall be within 3% of the targeted batch weights.

The materials may, however, be weighed cumulatively with the cement provided the cement is weighed first and there is a way of determining the cement quantity, suitable to the Engineer, on any required cement recorder printout.

C Mixing Requirements

C1 General Requirements

Before mixing operations begin, and at any other time that the Engineer considers it necessary, the water measuring equipment shall be checked for accuracy and calibrated under operating conditions.

Except as otherwise restricted by delivery or placement time, concrete may be mixed at the site of construction, at a central plant site (stationary plant), or entirely or in part in truck mixers.
The mixer shall be so operated that the batch being mixed will not become merged or intermixed with the following dry batch. If two or more dry batches become merged or intermixed while charging the mixer, or prior thereto, they shall only be used in a manner satisfactory to the Engineer.

Concrete shall be mixed until the cement and water are uniformly distributed throughout the mass and the mixture is homogeneous and uniform in color. Concrete batches that show a marked variation in consistency or composition or evidence of improper mixing shall be rejected and disposed of in a manner satisfactory to the Engineer.

Hand mixing of concrete will not be permitted except in case of emergency, and then only by permission of and under the direct supervision of the Engineer.

Concrete shall be produced in such quantity and at such a rate as proper placement and finishing will permit. The re-tempering of concrete that has become partially set will not be permitted.

C2 Mixer Requirements
C2a General Condition
The pickup and throwover blades of mixers having a rated capacity of 0.4 m³ (14 cubic feet) or less shall not show a wear loss of more than 13 mm (½ inch) and, in mixers of greater capacity, not more than 19 mm (¾ inch) from the original manufactured depth. Blades that do not meet such requirements shall be replaced or reconditioned.

When compliance with the blade wear requirements is questionable, or when the uniformity of mixing is questionable due to excessive accumulation of hardened concrete or other reasons, slump tests will be taken at approximately the 15 and 85 percentage points during unloading. If the results of these tests show a slump variation greater than 40 mm (1 ½ inch), the use of that mixing unit shall be discontinued until the cause has been corrected.

C2b Manufacturer's Rating Plate
All mixers shall carry the manufacturer's plate showing the serial number of the unit and its rated capacity.

C2c Drum Speed for Stationary Mixers
While the mixer is in operation, the drum speed shall be as specified by the manufacturer; however, if the specified speed does not provide satisfactory mixing or if no drum speed is specified, the Engineer shall have the right to designate a satisfactory drum speed.

C2d Auxiliary Equipment Requirements
Mixers shall be equipped with a timing device, a discharge locking device, and a water measuring device; all of which shall be so constructed and incorporated in the mixer design as to operate mechanically and automatically during each batching cycle.

The water measuring equipment shall be of such design and construction as to permit rapid and easy adjustment and calibration. It shall not be subject to pressures other than atmospheric pressure. An adjustable indicator device shall be provided that shall be graduated to represent the volume of discharge in increments not greater than 1 L (½ gallon). The
Contractor shall furnish personnel, equipment, and accessories as may be required to calibrate or check the accuracy of the equipment, with the Engineer providing reasonable assistance.

C2e Mixer Capacity

The maximum volume of concrete that may be mixed in one batch shall not exceed the rated capacity of the mixer.

The batch volumes permitted above are contingent upon the ability of the individual mixer to hold these quantities of materials and properly mix them without spillage, leakage, or segregation during the charging, mixing, and discharging operations. No mixer with a capacity of less than a 0.25 m³ (1-sack) batch shall be used.

C2f Mixing Time

The mixing time per batch is defined as the time period beginning when the cement and aggregates are all in the mixer drum and ending when the discharge begins.

The minimum mixing time for single drum mixers shall be as recommended by the manufacturer of the mixer. In the absence of such recommendation, the minimum mixing time shall be as designated by the Engineer. The minimum mixing time shall be 60 seconds except as hereinafter permitted.

In the event there is evidence of inadequate mixing when the concrete is incorporated in the work, the Engineer reserves the right to increase the mixing time as needed.

In central mix plants with capacities in excess of 3.8 m³ (5 cubic yards) per batch, the mixing time may be reduced to 50 seconds after all solids are in the drum, provided uniform mixing is obtained as determined from tests. The samples and sampling, for uniformity tests, shall be provided by the Contractor under the direction of the Engineer, who will perform the testing and determine the adequacy of the mixing. Should the test results or subsequent job performance indicate non-uniformity in concrete mixing, the mixing time will be increased until the desired uniformity is obtained.

The number of revolutions at mixing speed shall not exceed 150. Any concrete mixed in excess of 150 revolutions shall be wasted.

C3 Turbine Type Mixers

Turbine type mixers shall meet the applicable requirements for conventional type mixers, except as modified herein. The mixer drum shall be maintained in good and clean condition, and shall not deviate by more than 19 mm (3/4 inch) at any point from being cylindrical in shape. The discharge gate of the mixer shall be maintained in mortar tight condition when it is in the closed position. Mixer paddles shall be replaced or reconditioned whenever they show a wear loss of more than 13 mm (5/16 inch) from the original factory dimensions.

The mixing water shall be added to the batch materials in the mixer in such a manner as to distribute the water to the inner or central areas of the drum. The flow of water shall start slightly before the solid batch materials are introduced into the mixer drum.
During the mixing operations, the paddles shall operate at a speed of not less than 20 nor more than 30 revolutions per minute. After all batch materials are in the drum, the concrete shall be mixed for 45 seconds or for 18 revolutions of the mixer paddles, whichever provides the longer mixing period.

C4  Horizontal Axial-Revolving Blade Type Mixers
The horizontal axial-revolving blade type mixer shall meet the applicable requirements for conventional type mixers except as modified herein.

The sequence of charging the aggregates and cement is contingent upon the method of introducing water into the mixer and therefore shall be subject to approval of the Engineer. After approval of the charging operations, the Engineer will determine the minimum mixing time for the mixer based on concrete uniformity tests conducted by the Contractor under the direction of the Engineer.

C5  Blank

D  Ready-Mixed Concrete

D1  Definition
Ready-mixed concrete shall be understood to mean:
(a) Any concrete that is proportioned and mixed in a central plant and hauled to the point of placement in revolving drum agitator trucks, or
(b) Concrete that is proportioned in a central plant and fully mixed in transit-mix trucks.

D2  General Requirements
All ready-mix concrete shall come from Certified Concrete Plants. Ready-mixed concrete shall be subject to, and shall meet all the requirements set forth elsewhere in these Specifications for concrete, except as those requirements may be modified in this section.

The use of ready-mixed concrete will not be permitted until the facilities and methods by which it is to be proportioned, mixed, and transported have been approved by the Engineer.

If ready-mixed concrete is not delivered to the site of the work at the designated rate, or if the delivery time, consistency, quality, air-content, or other properties of the concrete do not conform to the specified requirements, the Contractor shall discontinue its use.

The minimum load of concrete that will be permitted to be batched and delivered to the Project shall not be less than 1 m³ (cubic yard).

Slump and air-content requirements as they apply to ready-mixed concrete shall be determined at the time the concrete is incorporated into the work.

Central proportioning or mixing plants shall provide satisfactory facilities for the use of the plant technician in performing tests. Such facilities shall be provided with adequate lighting, heating and locks to prevent damage or loss of testing equipment.

D3  Notice of Inspection
In order to permit arrangements to be made for inspection of materials, the Contractor shall notify the Engineer at least 24 hours in advance of the
time scheduled for delivery of ready-mixed concrete. Failure on the part of
the Contractor to cooperate in this respect may result in delays in delivery
for which the Department will assume no responsibility.

D4 Central Plant Requirements

The central plant shall be designed, constructed, and equipped to permit
proportioning and mixing concrete of the various grades in accordance with
these Specifications. The weighing and measuring equipment shall be
designed and arranged to provide ready access for the purpose of checking
and calibration.

The Contractor shall inspect, test, and calibrate the scales according to
1901 and the Mn/DOT Concrete Manual.

The mixing water shall be measured on approved scales or by using an
approved water metering device. To be approved, the water meter shall
comply with the following.

(a) It shall have a discharge indicator capable of being set to within 5 L (1
gallon) of a predetermined quantity.

(b) It shall have a positive automatic shutoff valve that stops the flow of
water when the indicated quantity of water has been delivered.

(c) It shall operate within a maximum delivery tolerance of 1 percent of the
required water setting at the time of batching.

(d) It shall bear an approved inspection seal dating the time of the previous
calibration and adjustment, which shall be within 6 months prior to time
of use.

Unless evidence is furnished indicating that the water meter was
calibrated and adjusted within the previous 6 months by an authorized
service agency (as listed on the Mn/DOT Concrete Engineering Unit
website), it shall be calibrated and adjusted prior to use in accordance with
the weighing procedure described in the Mn/DOT Concrete Manual.

The mixer at the central plant shall be equipped with an acceptable
timing device that will not permit the batch to be discharged until the
specified mixing time has elapsed. In the event the timing device is not
available or is out of order, the specified mixing time shall be increased by
one-half minute.

D5 Transportation Units

D5a General Requirements

Transportation units intended for use in the delivery of concrete that has
previously been completely mixed shall be equipped with a watertight
revolving drum, suitably mounted and powered and containing properly
designed built-in mixing or agitating blades. They shall be capable of
delivering the concrete without segregation or loss of any of the batch
materials.

Transportation units intended for both mixing and agitating shall be
equipped with watertight revolving drums suitably mounted and powered
and fitted with properly designed mixing blades. They shall be capable of
combining all the ingredients into a homogeneous mixture. They shall be so
designed as to provide two drum speeds, as hereinafter specified, one for
mixing and the other for agitating. The unit shall be equipped with a
working counting device that will record the number of revolutions of the
mixer drum.

When compliance with the blade wear requirements is questionable, or
when the uniformity of mixing is questionable due to excessive
accumulation of hardened concrete or other reasons, slump tests will be
taken at approximately the 15 and 85 percentage points during unloading. If
the results show a slump variation greater than 40 mm (1 ½ inch), the use of
that mixing unit shall be discontinued until the cause has been corrected.

D5b Capacity of Transportation Units

The maximum capacity of the unit shall be as shown on the Truck
Mixer Manufacturer's Bureau Certification Plate attached to the unit. If the
unit will not satisfactorily mix the maximum volume shown, the batch
volume shall be reduced to an extent that will provide proper mixing.

D5c Mixing In Transit Mix Units

The materials shall be charged into the mixing drum in such a manner
that sufficient water is introduced prior to addition of any of the solid
materials to prevent packing action and to ensure adequate mixing. All
charging operations shall be performed without the loss of any of the
materials.

When the concrete is mixed in a truck mixer loaded to its rated capacity,
the number of revolutions of the drum or blades at mixing speed shall be not
less than 50 nor more than 150. All revolutions over 150 shall be at
agitating speed.

Unless the mixing unit is equipped with an accurate and dependable
device that will indicate and control automatically the number of revolutions
at mixing speed, the unit shall remain on the site of the proportioning plant
during the mixing period after which the drum speed shall be promptly
reduced to agitating speed and the unit shall then proceed to the point of
delivery, unless the delivery time is short enough so that the maximum
number of revolutions for mixing will not be exceeded in transit, or the
mixing operation is performed at the site of the work when required for
Type 3 concrete.

Any flushing water remaining in the drums shall be entirely discharged
prior to batching.

D5d Agitating

After the concrete has been completely mixed, either in a central plant
mixture or a transit-mix unit, it shall be continuously agitated, while in transit
to the point of placement, so as to maintain the concrete in a thoroughly
mixed and uniform mass until it is discharged from the unit.

D6 Delivery Requirements

Ready-mixed concrete shall be deposited in the work within specified
time limits as shown below. The time limits begin after the cement is added
to the other batch materials.
Type 1 Concrete - Concrete shall be deposited in the work within 90 minutes of initial mixing.

Type 3 Concrete – Concrete shall be deposited in the work within 60 minutes of the time the air entraining agent is added at the plant. When the entire dosage is added at the jobsite the time from initial mixing shall not exceed 90 minutes. In transporting mixed concrete, the use of open or tub type truck bodies, which are not equipped with paddles or blades for agitating, will be permitted only upon written permission from the Engineer and then only for Type 3 concrete.

D7 Certified Ready-Mix Plant Program

Mn/DOT requires quality control of concrete production under a Certification program for ready-mix concrete plants. The Prime Contractor is responsible to assure that all ready-mix concrete used is produced by a certified ready-mix plant.

To ensure that proper testing procedures and documentation are followed, the Ready-Mix Producer shall obtain and have on site a copy of the Current Mn/DOT Concrete Manual. The manual is available via the Mn/DOT Concrete Engineering Unit website.

To facilitate communication between the Producer and the Engineer regarding quality control, the Producer shall equip the Certified Ready-Mix Plant with a working facsimile machine.

D7a Certification Documents

The Contractor shall obtain all of the ready-mix concrete used on this Contract from a Certified Concrete Plant meeting all of the pertinent requirements of Mn/DOT 1604 and the following:

It is the Prime Contractor's responsibility to ensure that the Ready-Mix Concrete Producer adheres to all of the requirements. At the time of delivery, a Certificate of Compliance shall accompany each truckload of ready-mixed concrete used by the Contractor or any sub-Contractor on this Contract. A computerized Certificate of Compliance is required when supplying any concrete [including small quantities < 20 m³ (26.2 cubic yards)] for an Agency Contract. Computerized means that the concrete mix design quantities batched are recorded from load cells and meters. If the computer that generates the Certificate of Compliance malfunctions, the Producer may finish any pours that are in progress provided the plant issues handwritten Certificates of Compliance on the most current version of Mn/DOT form TP 00042. New pours shall not commence without a working computerized Certificate of Compliance.

The Certificate of Compliance shall label each item of information and shall include:
1) Name of the ready-mix concrete plant
2) Name of the Contractor
3) Date
4) State Project Number (SP) or (SAP)
5) Bridge Number (when applicable)
6) Time concrete was batched
7) Truck number
8) Quantity of concrete in this load
9) Running total of this concrete mix batched on this day for this project
10) Type of concrete (Mn/DOT Mix Designation Number)
11) Cementitious Materials (portland cement, ground granulated blast furnace slag, fly ash, silica fume, others) including brand, type and production mill and production power plant for fly ash using MN/DOT Standard Abbreviations
12) Admixture brand and product name using MN/DOT Standard Abbreviations
13) Aggregate sources using State Pit Numbers
14) Admixture quantity per 100 wt. and/or oz/cm (cy)
   a) air-entraining admixtures,
   b) water reducing admixtures,
   c) other admixtures
15) The Certificate of Compliance shall list the batch information for all materials and use Mn/DOT standardized labels to represent each category in the order listed below. It is preferable that all the information is presented across the page (a through k) but presenting the information using two lines is satisfactory provided that the materials are identified in each line of information and is presented in the order listed. Mn/DOT Standard Abbreviations for approved product sources are available on the Concrete Engineering Unit website.
16) Total Water (Batch Water + Free Moisture) (kg (lb.))
17) The Certificate of Compliance shall compute the water available to add in liters (gallons) [(Mix Design Water) (CM (CY's)) – Total water]
18) The ticket shall also include the following information printed with enough room beside each item to allow the field inspector to record the appropriate test results: air content, air temperature, concrete temperature, slump, cylinder number, location/part of structure, time discharged, and signature of Inspector.
19) Location for Producer’s Representative signature.

The Certificate of Compliance shall provide space for water adjustment information, including:
   a) Temper or trim water in liters (gallons) added to truck at plant (filled in by batchperson or driver)
   b) Trim water in liters (gallons) added to truck at the jobsite (filled in by driver)
   c) Total actual water in kg (lb.) = (Total Water from Certificate of Compliance + any additions) (filled-in by Field Inspector)

Note: Drivers are required to fill-in spaces. Enter Zero (0) if no water is added.
Metric Certificate of Compliance

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>STANDARD LABEL</th>
</tr>
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<tbody>
<tr>
<td>a) Ingredients (aggregate, cementitious, water, admixtures)</td>
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<td>Source</td>
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<tr>
<td>c) Total Moisture Factor (in decimals to 3 places)</td>
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<td>f) Absorbed moisture in the aggregates (kg/m³)</td>
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<td>h) Free moisture (kg/m³)</td>
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<tr>
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<td>CM Targ</td>
</tr>
<tr>
<td>j) Target batch weights (kg)</td>
<td>Target</td>
</tr>
<tr>
<td>k) Actual batch weights (kg)</td>
<td>Actual</td>
</tr>
</tbody>
</table>

Definitions

Mix Design Water – The recommended water content for one cubic meter (yard) of concrete as noted on Mn/DOT Estimated Composition of Concrete Mixes Form TP-02406.

Total Moisture Factor – See 5-694.311 of Concrete Manual

Absorption Factor – See 5-694.311 of Concrete Manual

Free Moisture – The water that is carried on the surface of the aggregate that becomes part of the total water.

Batch Water – Water actually batched into the truck by the batcher.

Total Water = Batch Water + Free Moisture

Temper Water – Water added in mixer to adjust slump.

Trim Water – Water added to the truck after batch was discharged from plant.

Total Actual Water - The water in the concrete mixture at the time of placement from any source other than the amount absorbed by the aggregate. It includes all batch water placed in the mixer, free moisture on the aggregate and any water added to the ready mix truck prior to placement.

Ready-Mix Producer or "Producer" – Party that is producing the concrete for the Contract. It is understood that the Ready Mix Producer is the agent of the Prime Contractor.
English Certificate of Compliance

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A Mn/DOT Certified Technician representing the Producer shall review the first Certificate of Compliance for each mix type, each day, for accuracy and hand sign the Certificate at a location designated for signature. By signing the Certificate of Compliance the representative agrees to the terms of this policy and certifies that the materials itemized in this shipment comply with the applicable Minnesota Department of Transportation specifications and the project plans.

D7b Quality Control Testing and Sampling

The Prime Contractor/Producer, supplying concrete from a Ready-Mix Plant involved in the Certified Plant Program, will provide testing of the materials in the concrete as outlined below. A Plant Level II Technician Quality Control Supervisor, certified by Mn/DOT, shall oversee all testing and plant operations. The Quality Control Supervisor shall remain on site during concrete production or accessible by cellular phone to assure their presence at the plant site within one hour. The Quality Control Supervisor will maintain or oversee the maintenance of a plant diary. The diary, kept at the plant site, will document yards produced each day, tests performed, material problems, breakdowns, weather, etc., all to the approval of the Engineer.

The testing rates stated in the Schedule of Materials Control are minimums. Changes in the material require taking additional tests. Changes include but are not limited to: variable gradation results, new aggregates arriving on site, moisture conditions changing due to weather, or any other...
changing condition that warrants additional testing in the opinion of the 
Engineer.  **The Agency may determine when additional testing is 
necessary.**

Mechanical shakers are required for sieve analysis of fine and coarse 
aggregates.  AASHTO Standard Specifications for Transportation Materials 
and Methods of Sampling and Testing discuss the equipment and calibration 
necessary for performing the required tests.

The following is a list of the applicable tests and standards.

- **AASHTO T-27**  Sieve Analysis of Fine and Coarse Aggregates
- **AASHTO T-255**  Total Moisture Content of Aggregate by Drying
- **AASHTO M-92**  Wire-Cloth Sieves for Testing Purposes.  The sieves 
  shall comply with the requirements of 5-693.420B of the Department's 
  Bituminous Manual "Equipment Calibration and Verification Policies and 
  Procedures for Laboratory certification".
  The scales shall comply with the requirements of Mn/DOT's Bituminous 
  Manual "Calibration of weigh scales".

The provisions of 2461.4D3 apply regarding requirements to notify the 
Engineer of intent to pour concrete.  If the Ready-Mix Producer needs to 
change plants for an unexpected reason, it is allowable on an infrequent 
basis if the Quality Control Supervisor obtains approval from the Project 
Engineer or Metro Inspection (for the Metro District) before the plant 
change is made.

Only certified cementitious sources are allowed.  When requested by the 
District Materials Engineer, the Ready-Mix Producer is required to obtain 
samples of cementitious materials for subsequent testing by the Agency. 
The Producer shall place them in an Agency provided container sealed to 
prevent contamination.  The Ready-Mix Producer shall identify the samples 
with a copy of the rail or transport invoice that identifies the brand, mill 
location and date sampled, and retain them for the Agency Plant Monitor.  
The Agency Plant Monitor shall watch the material sampling process 
whenever possible.

**D7c  Moisture Content**

- All moisture tests are run by a Plant Level I Technician certified by 
  Mn/DOT.
- The Ready-Mix Producer shall determine the moisture content in all 
  fractions of the aggregate according to the Schedule of Materials Control.  
  Changes in the material may require additional testing.  The Producer is 
  responsible for all costs associated with determining the moisture content, 
  including equipment, labor, and materials.

The moisture content of the aggregate is determined by the oven dry 
method as outlined in the Mn/DOT Concrete Manual.  In addition to the 
standard moisture test, the Producer may choose to determine moisture 
content in the **fine aggregate** by use of a moisture probe.  This method is 
acceptable if an Agency Representative has approved the moisture probe. 

To obtain approval for the use of a moisture probe, the Producer must 
calibrate the moisture probe using the method described in 5-694.128 of the
After approval, the Producer is required to verify and chart both the probe moisture content and the oven-dry verification moisture test at a minimum rate of once per week. The Engineer may reduce this rate of verification if the comparisons justify it. The written permission of the Engineer is required to use other methods.

The Ready-Mix Producer will provide the Agency with all documentation for each moisture test, which is kept in a 3-ring binder at the plant site. The moisture content of each aggregate is charted and available at the plant. The Producer must allow Agency personnel to observe the batching process to verify weights shown on the Certificate of Compliance.

Gradations

All gradation testing is performed by a Plant Level I Technician certified by Mn/DOT. Testing rates shall be determined according to the Schedule of Materials Control.

The Ready-Mix Producer shall determine the gradation of the fine aggregate to insure conformity to Mn/DOT Specification 3126 and the coarse aggregates to insure conformity to Mn/DOT Specification 3137. This gradation testing will serve as the quality control for the Producer's material. The Producer is responsible for all costs associated with running gradations including equipment, labor and materials. The Producer shall perform all testing at the plant site to assure immediate resampling and testing of failing material.

The Producer shall run gradations and perform calculations as outlined in the Mn/DOT Concrete Manual. The Producer shall split and bag all process control samples and clearly identify them (Date, Test No., Time, Type of Material, Plant, Sampling Location) and retain them for a period of one week for companion sampling by the Agency.

The Ready-Mix Producer shall document the results of all gradations on the Weekly Concrete Aggregate Report (Mn/DOT Form 2449) utilizing every other column to provide room for Agency companion results. Supporting documentation for all gradations is kept in a 3-ring binder at the plant site. The Ready-Mix Producer will chart all sieves of the coarse aggregate and the 2.36 mm (#8), 600 µm (#30), and 300 µm (#50) sieves of the fine aggregate with procedures outlined in the Concrete Plant I Certification Course. In addition, the Producer shall plot the results of the Agency verification (audit) samples on the chart having the process control tests. The gradation charts must remain at the plant site.

Mn/DOT Certified Agency Plant Monitors will, during production for this project, take verification samples for quality assurance according to the Schedule of Materials Control. **(NOTE: Where problems with compliance with the Certified Ready Mix Program occur, plant inspections and testing rates shall increase).** The Agency Plant Monitor will split these samples and provide one-half of the sample for the Ready-Mix Producer. The Ready-Mix Producer shall test the split sample as a comparison check with the Agency results. The Ready-Mix Producer shall use their comparison check results as part of their quality control test
program. This sample can be used in fulfilling the testing rate requirement listed in the Schedule of Materials Control.

Agency Plant Monitors shall observe the actual water batched on a minimum of one load of concrete each time a verification gradation is collected. This observation includes: watching the ready-mix truck reverse the drum after washing to remove all wash water, checking to verify that an accurate moisture test is utilized during batching, confirming that the water measuring device is providing accurate data, and verifying that any additional water added to adjust the slump is recorded. The Agency Plant Monitor shall document the actual water batched on the Weekly Certified Ready Mix Plant Report (Mn/DOT Form 24143) and submit to the Concrete Engineering Unit with the Weekly Concrete Report (Mn/DOT Form 2448).

If the gradation tests on split samples from quality control or verification samples result in a variation between the Producer and the Agency greater than that set forth below, the two parties will cooperatively take and split a new sample. The Producer's representative shall test the sample while witnessed by the Agency Plant Monitor. This will serve as a check on the process to correct deviations from the standard testing procedure. If this problem continues, the Project Engineer, the District Materials Engineer and the Concrete Engineer will make a total review of this plant.

If the results still do not agree, the parties shall resolve the dispute by Third Party Resolution according to procedures described in the Mn/DOT Contract Administration Manual.

Allowable variations on percent passing any sieve:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>% Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm - 9.5 mm (2 in. - 3/8 in.)</td>
<td>+ or - 6</td>
</tr>
<tr>
<td>4.75 mm - 600 µm (#4 - #30)</td>
<td>+ or - 4</td>
</tr>
<tr>
<td>300 µm (#50)</td>
<td>+ or - 3</td>
</tr>
<tr>
<td>150 µm (#100)</td>
<td>+ or - 2</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>+ or - 0.6</td>
</tr>
</tbody>
</table>

The Ready-Mix Producer, after an acceptable time period, may request a reduction in testing rates if past results warrant. Such a request is subject to approval by the Mn/DOT Concrete Engineer. This approval is only based on extraordinary procedures performed by the Aggregate Supplier and Ready-Mix Producer to insure consistency and quality control. Extra fractions and bins are an example of such a procedure.

Prior to the production of Agency concrete each construction season, an Agency Plant Monitor shall perform a thorough on site inspection of the concrete plant to complete a Concrete Plant Contact Report (Mn/DOT Form 2163). This Contact Report contains the information necessary to assure that the plant can produce concrete meeting specifications. The Producer signs the report thereby certifying compliance with the Certified Ready Mix requirements and continual maintenance of the plant as reviewed.
D7f Non-Compliance

If a proposed plant cannot produce concrete, perform testing, or report information as required during completion of the Concrete Plant Contact Report, concrete from this plant is not acceptable.

After completing the Concrete Plant Contact Report and starting the Project, any procedural changes that cause non-compliance with this program will result in cessation of further production of concrete from this Plant. Decertification will also occur at any plant that continually produces concrete that is in noncompliance as detailed above. Complete disregard of this specification or fraudulent test reports are grounds for immediate Decertification.

Decertification could include any or all, but is not limited to, the following actions:
1) Revocation of Plant Certification.
2) Revocation of Technician Certification for individual(s) involved.
3) Loss of bidding privileges as determined by the State Construction Engineer.
4) Criminal prosecution for fraud as determined by the Attorney General.

Decertification actions are determined by the Mn/DOT Concrete Engineer.

2461.5 MEASUREMENT AND PAYMENT

All costs associated with this Certified Ready-Mix Plant Program are considered incidental with no further compensation.

Only when payment is prescribed under the provisions hereof will the quantity of concrete mixture produced and furnished be measured as a separate item. Then, the volume of fresh concrete will be measured as the computed, theoretic volume based on mass (weight) of the batch ingredient. The quantities so determined will be reduced for payment by all accountable waste.

In general, whenever practicable, payment for the concrete mixture used will be made on the basis of structure dimensions as provided for in the detailed Specifications for the item of work involved. In cases where concrete is furnished for incorporation in miscellaneous items for which there is no detailed Specification or Pay item, no direct compensation will be made for the concrete used.

Payment for Concrete of each mix number or grade specified, at the Contract price per unit of measure will be compensation in full for all costs of producing and furnishing the concrete and for all costs of placing, finishing, and curing the concrete as specified, except for such costs that are specifically compensated for under other Contract items.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2461.501</td>
<td>Concrete, Mix. No. __</td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>
2471 Structural Metals

2471.1 DESCRIPTION
This specification outlines the requirements for shop and/or field work consisting of manufacturing, fabricating, and/or coating structural metals.

2471.2 MATERIALS
Domestic material is required on all Federal Aid projects. The Mill Test Reports (MTR’s) for these projects shall show that the material was melted and manufactured in the U.S.A. If there is insufficient information on the MTR, necessary test results shall be provided before the material can be accepted. If foreign material is supplied, the provisions of 1601 shall apply.

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

All materials furnished by a mill, warehouse, or processor shall have supporting certified MTR's in accordance with all applicable ASTM specifications.

A  Low Carbon Structural Steel ..................................... 3306
B  General Requirements for Structural Steel .................. 3308
C  Structural Alloy Steel
   C1  High Strength Low Alloy Structural Steel .............. 3309
   C2  High Strength Low Alloy Columbium-Vanadium Structural Steel .............................................. 3310
   C3  Stainless Steel ..................................................... 3312
D  Pin and Roller Steel
   D1  Hot Rolled Bar Steel ............................................ 3313
   D2  Cold Finished Bar Steel ..................................... 3314
E  Steel Forgings.......................................................... 3315
F  High Performance Steel (Y.S. 345 MPa (50 ksi)) ... 3316
G  High Performance Steel (Y.S. 485 MPa (70 ksi)) ... 3317
H  Gray Iron Castings .................................................. 3321
I  Carbon Steel Castings .............................................. 3322
J  Alloy Steel Castings ................................................ 3323
K  Blank
L  Malleable Iron Castings ............................................ 3324
M  Bronze
   M1  Wrought Plates .................................................. 3325
   M2  Castings, Type 1 .............................................. 3327
   M3  Castings, Type 2 ............................................... 3328
   M4  Lubricated Bearing Plates and Bushings ............. 3329
2471.2

N  Sheet Brass ................................................................. 3331
O  Sheet Copper ............................................................. 3332
P  Blank
Q  Blank
R  Sheet Lead ............................................................... 3335
S  Sheet Metal Products ................................................ 3351
T  Aluminum-Wrought and Extruded .............................. 3336
U  Pipe
   U1  Cast Iron Soil Pipe .............................................. 3252
   U2  Structural Steel Tubing ....................................... 3361
   U3  Structural Steel Pipe ......................................... 3362
   U4  Aluminum Tube for Pipe Railing .......................... 3363
   U5  Wrought Steel ................................................... 3364
   U6  Cast Iron Water Pipe .......................................... 3365
   U7  Copper Water Tube and Fittings ............................ 3366
   U8  Rigid Steel Conduit ............................................ 3801
V  Anchor Rods .......................................................... 3385
W  Fasteners .............................................................. 3391
X  Galvanized Hardware .............................................. 3392
Y  Galvanized Structural Shapes ................................... 3394

2471.3  FABRICATION REQUIREMENTS

A  General

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

   Fabricator shall mean the manufacturer or supplier of fabricated
   structural metals. In the event the Contractor does the work, the term
   shall also mean the Contractor or the Contractor's agent.

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

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

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

   When fabricated components will be installed on a previously
   constructed structure, the Contractor shall measure field dimensions
   as specified in 2433.
A1 Definitions
A1a Minor Structural Components
Minor structural components shall mean materials used in the following applications:
1. Bridges: Bearing assemblies, sole plates, expansion joint devices, shear connectors, ballast plates, diaphragms for bridges (except curved steel bridges), pile and appurtenances, drainage systems, guardrail connections, railings, fencing, conduit systems, and protection angles.
2. Electric lighting, traffic signs, and signal systems.
3. Pedestrian bridges.
4. Any other system or component that is designated by the Engineer as a minor structural component.

A1b Major Structural Components
Major structural components shall mean all components other than minor structural components.

A2 Certification Requirements
For the fabrication of rolled beam bridges having a pay quantity for structural steel of less than 136,000 kg (300,000 pounds), pedestrian bridges, steel diaphragms having a linear quantity of more than 1500 m (5,000 feet), diaphragms designated major structural components (curved steel bridges), or any other item designated by the Engineer, the Fabricator shall be certified under AISC Quality Certification Program Category, Simple Steel Bridge Structures (Sbr).

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

For the fabrication of Fracture Critical items the Fabricator shall be certified under AISC Quality Certification Program Category, Major Steel Bridges (Cbr) with Fracture Critical Member endorsement (F).

The Contractor/Fabricator performing coating applications must demonstrate qualification by obtaining an AISC Sophisticated Paint Endorsement (SPE), an SSPC QP Certification, or a quality certification system acceptable to the Engineer.

B Shop Detail Drawings
B1 General Requirements
Shop detail drawings shall consist of the following: detailed plans showing the dimensions and sizes of materials; any details and information necessary for fabrication; bolt lists for shop and field erection; blocking and camber diagrams; a match marking diagram; a
radiographic diagram showing weld locations and identification in accordance with 2471; and a complete field erection plan showing piece marks. Welding symbols shall be in accordance with ANSI/AWS A2.4-Standard Symbols for Welding, Brazing, and Nondestructive Examination. The Fabricator shall place Welding Procedure Specification (WPS) numbers in the tail of the arrow.

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

Shop drawings shall note all dimensions measured in the field.

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

B2 Format

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

The size of the sheets for the drawings shall be 559 mm (22 inches) wide by 864 mm (34 inches) long with a 13 mm (½ inch) border on all edges except the left 559 mm (22 inch) edge shall have a 50 mm (2 inch) border. Each sheet shall have a title box in the lower right hand corner which will include the following information: the Department's structure number; Project number; the Federal Project number when applicable; the Fabricator's name; the Fabricator's Contract number; the detailer's and checker's initials; the date of preparation; and a brief description of the details shown on each sheet. The height of letters and numerals on each drawing shall be not less than 3.5 mm (0.14 inch). The text, details, lines, and dimensions shall be of such quality that when they are reduced in size to 280 mm by 432 mm (11 x 17 inches), or when they are projected in full enlargement of microfilm (that has been reduced in ratio of 24 to 1), they will be clearly readable. Bolt lists may be furnished on the Fabricator's own standard sheets.

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

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

B3 Submittal for Engineer's Review and Approval

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

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

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

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

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

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

B4 Submittal for Completed Work

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

Any alterations or corrections made on copies that are submitted to the Department shall be made with waterproof drawing ink. Translucent tracings, intermediate media or duplicates used for making reproductions shall be free of dirt, opaqueness, "graying in", unnecessary lines, watermarks, folds, or any other property that might impair the transparency. They shall be suitable for making copies on standard reproduction equipment. All duplicate reproducibles shall be photographic silver halide fixed line positives or archival-quality xerographic positives on polyester base with matte drafting surfaces on both sides. Either option must have a distortion accuracy of plus or minus 1 percent. The minimum line density shall be 1.3 on a standard 18-percent gray card. Opaquing of the optional intermediate negatives and bleaching of the final reproducibles may be required to obtain reproducibles of microfilm quality. The film base shall be 76 to 102 µm (0.003 to 0.004 inch) in thickness. The sheet size shall be 280 mm by 432 mm (11 x 17 inches). For railroad bridges, two sets will be required, one of which shall be 280 mm by 432 mm (11 x 17 inches) and the other shall be sized as required by the railroad.

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

C  General Fabrication Practices

General structural, and assembly practices shall be performed in accordance with the AASHTO/NSBA Steel Bridge Collaboration "Steel Bridge Fabrication Guide Specification" and all applicable AWS welding codes, except as modified within. Structural Welding shall be performed in accordance with ANSI/AASHTO/AWS D1.5-Bridge Welding Code, for major structural components, and/or ANSI/AWS D1.1-Structural Welding Code Steel, for minor structural components, except that all welder and welding operator qualification tests shall be witnessed by a Certified Welding Inspector (CWI) or equivalent, or as modified by this specification.

Prior to fabrication of any structural metal items, the Fabricator shall supply a Quality Control Plan (QCP), for approval, to the Engineer. The QCP shall describe, in detail, the methods, equipment, Non Destructive Testing (NDT), and frequency of testing used to ensure that the requirements of this Specification are met. The
AASHTO/NSBA-Steel Bridge Fabrication QC/QA Guide Specification, shall be used as basis for approval of the QCP.

If, during the course of the work, the Engineer determines that fabrication work is not being conducted according to the approved QCP, or that approved fabrication procedures are not being followed, the materials shall be considered in non-conformance to the specifications and subject to rejection. In such cases, the Fabricator shall immediately correct the procedure, conduct additional tests, and submit written Non-conformance Reports, containing all data the Engineer requires, to ensure compliance with the QCP. All costs of required additional testing shall be at no cost to the Department.

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

C1 Prefabrication Conference

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

C2 Notification

The Fabricator shall provide the Engineer with 5 working days of advance notification prior to the start of fabrication so that inspection may be provided. No material shall be manufactured or work on before the Engineer has been notified.

C3 Identification of Materials

Before fabrication begins, the Fabricator shall furnish a copy of all purchase orders, MTR's, or other documentation satisfactory to the Engineer, indicating that the materials meet the physical, chemical, and source (mill) requirements of these specifications for each heat of steel used in the work. Copies of purchase orders shall be furnished when the orders are placed. The Fabricator shall indicate, in writing or by ink stamp, that the MTR's have been checked for compliance with the applicable specification. The name of the individual who checked the MTR and the date of inspection shall be included. If the Engineer determines that the documentation is incomplete for some or all of the materials to be used, the Fabricator shall sample and test materials as directed by the Engineer, and all work shall be done at no cost to the Department. When requested by the Engineer, the Fabricator shall furnish scale weights of individual members or sections.

A Fabricator of minor structural components may supply to the Engineer, a Certificate of Compliance (COC) and shipping documents for each pay item, in lieu of submitting all the appropriate paperwork (purchase orders and MTR's) with the following exceptions:
1) pedestrian bridges 2) post and truss chord materials for traffic signs 3) high mast light poles 4) modular expansion devices 5) pot bearings 6) other items designated by the Engineer. Submitting a COC does not relieve the Fabricator of having to have all appropriate documents on file for a minimum of 7 years.

During each stage of fabrication of major structural components, the Fabricator shall provide and maintain identification sufficient to establish the heat of the material from which any component is fabricated. The Fabricator shall maintain a list that shows heat numbers referenced to the material incorporated into each component. The Fabricator shall furnish a copy of this list to the Engineer. Material that loses its identity shall be rejected unless the identity can be reestablished to the satisfaction of the Engineer. Identifying and re-establishing the identity of such material shall be at no cost to the Department.

Wide flange beams, flanges, webs, splice plates, welded cover plates, and fracture critical members shall have identification numbers placed on each individual piece of material. Identification numbers shall be referenced to the corresponding heat number. Identification coding of material shall be done using non-oil-based markers or low stress die stamps.

C4 Weld Identification System
For purposes of identifying welds subject to radiographic and/or ultrasonic testing, the Fabricator must use the Mn/DOT standard weld identification system or an alternate system approved by the Engineer, prior to implementation. The traceability system shall have a unique identification assigned to all welds being examined, and shall not be repeated. The identification number shall be documented on the shop detail drawings and shall be traceable back to the original member examined.

C4a Standard Weld Identification System
(1) Piece Mark
The Fabricator’s piece identification from the approved shop detail drawings.
(2) Splice Plane Number
For purposes of this document a splice plane is defined as a 1 m (3 foot) wide vertical section of a piece that contains a full penetration welded splice in any component of the piece. Any other full penetration welded splice in any component of the piece within the 1 m (3 foot) vertical splice plane is in the same splice plane.

The number of the splice plane on the piece starting from the left end of the piece is shown on the radiographic diagram.
(3) Piece Components Code

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

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

(4) General Notes

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

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

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

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

C5 Storage of Materials

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

C6 Nonconformances

The Fabricator shall have an established Quality System outlined in their QCP for controlling nonconforming material, which shall include procedures for identification, isolation, and disposition.

The Fabricator shall properly document all nonconformances using a Nonconformance Report form. The Nonconformance Report form shall be submitted to the Engineer documenting any deviation from the QCP, approved shop drawings, Project Plan, and/or specifications. The Nonconformance Report form shall include the following items: company name and address; report title; Nonconformance Report number; date; company job number; piece mark; owner of bridge/structure; contractor; Owners Project Number; location; a detailed description of the nonconformance; photo, sketch, or drawing; proposed repair/disposition of the nonconformance; and the Quality Control Manager's signature and date. The Fabricator will be advised,
in writing, by the Engineer, of the final resolution of the nonconformance.

D  Structural Components

D1  Welded Stud Shear Connectors

In accordance with OSHA Subpart R 1926.754, shear stud connectors or other similar devices shall not be attached to the top flange of beams or other steel components, until after the decking falsework, or other walking surfaces, have been installed.

D2  End Connection Angles

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

D3  Bolts

All bolts shall be High Strength Structural Steel Bolts (3391) except that Common Structural Steel Bolts may be used for connections in expansion and deflection devices and in hand railings. Structural Bolts shall project through the nut not less than 3 mm (1/8 inch) nor more than 10 mm (3/8 inch).

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

D4  Pins and Rollers

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

Pin threads shall conform to American Standard Coarse Thread Series Class 2, free fit as specified in ANSI B1.1. Pin ends and nuts having a diameter of 35 mm (1-3/8 inches) or more, shall be threaded 6 threads per 25 mm (1 inch). The nuts shall be made of structural steel (3306, 3309, 3310) and be recessed, hexagonal in shape, and galvanized per 3392. The grip face of the nut shall be machined square to the axis of the pin. Pins and nuts shall be accurately made so that the recessed face of the nuts will bear uniformly against the end face of the pin when the nut is turned up tight. The threaded portion of the pin shall project at least 6 mm (¼ inch) through the nut after assembly. Where a recessed cut is made between the threads and the shoulder of the pin, it shall not be wider than 6 mm (¼ inch), nor deeper than the base of the thread.
D5  Shims
Shims shall mean all metal plates that are not required by the Plans and that bring metal surfaces of members into contact or bring the structure to the required grade or alignment.

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

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

E  Structural Fabrication
E1  Cutting
All metals shall be neatly and accurately cut to the required size with proper allowance being made to provide for necessary or required finishing operations. The maximum permissible deviation from true lines shall be 2 mm (1/16 inch). True lines shall mean theoretical lines exactly corresponding to and used to transfer Plan dimensions to materials for cutting, drilling, and fitting.

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

E1a  Re-entrants
All interior and re-entrant corners shall have a minimum radius of 25 mm (1 inch). Filleted corners less than 25 mm (1 inch) in radius shall be formed by drilling.

E1b  Shearing
Shearing shall not be used for the purpose of cutting nonferrous metals where the thickness is greater than 13 mm (1/2 inch).

E2  Machining
E2a  General
Any required heat treatment shall be done prior to final machining. Heat treatment shall mean any method of intentionally and systematically applying heat at a temperature below the melting point of any ferrous castings, weldment, or other component.

E2b  Machining Tolerances
The standard machining tolerances for all members requiring machine finish shall be plus or minus 760 µm (0.03 inch). This tolerance shall apply to the following and all similar dimensions:
(1) Spacing between bearing assembly pintles and pintle holes.
(2) Depth of pintle holes and height of pintles after welding.
(3) Thickness of each individual plate that makes up a bearing assembly.
E2c  Machine Lubricant
Machine lubricant used on structural material requiring machine work or drilling shall be such that it can be completely removed, by approved methods, to a thoroughly clean and dry surface.

E2d  Edge and Corner Finishing
For painted bridge members: All corners of edges shall be beveled a minimum of 2 mm (1/16 inch). When material is cut to final size by thermal cutting, grinding or milling of edges shall be done to remove thermal cutting marks sufficient to achieve and measure required painting surface profile.

E2e  Finishing
Warped or deformed plates shall be machine finished or straightened by an approved method to provide the proper fit. Surfaces that will be in contact bearing with other structural parts shall be machine finished, as required, to achieve full contact for all parts. Full contact shall be defined as surface flatness that is less than 0.005 x nominal dimension of the part.

E3  Bending
Before bending, the corners of the plates shall be rounded to a radius of 2 mm (1/16 inch) throughout the portion of the plate at which the bending is to occur. Metals shall be bent prior to any coating or required heat treatment. Bending shall not cause fractures, kinks, reduced section below minimum, or other defects in the material.

E4  Cambering and Curving
Vertical camber and horizontal curvature shall be measured for final acceptance after all welding and heating operations are completed and the flanges have cooled to uniform ambient temperature. Horizontal curvature shall be checked with the girder in the vertical position.

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

E5  Straightening Material
Material shall be straightened by methods that will not shear, fracture, stress, or damage the bolts, welds, or base metal. Heat straightening shall be done by methods approved by the Engineer. Any material damaged during straightening operations shall be replaced with new material at no cost to the Department.

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

E6  Dimensional Tolerances
The maximum variation from flatness for fascia beam webs shall be one-half the limit given in ANSI/AASHTO/AWS D1.5-Bridge Welding Code (BWC).
Structural Welding

F1 General

No welding including weld repair, or any deviation from the approved shop drawings or Project Plan shall be permitted without written approval from the Engineer.

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

The Fabricator must submit information or Procedure Qualification Records (PQR's) demonstrating, to the satisfaction of the Engineer, that the proposed WPS's meet the requirements of the BWC. PQR's, once accepted, are valid indefinitely.

It shall be the Fabricator's responsibility to provide advance notification so that the Engineer can witness welding or testing or both. When the Engineer is unavailable to witness qualification or certification welding or testing, the Fabricator shall arrange and bear all costs of having an approved third party as a witness.

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

F1a Welded Flange Splices

Welded flange splices shall be at least 300 mm (12 inches) from web splices. For welded girders having radii less than 580 m (1900 feet), additional splices will be permitted only on individual flanges that are uniform in thickness and greater than 12 m (39 feet) in length. The splices will be permitted in addition to the required splices shown on the Plans. No flange shall contain more than two additional splices.

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

F2 Preparation of Base Metal

Members or parts that have been coated (including metallizing and galvanizing) shall have all of the coating material removed from within a minimum of 50 mm (2 inches) on either side of the weld area.
F3 Conditions for Welding
Preheat shall be applied in a manner that does not produce visible moisture in the weld joint prior to welding.

G Fracture Critical Members
Requirements of the ANSI/AASHTO/AWS D1.5 Bridge Welding Code, Fracture Control Plan (FCP) for Fracture Critical Bridge Members shall apply to fracture critical members as modified by these specifications.
Fracture Critical members shall be those members that are designated Fracture Critical in the Plans. Welds in designated members, not subject to tension forces, will be exempted from these requirements, if written approval is obtained from the Engineer.
No welding or drilled holes for temporary attachments to rolled beams or girders will be permitted.

H Hole Forming Operations

H1 Bolt Holes
All holes for bolts shall be drilled full size from the solid except where punching is allowed by this specification. Sub-punching or sub-drilling of holes will not be permitted unless written permission is obtained from the Engineer.
Except for field connections and field splices, material forming parts of a member composed of not more than five thicknesses of metal may be punched 2 mm (1/16 inch) larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than 19 mm (3/4 inch) for structural steel, 16 mm (5/8 inch) for high strength steel, or 13 mm (1/2 inch) for quenched and tempered alloy steel and non-ferrous metals.
Holes shall be clean cut without sharp, torn, or ragged edges. Holes shall be drilled after any required bending, cambering, curving, or heat-treating of the member.

H1a Special Assembly
When Special Assembly is specified in the Contract, the connection holes in flange and web splices shall be drilled full size in the assembled position. Connection holes in secondary members, which include diaphragms, diaphragm stiffeners, lateral bracing, and lateral bracing connection plates, shall be drilled oversized (Bolt diameter + 5 mm (3/16 inch)) to facilitate alignment. Predrilled splice plates may be used as a template only once. For oversized holes, hardened washers, conforming to ASTM F436, shall be placed under both the bolt head and nut.

H1b Full Assembly
When Full Assembly is specified in the Contract, all bolt holes for field connections, in all members and component parts of each
structural unit, shall be drilled from the solid to the specified size while assembled. Predrilled splice plates may be used as a template only once.
H1c Punched Bolt Holes
The diameter of the die shall not exceed the diameter of the punch by more than 2 mm (1/16 inch). If any holes must be enlarged to admit the bolts, a written repair procedure shall be submitted to the Engineer for approval.
H1d Field Connection Bolt Holes
Holes for floor beams, stringer end field connections, and holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames, shall be drilled full size to a steel template while assembled.
Holes for field splices of rolled beam stringers continuous over floor beams or cross frames and all holes for floor beams, cross frames or bent plate diaphragms may be drilled full size unassembled to a steel template with written approval from the Engineer.
The drilling of field connection holes to full size, using a steel template, shall be done after the template has been located to the proper position and angle, and firmly bolted in place. Templates used for drilling matching members, or the opposite faces of a single member, shall be exact duplicates.
H2 Boring Pin Holes
The final surface of pin holes shall be produced by a finishing cut. The diameter of the pin hole shall not exceed that of the pin by more than 0.5 mm (1/64 inch) for pins 127 mm (5 inches) or less in diameter, or by 0.8 mm (1/32 inch) for larger pins.
The distance outside-to-inside of end holes in tension members and inside-to-inside of end holes in compression members shall not vary from that specified more than 0.8 mm (1/32 inch). Boring of pin holes in built-up members shall be done after the member has been assembled.
I Blank
J Shop Assembly
All fabrication work, including weld inspection, nondestructive testing and any necessary repairs, shall be completed before any component is placed in the assembly. The Fabricator shall furnish to the Engineer, upon request, a written record of each shop assembly set-up. These records shall show the following assembly dimensions, both theoretical (as shown on a blocking diagram) and actual measurements: (1) Elevations at bearing points, field splice locations, and Plan ordinates closest to mid span.
(2) Span lengths.
(3) Alignment offsets.

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

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

J1 Special Assembly

Unless otherwise required by the Contract, major structural components, pedestrian truss bridges, overhead sign trusses, and modular/finger expansion joint devices shall be assembled at the fabrication shop. Beams or girders shall be line assembled with a length no shorter than the length supported by three adjacent points of bearing and with all indicated and included pieces completely assembled.

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

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

J2 Full Assembly

When Full Assembly is specified by the Contract the following additional requirements shall apply.

(1) The main members shall be assembled for the length as set forth in the Contract and the width of the assembly shall be the full width of the structural unit.

(2) The assembly shall include all components such as diaphragms, brackets, laterals, wind frames, links, and transverse floor systems. The assembly need not include components such as expansion and deflection devices and bearings.

J3 Match Marking

Connecting parts assembled in the shop to assure proper fit in the field shall be match-marked using low stress die stamps, prior to disassembly.

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

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

K Uncoated Weathering Steel Surfaces

For uncoated 3309 or other types of weathering steel specified in the Plans, all foreign matter such as oil, grease, dirt, and concrete spatter, shall be removed from the steel in accordance with SSPC-SP 1 - Surface Preparation Specifications - Solvent Cleaning. In addition, all uncoated weathering steel, including all contact areas of bolted structural connections, shall be blast cleaned in the shop or field in accordance with SSPC-SP6/NACE No. 3 - Commercial Blast Cleaning.

L Coating

Coating shall be interpreted to mean any protective barrier including paint, galvanizing, or metallizing.

Prior to performing work the Contractor shall supply a Quality Control Plan (QCP) that is acceptable to the Engineer. The AASHTO/NSBA-Steel Bridge Fabrication QC/QA Guide Specification and the AASHTO/NSBA Guide Specification for Coating Systems with Inorganic Zinc-Rich Primer, shall be used as basis for approval of the QCP.

The coating material(s) shall not be applied to a part/component until all fabrication work and required inspections of the part/component have been completed and approved by the Engineer. Any material coated prior to the Engineer's approval shall be subject to rejection under 1512 and/or removal of all coating materials.

L1 Galvanizing

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

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

Material to be galvanized shall be free of paint, lacquer, crayon markings, etc. No closed or blind sections of pipe shall be galvanized. All steels to be galvanized shall be blast cleaned in accordance with SSPC-SP 6/NACE No. 3, before pickling.

Malleable iron castings shall be heat-treated and large gray iron castings of non-uniform thickness shall be normalized before pickling.
Galvanized items that have undergone warpage or distortion shall be straightened to a maximum tolerance of 3 mm in 3000 mm (1/8 inch in 10 feet), or as directed by the Engineer.

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

Repair of galvanized surfaces, for other than duplex paint systems, shall be done in accordance with ASTM A 780, Annex A1. Materials used for repair shall be applied in accordance with the manufacturer's recommendation.

L2  Metallizing

All steel surfaces to be metallized shall be blasted and cleaned in accordance with AWS C2.18-Guide for Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites.

Zinc metallizing wire or powder of purity equal to that required in the Federal Specification MIL-W-6712 (99.9 percent zinc), shall be used. The total thickness of the coating shall be an average of 254 µm (0.010 inch) with a minimum of 190 µm (0.0075 inch).

Preheat the substrate to 120ºC (250ºF) to eliminate surface condensation and reduce shrinkage and differentials between the coating and the substrate. No metallizing will be allowed without written approval from the Engineer.

L3  Painting

All surface preparation and painting shall conform to 2479 unless otherwise specified in the Contract.

M  Fabricator Inspection

The Fabricator shall have Quality Control personnel present as required by the approved Quality Control Plan (QCP) and this specification.

M1  Nondestructive Testing (NDT)

The Fabricator shall perform NDT in all areas designated in the Contract and/or the applicable welding code. Performance of NDT shall be done by trained personnel who have, as a minimum, 2 years experience as an American Society for Nondestructive Testing (ASNT) NDT Level II operator. All NDT qualifications shall be per ASNT-TC-1A. A copy of the NDT operators training and certification records shall be submitted to the Engineer prior to any inspections being performed. The Fabricator shall also supply to the Engineer a copy of the written practice(s) and procedures for each NDT method to be used. A final written report of all NDT shall be submitted to the Engineer, with interim test reports submitted as performed.

For the Nondestructive Testing of bridge components, tension areas are defined as follows:
(1) The top half of the rolled beam or girder in zones designated in the Plans as "Area A".
(2) The bottom half of the rolled beam or girder in zones outside of "Area A".
(3) Any location in a rolled beam or girder where the superstructure curvature is more than 4 degrees.
(4) Any other tension area as designated in the Project Plan.

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

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

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

M1a Visual Inspection (VT)

Visual inspection shall be performed during the entire welding process and again after the weld is completed, cooled, and cleaned of all slag and residue.

M1b Dye Penetrant Testing (PT)

All edges of complete penetration groove welds, on major structural components, shall be checked by Dye Penetrant Inspection for 75 mm (3 inches) on each side of the centerline of the weld or 25 mm (1 inch) beyond either side of the weld area, whichever is greater. Magnetic Particle Inspection may be substituted.

M1c Magnetic Particle Testing (MT)

At least 300 mm (12 inches) of every 3 m (10 feet) length of all fillet welds in major structural components and pedestrian bridges, shall be MT'd, except that all bearing stiffener welds shall be 100% tested. These tests shall be located at random areas of the weld. At least 20 percent of all weld terminations shall be tested. Base plate and gusset plate welds for overhead signs and high mast light poles shall be MT'd 100 percent. The prod method shall not be used unless designated or authorized by the Engineer.
M1d Radiographic Testing (RT)
All developed radiographic film shall have a film density between 2.5 and 3.5 and shall be furnished to, and become the property of, the Department.

N Department Inspection
N1 General
All major and minor structural steel components shall be inspected by the Engineer prior to being incorporated in the work. This may involve performing inspections at the mill, foundry, fabrication shop, or in the field, as considered necessary by the Engineer.

The purpose of Department inspection(s) is to establish compliance with those test requirements and process controls that are outlined in the Contract documents as required by federal and state laws. The Department inspection(s) are not intended to supplement or replace the supplier's own Quality Control, nor shall it relieve the supplier of the responsibility for the correction of errors and faulty workmanship, or for the replacement of imperfect materials.

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

The Fabricator shall be responsible for providing Department Inspectors with suitable hard hats, face and hand shields, safety glasses, respirators, and other safety equipment necessary the Inspector's safety while performing structural metals inspections.

The Fabricator shall give the Engineer at least 5 working days notice prior to beginning work so that inspection may be provided. No material shall be manufactured or work done before the Engineer has been notified. Any work that has been done without notice shall be subject to rejection of the work in accordance with 1512, or may be subject to additional NDT, at no cost to the Department.

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

Material shipped to the project site without a Department inspection tag will be considered unacceptable and subject to 1512.

N2 Facilities for Inspection
The Contractor shall furnish an office and any needed tools and assistance to the Inspector for a period of 30 days prior to work being started until 30 days after the material is shipped.

The Inspector's office shall:
(a) Have a minimum floor space of 9.3 m² (100 square feet).
(b) Contain a minimum of two desks, or a desk and table, two chairs, a file case, and other necessary furniture.
(c) Be clean, modern, and have adequate lighting, heating, and ventilation.
(d) Be separated from other activities by being in a completely partitioned area and provided with a separate locking door.
(e) Have telephone service and a separate dedicated computer data line.

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

The cost of furnishing, maintaining, and repairing, or replacing inspection facilities shall be considered incidental to the cost of steel bridge construction.

O Blank

P Marking and Shipping

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

Connection plates for a member shall be bolted in position for shipment. Pins, bolts, nuts, and washers shall be shipped in suitable weatherproof containers not exceeding 230 kg (500 pounds). Pins shall be shipped with nuts in place. Bolts (of one length and diameter), nuts, and washers shall be packaged in accordance with ASTM A 325 - Packaging and Package Instructions.

The loading, transporting, unloading, handling, and storage of material shall be carefully conducted so that the material will be kept clean and free of damage. Coated material shall be padded during these operations to the extent necessary to prevent damage of the coating. All beams and girders shall be shipped in an upright position unless otherwise approved. Material shall be securely blocked in a manner that will prevent buckling, warping, or twisting during transportation. Cambered members shall be securely blocked to prevent loss of camber.
2472

2472 Metal Reinforcement

2472.1 DESCRIPTION
This work shall consist of the furnishing of metal reinforcement of the type, shape and size specified, and its satisfactory placement at the locations required by the Contract, in concrete structures other than concrete pavement and concrete base.

2472.2 MATERIALS
A Reinforcement Bars ........................................ 3301
B Steel Fabric .................................................... 3303
C Spiral Reinforcement ........................................... 3305

2472.3 CONSTRUCTION REQUIREMENTS
A Bending
Bars shall be bent to the shapes shown in the Plans and may be bent cold. Hot bent bars shall not be heated above the dull cherry-red range (a maximum of 650°C (1200°F)) and shall not be quenched.

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

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

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

All systems for handling epoxy coated reinforcement bars shall have adequately padded contact areas where ever possible. All bundling bands shall be padded and all bundles shall be lifted with a strong back, multiple supports, or platform bridge so as to prevent bar-to-bar abrasion from sags in the bar bundle. Bars or bundles shall not be dropped or dragged. Bars or bundles shall be adequately supported in transit in a manner that will prevent damage to the coating.
When epoxy-coated reinforcing steel delivered to the project site or storage yard is, or is expected to be, exposed to the weather for more than 60 days, the reinforcement shall be covered to protect against sunlight, salt spray and weather exposure. Provisions shall be made for air circulation around the reinforcement to minimize condensation under the protective covering.

C Placing, Supporting, and Tying Bar Reinforcement

C1 General Requirements

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

Reinforcement bars shall be firmly supported and securely tied in their proper position. All peripheral intersections shall be tied, and a sufficient number of intermediate intersections shall be tied to ensure that no shifting or displacement of the bars will occur during subsequent operations. Wire used for tying shall be black, soft iron wire, not lighter than 1.5 mm (16 gauge). Welded ties shall not be used.

Concrete shall not be placed for any unit until the placement, support system, and tying of the reinforcement bars has been inspected and approved.

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

(a) Be fabricated from stainless steel, or
(b) Have hot-dip galvanized, epoxy or plastic coated tips extending at least 12.5 mm (½ inch) above the sheathing.

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

C2 Special Requirements for Bridge Slabs

In addition to the General Requirements, supporting and tying reinforcement bars for bridge slabs shall be governed by the maximum spacing requirements of Table 2472-1. These spacing requirements define only the maximum permissible distances between ties or lines of support. Table 2472-1 does not relieve the Contractor of responsibility for providing additional supports or ties as necessary for holding and supporting bars firmly in their correct position.

For bridge slabs, the primary support for the bottom transverse reinforcement bars shall be Slab Bolsters, as shown and defined under Bar Support Specifications and Standard Nomenclature in the CRSI manual. The bolsters shall be placed on the falsework sheathing in
continuous lines approximately parallel to the beams, girders, or centerline of the roadway, at locations that will permit supports for the top transverse reinforcement bars to be placed directly over them on the bottom transverse bars.

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

For all interior bays on beam span bridges, slab bolsters and upper continuous high chairs shall be placed within 150 mm (6 inches) of the edge of beam flanges. The maximum spacing of all slab bolsters and upper continuous high chairs shall be 915 mm (3 feet) for #10 and #13 bars, and 1220 mm (4 feet) for #16 - #22 bars.

The top mat of bridge slab reinforcing shall be tied down with tie wires to the in-place beam stirrups or shear connectors at spacing not to exceed 1500 mm (5 feet), measured longitudinally along each beam.

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

<table>
<thead>
<tr>
<th>Table 2472-1</th>
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<tr>
<td>Maximum Spacing of Supports and Ties for Bridge Slabs</td>
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<table>
<thead>
<tr>
<th>Bar Size Number</th>
<th>Maximum Spacing for Slab Bolsters &amp; Continuous Type High Chairs</th>
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<tbody>
<tr>
<td>10 &amp; 13</td>
<td>900 mm (3 feet)</td>
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<tr>
<td></td>
<td>900 mm (3 feet)</td>
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<td>600 mm (2 feet)</td>
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<td>16, 19 &amp; 22</td>
<td>1200 mm (4 feet)</td>
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<tr>
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<td>1200 mm (4 feet)</td>
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<td>900 mm (3 feet)</td>
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The bottom layer of longitudinal reinforcement bars for slab span bridges, cast-in-place concrete girders, beams, struts, and similar sections shall be supported on beam bolsters or heavy beam bolsters commensurate with the mass to be supported. Precast concrete block or brick supports will not be permitted on formed surfaces.
Subsequent layers of longitudinal bottom reinforcement, except for those bars which can be tied to vertical bars, shall be supported by upper beam bolsters or upper heavy beam bolsters. Any deviation from these requirements shall be subject to approval by the Engineer.

When the Contractor has completed placement and tying of the reinforcement bars for a section of bridge slab, and before concrete delivery has been ordered for that section, the strike-off rails or guides shall be set to correct elevation. The Contractor shall then notify the Engineer that the section is ready for a final check, and shall, in the presence of the inspector, operate the strike-off device over the entire section. A filler strip, 6 mm (¼ inch) less in thickness than the minimum concrete cover requirement, shall be attached to the bottom of the strike-off during this check as a means of detecting areas where the top reinforcement may encroach on the required clearance. Placement of concrete for a bridge slab without having first afforded the Engineer the opportunity of checking the reinforcement as defined above shall be subject to 1512.

C2a Special Requirements for Epoxy Coated Bars

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

Wire bar supports shall be epoxy coated. The coating shall be well bonded and resist abrasion. Epoxy coating for bar supports shall be at least 127 µm (0.005 inch) in thickness and shall meet requirements of 3301. Wire bar supports that will bear on falsework sheathing for concrete surfaces that will remain exposed in the completed structure shall have plastic coated tips or additional epoxy coating on the legs of the supports. This additional material shall extend at least 13 mm (½ inch) above the sheathing, but it shall not include portions of the supports other than the legs. The total coating thickness of the 13 mm (½ inch) portion, including the initial 127 µm (0.005 inch) of epoxy coating, shall be a minimum of 2.5 mm (3/32 inch), and the color shall be gray. Plastic or epoxy material shall be incompressible and abrasion resistant.

Damage caused during shipment of epoxy coated bars or by the installation procedures need not be repaired in cases where the damage area is 6 by 6 mm (¼ by ¼ inch) or smaller and the sum of all damaged areas in each 300 mm (1 foot) length of bar does not exceed 2 percent of the bar surface area. All damages larger than 6 mm (¼ inch) square
shall be repaired as recommended by the manufacturer and all bars with total damage greater than 2 percent of bar surface area shall be rejected and removed. The total bar surface area covered by patching material shall not exceed 5 percent.

D **Splicing Metal Reinforcement**

Reinforcement shall be furnished in the lengths indicated in the Plans. No splices, except those shown in the Plans, will be permitted without authorization from the Engineer, except as noted hereinafter for spiral reinforcement. When the Engineer authorizes field splices, the location and details of the splice shall be subject to the approval of the Engineer.

D1 **Lap Splices**

Lap splices shall be as indicated in the plans. If not shown in the Plans, bar reinforcement shall be lapped at least 36 diameters for No. 22 bar and smaller, at least 40 diameters for No. 25 through No. 36 bar and lap lengths for No. 43 and No. 57 bars shall be approved by the Engineer.

Wire mesh reinforcement shall be lapped at least the width of one full mesh plus 50 mm (2 inches) for transverse laps or one full mesh plus 50 mm (2 inches) plus 2 end overhangs for longitudinal laps.

D2 **Couplers for Reinforcement Bars**

Reinforcement bar couplers shall be provided at construction joints in the locations as shown in the Plans. Couplers shall be epoxy coated in conformance to 3301, and shall develop at least 125% of the yield strength of the reinforcement bar. The fatigue design limit shall be not less than 83 mega-Pascals (12 ksi) when tested in accordance with procedures recommended in NCHRP Project 10-35. Coupler details, yield strength and fatigue test results, and the name of the manufacturer shall be submitted to the Engineer for approval prior to installation. When assembling threaded couplers, the bar shall be inserted into the coupler to the full depth of the thread, and the assembly shall then be torqued to the manufacturer's recommended value.

E **Spiral Reinforcement**

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

The spiral cages may be made rigid by tying the vertical column bars to the spiral wires at their intersections, or by the use of metal spacer strips. The number of intersections tied, or the number of spacer strips used, shall be sufficient to ensure a rigid noncollapsible cage with properly spaced loops when the cage is in its final position. Tack welding will not be permitted.
Spiral reinforcement cages shall preferably be furnished full length but may be furnished in two pieces with sufficient added stock to provide for lapping the two adjoining ends not less than one and one-half turns.

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

2472.4 METHOD OF MEASUREMENT
A Reinforcement Bars
Reinforcement bars, including those in bar mats, will be measured by the mass incorporated into the structure, based on the Table 2472-2. The quantity measured will include only those splices that are shown in the Plans. Bar supports and tie wires will not be measured for payment.

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

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

B Steel Fabric
Steel fabric will be measured by the mass incorporated into the structure, based on the quantity shown in the Plans. The quantity measured will include only splices that are shown in the Plans, and will not include bar chairs, spacers, or tie wires.
2472.4

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

D  Couplers
Reinforcement bar couplers will be measured by the number of couplers installed in accordance with the contract and as directed by the Engineer.

2472.5  BASIS OF PAYMENT
In general, metal reinforcement will be paid for under the item numbers specified in the detailed Specifications for the type of structure in which it is used. In cases of structures of types for which there is no detailed Specification, payment will be made on the basis of the following schedule, which bid price and payment will be compensation in full for furnishing, fabricating, delivering, and placing the metal reinforcement as specified.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2472.501</td>
<td>Reinforcement Bars</td>
<td>kilogram</td>
</tr>
<tr>
<td>2472.511</td>
<td>Steel Fabric</td>
<td>kilogram</td>
</tr>
<tr>
<td>2472.521</td>
<td>Spiral Reinforcement</td>
<td>kilogram</td>
</tr>
<tr>
<td>2472.525</td>
<td>Couplers (Reinforcement Bars) T-</td>
<td>each</td>
</tr>
</tbody>
</table>

2478  Organic Zinc-Rich Paint System

2478.1  DESCRIPTION

A  General
This specification consists of the following: surface preparations; furnishing and applying the coating; protection and curing the coating; protection of pedestrians, vehicular traffic, and property against damage; and all other work incidental to these operations. This specification applies to full system applications, in shop or field, of new construction and recoating of existing structures using an Organic Zinc-Rich Paint System.

B  Definitions
Whenever the following terms are used in this specification, the terms shall have the following meaning:

1. Engineer: Shall be defined as in 1103, except for shop applied paint coats, where Engineer shall mean the Department Bridge Construction and Maintenance Engineer.
2. Contractor: Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and applies the coatings.
(3) Shop (in shop coating): The indoor facility where structural metals are prepared and coated.

(4) Field Coating: The outdoor on-site coating of new or previously coated steel structures before or after erection.

(5) Quality Assurance (QA): The process and person(s) responsible for verification of the conformance of materials and methods of application to the governing specification, in order to achieve a desired result.

(6) Quality Control (QC): The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality.

(7) Quality Assurance Inspector (QAI): The departments representative responsible for duties specified in the Quality Assurance Plan, with the authority to accept work that meets Contract requirements.

(8) Contact surfaces: Those surfaces in the completed structure that touch other surfaces.

(9) Corner: The intersection of two surfaces.

(10) Edge: An exposed, through-thickness surface of a plate or rolled shape. This may be the as-rolled side face of a beam flange, channel flange or angle leg, or may result from thermal cutting, sawing, or shearing. Edges may be planar or rounded, and either perpendicular or skewed to adjacent faces.

(11) Non-contact surfaces: Surfaces that are not in direct contact with other surfaces.

(12) Prime Coat: Application of a zinc-rich coating to a bare metal substrate.

(13) Coating thickness: The Dry-Film Paint Thickness (DFT).

(14) Mist Coat (Fog Coat or Tack Coat): (a) thin, mist-spray application of a coating to improve adhesion and uniformity of the subsequent full application of the same coating. (b) A light coat of unspecified DFT used to prevent rust staining of steel substrates or temporarily inhibit corrosion.

(15) Stripe Coat: A coating, of sufficient thickness to completely hide the surface being coated, on all edges, corners, seams, crevices, interior angles, junctions of joining members, bolt heads, nuts and threads, weld lines, and similar surface irregularities. This coating shall be followed, as soon as practicable, by the application of the full prime, intermediate, or finish coat to its specified thickness.

(16) Qualified: Holding appropriate documentation and officially on record as competent and experienced to perform a specified function or practice of a specific skill.
2478.2 MATERIALS

A  Zinc-Rich Paint Systems ............................................ 3520

B  General

The Contractor shall:

1. Use only paint systems listed on the Mn/DOT 3520 Approved Product List for Organic Epoxy Zinc-Rich Systems, unless written approval is obtained from the Engineer.

2. Deliver the paint to the site in the original containers. Each container shall not exceed 20 liters (5 gallons) in capacity. The contents cannot be altered without the written permission of the Engineer. In order to assure proper mixing proportions, package multi-component coatings in separate containers or kits.

3. Supply the manufacturer's Material Safety Data Sheet(s) (MSDS) and material certifications with each shipment of paint, and written instructions for mixing, handling, and application of the coatings. The Contractor shall provide, to the Engineer, a copy of all documentation.

4. Have available a qualified manufacturer's technical representative to assist during coating application.

2478.3 GENERAL REQUIREMENTS

A  Contractor Qualifications and Documentation

1. The Contractor shall provide the Quality Assurance Inspector (QAI) or Engineer with evidence that painters, applicators, and Quality Control personnel have been trained by the paint manufacturer's technical representative on the application of the paint system being applied on the bridge project. The Engineer shall approve the content and structure of the training.

B  General

Painting shall be in accordance with the manufacturer's written recommendations, except as may otherwise be specified in this specification. If the manufacturer's DFT recommendations differ from those specified, the Contractor shall submit a request in writing to the Engineer, prior to painting, for DFT deviation to manufacturer's written recommendations.

For new construction, erection markings shall be preserved or transferred so as to be legible at the time the members are erected. Markings shall be removable or shall be placed at locations that are not visible in the completed structure. The material used for the markings shall be compatible with the paint coats, so the paint system will not be damaged.

When painting a structure erected under a previous contract, disassembly of portions of the structure or removal of appurtenances to expose contact surfaces or otherwise inaccessible metal surfaces is not
required unless specifically stated in the Plans or Special Provisions. For new construction projects, all contact surfaces shall be painted with the zinc primer at the recommended DFT, except contact surfaces completely sealed by welding, bolt heads, nuts and washers; and those metal appurtenances or surfaces that are to be embedded in or be covered by fresh concrete (such as shear devices and anchorages). The top surfaces of beams and girders shall receive a mist coat of primer.

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

The Contractor shall furnish a system for inspection that will provide the inspector safe access to all parts of the steel. If such a system requires hardware to be temporarily fastened to the steel for the support of the system, the hardware used shall be of a design that will avoid or minimize marring or damage to the paint. The Contractor shall repair any damages that occur, using approved procedures, at no cost to the Department.

C. Inspection

It is the Contractor's responsibility to perform Quality Control (QC) inspections of the shop/field painting. At least 30 days prior to starting work, the Contractor shall submit a Quality Control Plan (QCP) to the Engineer, for approval, which outlines their programs, procedures, and processes for assuring conformance to applicable requirements and specifications.

The QCP procedures shall include, at a minimum, but not be limited to, the following measurements at the given minimum frequencies:

(1) General
   a. Ambient temperature - every 8 hours (or the start of each shift).
   b. Dew point and humidity - every 8 hours (or the start of each shift).
   c. Surface temperature - every 8 hours (or the start of each shift).
   d. Date and time - each lot of work.
   e. Piece mark and bundle - each lot of work.
   f. DFT - SSPC-PA 2 or the PDS.
   g. Visual inspection - 100%.

(2) Prime Coat
   a. Primer coat batch number - every paint kit.
   b. Verification of surface cleanliness - examine visually within 1 hour prior to priming.
   c. Temperature of mixed primer - when mixing components.
   d. Proper mixing and straining - every pot mix.
   e. Primer induction time - every pot mix.
   f. Primer pot life - every pot mix.
g. Primer cure time - in accordance with manufacturer's recommendations.

h. Proper use of stripe coats - all applicable areas.

i. Primer coat evaluation and repair - in accordance with manufacturer's recommendations.

(3) Intermediate Coat

a. Intermediate coat batch number - every paint kit.

b. Verification of surface cleanliness - examine visually within 1 hour prior to applying the intermediate coat.

c. Temperature of mixed intermediate coating - when mixing components.

d. Proper mixing and straining - every pot mix.

e. Intermediate induction time - every pot mix.

f. Intermediate pot life - every pot mix.

g. Intermediate cure time - in accordance with manufacturer's recommendations.

h. Proper use of stripe coats - all applicable areas.

i. Intermediate coat evaluation and repair - in accordance with manufacturer's recommendations.

(4) Finish Coat

a. Finish coat component batch number - every paint kit.

b. Verification of intermediate coat surface cleanliness - initial and every 4 hour of painting.

c. Temperature of mixed finish coat - when mixing components.

d. Finish coat mixing and/or straining - every pot mix.

e. Finish coat induction time - every pot mix.

f. Finish coat cure time - in accordance with manufacturer's recommendations.

g. Proper use of stripe coats - all applicable areas.

h. Adhesion - as required by Engineer.

i. Paint system final evaluation and repair - visual, 100% of each element.

Written documentation of the measurements taken shall be provided to the QAI or Engineer during the course of the work and in its entirety at the completion of the job. If the QAI or Engineer determines that the approved QCP was not followed or the documentation is inadequate or incomplete, the paint system will be subject to rejection or payment reduction. Any subsequent testing to determine compliance must be approved by the Engineer and shall be conducted at the Contractor's expense.

D Surface Preparation

The QAI or Engineer will inspect the surface preparation during or after it is performed. The Contractor shall notify the Engineer at least 5
working days prior to the start of surface preparation and/or coating activities.

D1 Cleaning

D1a Solvent Cleaning

All areas containing organic and synthetic and other visible contaminants shall be solvent cleaned in accordance with SSPC-SP 1 Solvent Cleaning. Adequate precautions shall be taken to protect the adjacent environment and property during this operation.

D1b Abrasive Blasting

All surfaces to be prime coated shall be prepared by blast cleaning. Blast cleaning shall conform to the latest edition of SSPC-SP 10/NACE No. 2 Near-White Blast Cleaning. Job site visual standards and SSPC-VIS 1 Standard for Blasting Comparisons shall be used. The blast cleaning operations shall follow all current federal and local regulations.

The required profile range of the blast cleaning shall be from 1.0 to 2.5 mils. Re-blast the profiles not meeting the minimum tolerance of 1.0 mils to obtain the required minimum profile. Profiles exceeding 2.5 mils shall be rejected and submitted to the Engineer for approval.

Note: If approved by the Engineer, additional primer may be applied to compensate for surface profiles above 2.5 mils. However, final primer thickness shall not exceed the paint manufacturer's recommendations or cause deleterious conditions i.e., sags, runs, or mud cracking.

D1c Post Blasting

After blast cleaning, all blasting media shall be completely removed from all steel surfaces. Removal shall be done in a manner free of moisture or contamination to the blasted surfaces. In addition, structural steel members shall be free of all surface defects such as small seams, blisters, weld spatter, fins, laps, and tears. Surface defects shall be removed by grinding and all gouges shall be repaired before the prime coat is applied.

E Application of Paint

E1 General

(1) The prime, intermediate, and finish coats of paint shall all be as per 2478.2B(1).

(2) Painting shall not be started without approval of the surface preparation and paint by the Engineer. Prior to applying any paint, surfaces to be painted shall be free of flash rust, dust, dirt, grease, oil, moisture, overspray and other contaminants. Paint shall be applied in a neat, workmanlike manner. Regardless of the method of application, the resultant paint film shall be smooth and uniform without runs, drips, sags, pinholes, blisters, mudcracking, inadequate or excessive coating or other deleterious conditions.
(3) Paint shall not be applied to metal surfaces when weather conditions are unsatisfactory for the work or the conditions include an air temperature below 4ºC (40ºF), metal surfaces less than 3ºC (5ºF) above the dew point, air that is misty, or metal surfaces that are damp or frosted.

(4) Paint shall not be applied when other work operations, wind, or traffic, causes dust, dirt, or sand, to be carried in the air and onto the prepared or newly painted metal surfaces. Spray painting will not be permitted in areas where rebounding or blowing paint particles would be detrimental to persons, adjacent environment, or property, unless adequate protective shields are provided, or unless it is demonstrated that the work can be performed without undue scattering of wet paint particles. The QAI or Engineer shall have the authority to suspend spray painting operations whenever it becomes evident that the application is not properly controlled.

(5) Paint shall be thoroughly mixed before removal from containers, and shall be kept in suspension during application. Thinning of paint shall not be allowed except as detailed in the manufacturer's current written instructions and then only with written permission of the Engineer. After thorough mixing, the primer shall be strained through a 30 - 60 mesh screen or a double layer of cheesecloth. There shall be no un-dispersed agglomerates of zinc remaining in the paint after mixing.

(6) Prior to starting application of a subsequent coat, the previous coat shall be cured "to recoat" in accordance with the manufacturer's Product Data Sheet (PDS) and any areas that are found to be wrinkled, detached, distorted, scuffed, abraded, or otherwise unsatisfactory, shall be screened or scraped smooth and repainted. Any dust or chalk-like deposits shall be thoroughly removed. Whenever previously applied paint coats become defective for any reason, the Engineer shall require conditioning or replacement of these coats. If the maximum time interval specified by the manufacturer to apply subsequent paint coats is exceeded, all affected areas shall be completely blast-cleaned to SSPC-SP 10/NACE NO. 2 Near-White Blast Cleaning, and recoated. All such work shall be at the Contractor's expense.

(7) Areas to be field welded shall be left unpainted along the weld zone for a width of 50 mm (2 inches) on each side of the weld.

(8) When shop painting is required and it is not feasible to provide the complete paint system in the shop, such as for field welded areas, field splice plates, and fasteners, the Contractor shall apply the required paint coats to complete the paint system at the project site.
(9) Painted members shall not be handled until the paint is cured enough so that the member can be handled without damaging the paint.

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

(11) All paint repair procedures shall be submitted to the Engineer for approval.

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

E2 Brushes and Daubers

Paint may be applied by means of brushing where areas to be painted are unsuitable for spray painting, such as surfaces requiring stripe coats, small surface areas where over-spray would be excessive, and small areas requiring paint repair.

When brushes are used the paint shall be so manipulated under the brush as to provide a smooth, uniform coating over the entire surface, including all corners and crevices. The final brush strokes shall generally be horizontal and parallel each other. All brush hairs that are left on the paint surface shall be removed to alleviate the possibility of moisture leaching to the substrate.

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

During application of paint by brushing or daubers, the paint pot shall be equipped with an approved agitator.

E3 Spraying

Power spraying shall apply the paint in a fine, even spray. Paint applied with spray equipment may be brushed out immediately, when necessary, in order to obtain uniform coverage and to eliminate wrinkling, blistering, sags, runs, and air holes. Care shall be exercised to prevent dry spray. In no case shall the distance from the spray gun to the point of surface application be more than 600 mm (2 feet).

The paint pot shall be equipped with an approved agitator during spray painting work. The agitator or stirring rod shall reach to within 50 mm (2 inches) of the bottom of the pot and shall be in motion at all times during paint application. Such motion shall be sufficient to keep the paint well mixed. The air lines shall be equipped with approved water traps or an approved moisture removal system.

F Paint Coats

F1 Measurement of Paint Thickness

When paint thickness is referred to in this specification the word "thickness" shall mean the "Dry Film Thickness" (DFT). The paint thickness and average thickness shall be measured with a properly
calibrated thickness gage in accordance with SSPC-PA 2-Measurement of Dry Coating Thickness with Magnetic Gages.

If the coating thickness of any paint coat cannot be satisfactorily determined after being applied, a destructive test using a device such as a "Tooke Gauge" may be used to measure the DFT. Repair of the destructively tested area shall be performed using a procedure approved by the Engineer, and at no expense to the Department. Mechanical grinding to reduce paint thickness shall not be permitted. Paint thickness that is found to be deficient for any prime, intermediate, or top coat, shall be subject to complete removal of the paint system and recoated.

F2  Stripe Coats

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

Under no circumstances shall the stripe coat requirement on this specification be neglected. The QAI or Engineer shall approve the stripe coat prior to application of the applicable coat.

F3  Prime Coat

After preparing the surfaces as herein specified and after acceptance of the surface preparation by the Engineer, the primer coat shall be applied before there is any evidence of rusting on the surface. The prime coat shall have a minimum DFT of 3.0 mils.

Except as otherwise provided herein, the thickness of the prime coat shall not be less than 3.0 mils for any reading and average not less than 4.0 mils. For excessive thickness readings, final primer thickness shall not exceed the paint manufacturer's written recommendations and/or cause any deleterious conditions (i.e., sagging or mud cracking).

For contact surfaces of bolt splices, the thickness of the prime coat shall not exceed the manufacturer's certified thickness for Class B slip co-efficient.

F4  Intermediate Coat

The prime coat shall be completely "dry-to-topcoat" before application of the intermediate coat. Application of the intermediate coat shall not begin until:

(a) Expiration of the minimum drying time for the primer as recommended by the manufacturer.
(b) Approval of the prime coat by the Engineer.

All unsealed crevices and cavities between contact surfaces shall be filled with primer or caulked with a compatible product recommended
by the coating manufacturer. Before applying paint to the caulking compound, the caulk shall be allowed to cure in accordance with the manufacturer’s recommendations.

The color of the epoxy intermediate coat shall present a distinct contrast between the organic zinc-rich primer and the polyurethane topcoat.

The minimum DFT of the intermediate coat shall be 3.0 mils. The intermediate paint coat shall be applied to all prime coated surfaces that are exposed in the completed structure.

**F5 Finish Coats**

Finish coat shall match the Federal Standard 595 B or Mn/DOT Standard colors and have a semi-gloss finish.

The final coat of paint on surfaces that are readily exposed to view shall be uniform in color, and shall be free of visible lap marks and other blemishes. The minimum DFT of the finish coat shall be 2.0 mils.

**F6 Total Paint Thickness**

The total paint thickness of the entire paint system shall average not less than 10 mils. In the event that there is a deficiency in the total paint thickness over any part or all of a structure, but not to the extent that the Engineer considers additional paint applications are necessary, an equitable reduction in payment for the appropriate item of work will be made.

**G Markings for Identification**

The Contractor shall stencil the year of painting and the Specification numbers of the prime, intermediate, and top coats in numerals approximately 75 mm (3 inches) high on the interior surface of fascia beams, at the same corner the bridge name plate is displayed and again at the corner that is diagonally opposite that corner.

**H Fasteners**

**H1 Requirements for Coating**

Fasteners shall be free of all organic or other material that would interfere with proper adhesion of the coating. If the contractor requests the use of industrial cleaning solutions for the removal of fastener lubricants, they shall demonstrate to the Engineer that the proposed cleaning solutions will not contaminate or interfere with proper adherence of subsequently applied coating materials. The coating thickness shall not interfere with the proper fit of nuts and bolts.

**H2 Paint Thickness Requirements**

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

**I Blank**
J Handling, Storage, and Shipping of Painted Steel

Extreme care shall be exercised in handling the painted steel in the shop and field during shipping, erection, and construction of the bridge and components. Painted steel items shall not be moved or handled until the coating is cured in accordance with the manufacturer's data sheet. All coated components or products shall be protected during handling and loading by the use of nylon straps, padded hooks, slings, or other non-metallic lifting devices. The steel shall be protected from binding chains with softeners and edge protection devices. Hooks and slings used to hoist the steel shall be padded.

All completed items shall be stored in accordance with 1606 and the following provisions:

(1) All items shall be clearly tagged and/or permanently marked prior to final storage. Identification markings shall include, at a minimum, individual piece marks, bridge and project number(s), fabricator, and applicator job numbers.

(2) The final storage area shall be located out of any "traffic" lanes and in an area that can bear the full weight of the members or items. This area shall be stable enough so the bundles, members or items will not fall below the supporting substrate. All bundles, members or items shall be inspected and stored in one general location (unless approved by the Engineer) prior to final acceptance.

Individual items, or bundles of coated products, shall be adequately supported in transit in a manner that will prevent damage to the coating(s) and shall not be dropped or dragged. Shipping, bundling, or banding materials shall be padded to protect the components from direct contact with wood, steel or other packaging materials which could scratch, mar or otherwise damage the coated products finish. Softeners and edge protection devices shall be used in conjunction with high-density foam or other acceptable packaging materials at all points of contact.

K Paint Repair

All paint repair procedures shall be submitted, in writing, to the Engineer for approval.

2478.4 METHOD OF MEASUREMENT

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

A Shop Painting

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

B  Field Painting for New Construction

Field painting is required in the bolted field splice areas of newly constructed shop painted steel. Measurement will be based on the field splice area of acceptable paint coverage, as computed from the original construction plans. Paint repairs required to correct damage from field storage or erection shall be considered incidental to the bid price for structural steel.

C  Field Painting of an Existing Bridge

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

2478.5  BASIS OF PAYMENT

A  Shop Painting

Payment for item 2478.502, "Organic Zinc-Rich Paint (Shop)", at the contract price per square meter (square foot) shall be compensation in full for all costs of furnishing and applying an acceptable shop applied paint system in accordance with Specification requirements, including all necessary repairs to the paint coating that occur before unloading at the Project storage site.

B  Field Painting of Shop Painted Components

Payment for item 2478.503, "Organic Zinc-Rich Paint System (Field)", at the contract price per square meter (square foot) shall be compensation in full for all costs of preparing and applying field applied paint systems to shop primed bolted splice areas.

C  Painting of Existing (Old) Components or Structures

Payment for item 2478.506, "Organic Zinc-Rich Paint System (Old)", at the contract price per square meter (square foot) shall be compensation in full for all costs of surface preparation, furnishing, and applying coating system to existing (old) structural steel, in accordance with the Specification requirements.

D  Payment

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2478.502</td>
<td>Organic Zinc-Rich Paint System (Shop)</td>
<td>Square meter (square foot)</td>
</tr>
<tr>
<td>2478.503</td>
<td>Organic Zinc-Rich Paint System (Field)</td>
<td>Lump sum</td>
</tr>
<tr>
<td>2478.506</td>
<td>Organic Zinc-Rich Paint System (Old)</td>
<td>Square meter (square foot)</td>
</tr>
</tbody>
</table>
Inorganic Zinc-Rich Paint System

2479.1 DESCRIPTION

A  General

This specification consists of the following: surface preparations; furnishing and applying the coatings; protection of and curing the coatings; protection of pedestrians, vehicular traffic and property against damage; and all other work incidental to these operations. This specification shall be used on new work where shop applied primer and field applied intermediate and top coating is desired.

B  Definitions

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

(1) Engineer: Shall be defined as in 1103, except for shop applied paint coats, where Engineer shall mean the Department Bridge Construction and Maintenance Engineer.

(2) Contractor: Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and/or applies the coatings.

(3) Shop (in shop coating): The indoor facility where structural metals are prepared and coated.

(4) Field Coating: The outdoor on-site coating of new or previously coated steel structures before or after erection.

(5) Quality Assurance (QA): The process and person(s) responsible for verification of the conformance of materials and methods of application to the governing specification, in order to achieve a desired result.

(6) Quality Control (QC): The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality.

(7) Quality Assurance Inspector (QAI): The Department's representative responsible for duties specified in the Quality Assurance Plan, with the authority to accept work that meets Contract requirements.

(8) Contact surfaces: Those surfaces in the completed structure that touch other surfaces.

(9) Corner: The intersection of two surfaces.

(10) Edge: An exposed, through-thickness surface of a plate or rolled shape. This may be the as-rolled side face of a beam flange, channel flange or angle leg, or may result from thermal cutting, sawing, or shearing. Edges may be planar or rounded, and either perpendicular or skewed to adjacent faces.
Non-contact surfaces: Surfaces that are not in direct contact with other surfaces.

Prime Coat: Application of a zinc-rich coating to a bare metal substrate.

Coating Thickness: The Dry-Film Paint Thickness (DFT).

Mist Coat (Fog Coat or Tack Coat): (a) Thin, mist-spray application of a coating to improve adhesion and uniformity of the subsequent full application of the same coating. (b) A light coat of unspecified DFT used to prevent rust staining of steel substrates or temporarily inhibit corrosion.

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

Qualified: Holding appropriate documentation and officially on record as competent and experienced to perform a specified function or practice of a specific skill.

2479.2 MATERIALS
A  Zinc-Rich Paint Systems ........................................... 3520
B  General
   The Contractor shall:
   (1) Use only paint systems listed on the Mn/DOT 3520 Approved Products List for Inorganic Zinc-Rich Systems, unless written approval is obtained from the Engineer.
   (2) Deliver the paint to the site in its original containers. Each container shall not exceed 20 liters (5 gallons) in capacity. The contents cannot be altered without the written permission of the Engineer. In order to assure proper mixing proportions, package multi-component coatings in separate containers or kits.
   (3) Supply the manufacturer's Materials Safety Data Sheet(s) (MSDS) and material certifications with each shipment of paint, and written instructions for mixing, handling, and application of the coatings. The Contractor shall provide, to the Engineer, a copy of all documentation.
   (4) Have available a qualified manufacturer's technical representative to assist during coating application.

2479.3 GENERAL REQUIREMENTS
A  Contractor Qualifications and Documentation
   (1) The Contractor shall provide the Quality Assurance Inspector (QAI) or Engineer with evidence that painters, applicators, and Quality Control personnel have been trained by the paint
manufacturer's technical representative on the application of the paint system being applied on the bridge project. The Engineer shall approve the content and structure of the training.

B  General

Painting shall be in accordance with the manufacturer's written recommendations, except as may otherwise be specified in this specification. If the manufacturer’s DFT recommendations differ from those specified, the Contractor shall submit a request in writing to the Engineer, prior to painting, for DFT deviation to manufacturer's written recommendations.

For new construction, erection markings shall be preserved or transferred so as to be legible at the time the members are erected. Markings shall be removable or shall be placed at locations that are not visible in the completed structure. The material used for the markings shall be compatible with the paint coats, so the paint system will not be damaged.

When painting a structure erected under a previous contract, disassembly of portions of the structure or removal of appurtenances to expose contact surfaces or otherwise inaccessible metal surfaces is not required unless specifically stated in the Plans or Special Provisions. For new construction projects, all contact surfaces shall be painted with the zinc primer at the recommended DFT, except contact surfaces completely sealed by welding, bolt heads, nuts and washers; and those metal appurtenances or surfaces that are to be embedded in or be covered by fresh concrete (such as shear devices and anchorages). The top surfaces of beams and girders shall receive a mist coat of primer.

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

The Contractor shall furnish a system for inspection that will provide the inspector safe access to all parts of the steel. If such a system requires hardware to be temporarily fastened to the steel for the support of the system, the hardware used shall be of a design that will avoid or minimize marring or damage to the paint. The Contractor shall repair any damages that occur, using approved procedures, at no cost to the Department.

C  Inspection

It is the Contractor's responsibility to perform Quality Control (QC) inspections of the shop/field painting. At least 30 days prior to starting work, the Contractor shall submit a Quality Control Plan (QCP) to the Engineer, for approval, which outlines their program, procedures, and processes for assuring conformance to applicable requirements and specifications.

The QCP procedures shall include, at a minimum, but not be limited
to, the following measurements at the given minimum frequencies:

(1) General
   a. Ambient temperature – every 8 hours (or the start of each shift).
   b. Dew point and humidity – every 8 hours (or the start of each shift).
   c. Surface temperature – every 8 hours (or the start of each shift).
   d. Date and time – each lot of work.
   e. Piece mark or bundle – each lot of work.
   f. Dry film thickness – SSPC-PA 2 or the product data sheet.
   g. Visual inspection – 100%.

(2) Prime Coat
   a. Primer component batch number – every paint kit.
   b. Verification of surface cleanliness – examine visually within 1 hour prior to priming.
   c. Temperature of mixed primer – when mixing components.
   d. Proper mixing and straining – every pot mix.
   e. Primer induction time – every pot mix.
   f. Primer pot life – every pot mix.
   g. Primer cure time – in accordance with manufacturer's recommendations.
   h. Proper use of stripe coats – all applicable areas.
   i. Primer coat evaluation and repair – visual, 100% of each element.
   j. Primer coat time – in accordance with manufacturer's recommendations.

(3) Intermediate Coat
   a. Intermediate coat batch number – every paint kit.
   b. Verification of surface cleanliness - examine visually within 1 hour prior to applying the intermediate coat.
   c. Temperature of mixed intermediate coating - when mixing components.
   d. Proper mixing and straining - every pot mix.
   e. Intermediate induction time - every pot mix.
   f. Intermediate pot life - every pot mix.
   g. Intermediate cure time - in accordance with manufacturer's recommendations.
   h. Proper use of stripe coats - all applicable areas.
   i. Intermediate coat evaluation and repair - in accordance with manufacturer's recommendations.
Finish Coat

- Finish coat component batch number – every paint kit.
- Verification of intermediate coat surface cleanliness – initial and every 4 hours of painting.
- Temperature of mixed finish coat – when mixing components.
- Finish coat mixing and/or straining – every pot mix.
- Finish coat induction time – every pot mix.
- Finish coat pot life – every pot mix.
- Finish coat cure time – in accordance with manufacturer’s recommendations.
- Proper use of stripe coats – all applicable areas.
- Adhesion – as required by Engineer.
- Paint system final evaluation and repair – visual, 100% of each element.

Written documentation of the measurements taken shall be provided to the QAI or Engineer during the course of the work and in its entirety at the completion of the job. If the QAI or Engineer determines that the approved QCP was not followed or the documentation is inadequate or incomplete, the paint system will be subject to rejection or payment reduction. Any subsequent testing to determine compliance must be approved by the Engineer and shall be conducted at the Contractor’s expense.

D Surface Preparation

The QAI or Engineer will inspect the surface preparation during or after it is performed. The Contractor shall notify the Engineer at least 5 working days prior to the start of surface preparation and/or coating activities.

D1 Cleaning

D1a Solvent Cleaning

All areas containing organic and synthetic and other visible contaminants shall be solvent cleaned in accordance with SSPC-SP 1 Solvent Cleaning. Adequate precautions shall be taken to protect the adjacent environment and property during this operation.

D1b Abrasive Blasting

All surfaces to be prime coated shall be prepared by blast cleaning. Blast cleaning shall conform to the latest edition of SSPC-SP 10/NACE No. 2 Near-White Blast Cleaning. Job site visual standards and SSPC-VIS 1 Standard for Blasting Comparisons shall be used. The blast cleaning operations shall follow all current federal and local regulations.

The required profile range of the blast cleaning shall be from 1.0 to 2.5 mils. Re-blast the profiles not meeting the minimum tolerance of 1.0 mils to obtain the required minimum profile. Profiles exceeding
2.5 mils shall be rejected and submitted to the Engineer for approval. Note: If approved by the Engineer, additional primer may be applied to compensate for surface profiles above 2.5 mils. However, final primer thickness shall not exceed the paint manufacturer's recommendations or cause a deleterious condition (i.e., sags, runs, or mud cracking).

D1c Post Blasting

After blast cleaning, all blasting media shall be completely removed from all steel surfaces. Removal shall be done in a manner free of moisture or contamination to the blasted surfaces. In addition, structural steel members shall be free of all surface defects such as small seams, blisters, weld spatter, fins, laps, and tears. Surface defects shall be removed by grinding and all gouges shall be repaired before the prime coat being applied.

E Application of Paint

E1 General

(1) The prime, intermediate, and finish coats of paint shall all be as per 2479.2B(1).

(2) Painting shall not be started without approval of the surface preparation by the Engineer. Prior to applying any paint, surfaces to be painted shall be free of flash rust, dust, dirt, grease, oil, moisture, overspray and other contaminants. Paint shall be applied in a neat, workmanlike manner. Regardless of the method of application, the resultant paint film shall be smooth and uniform without runs, drips, sags, pinholes, blisters, mudcracking, inadequate or excessive coating thickness, or other deleterious conditions.

(3) Paint shall not be applied to metal surfaces when weather conditions are unsatisfactory for the work or the conditions include an air temperature below 4°C (40°F), metal surfaces less than 3°C (5°F) above the dew point, air that is misty, or metal surfaces that are damp or frosted.

(4) Paint shall not be applied when other work operations, wind, or traffic, causes dust, dirt, or sand, to be carried in the air and onto the prepared or newly painted metal surfaces. Spray painting will not be permitted in areas where rebounding or blowing paint particles would be detrimental to persons, adjacent environment, or property, unless adequate protective shields are provided, or unless it is demonstrated that the work can be performed without undue scattering of wet paint particles. The QAI or Engineer shall have the authority to suspend spray painting operations whenever it becomes evident that the application is not properly controlled.

(5) Paint shall be thoroughly mixed before removal from containers, and shall be kept in suspension during application. Thinning of
Paint shall not be allowed except as detailed in the manufacturer's current written instructions and then only with written permission of the Engineer. After thorough mixing, the primer shall be strained through a 30 - 60 mesh screen or a double layer of cheesecloth. There shall be no un-dispersed agglomerates of zinc remaining in the paint after mixing.

(6) Prior to starting application of a subsequent coat, the previous coat shall be cured "to recoat" in accordance with the manufacturer's Product Data Sheet (PDS) and any areas that are found to be wrinkled, detached, distorted, scuffed, abraded, or otherwise unsatisfactory, shall be screened or scraped smooth and repainted. Any dust or chalk-like deposits shall be thoroughly removed. Whenever previously applied paint coats become defective for any reason, the Engineer shall require conditioning or replacement of these coats. If the maximum time interval specified by the manufacturer to apply subsequent paint coats is exceeded, all affected areas shall be completely blast-cleaned to SSPC-SP 10/NACE NO. 2 Near-White Blast Cleaning, and recoated. All such work shall be at the Contractor's expense.

(7) Areas to be field welded shall be left unpainted along the weld zone for a width of 50 mm (2 inches) on each side of the weld.

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

(9) Painted members shall not be handled until the paint is cured enough so that the member can be handled without damaging the paint.

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

(11) All paint repair procedures shall be submitted to the Engineer for approval.

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

E2 Brushes and Daubers

Paint may be applied by means of brushing where areas to be painted are unsuitable for spray painting, such as surfaces requiring stripe coats, small surface areas where over-spray would be excessive, and small areas requiring paint repair.

When brushes are used the paint shall be so manipulated under the brush as to provide a smooth, uniform coating over the entire surface, including all corners and crevices. The final brush strokes shall
generally be horizontal and parallel to each other. All brush hairs that are left on the paint surface shall be removed to alleviate the possibility of moisture leaching to the substrate.

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

During application of paint by brushing or daubers, the paint pot shall be equipped with an approved agitator.

E3 Spraying

Power spraying equipment shall apply the paint in a fine, even spray. Paint applied with spray equipment may be brushed out immediately, when necessary, in order to obtain uniform coverage and to eliminate wrinkling, blistering, sags, runs, and air holes. Care shall be exercised to prevent dry spray. In no case shall the distance from the spray gun to the point of surface application be more than 600 mm (2 feet).

The paint pot shall be equipped with an approved agitator during spray painting work. The agitator or stirring rod shall reach to within 50 mm (2 inches) of the bottom of the pot and shall be in motion at all times during paint application. Such motion shall be sufficient to keep the paint well mixed. The air lines shall be equipped with approved water traps or an approved moisture removal system.

F Paint Coats

F1 Measurement of Paint Thickness

When paint thickness is referred to in this specification the word "thickness" shall mean the "Dry Film Thickness" (DFT). The paint thickness and average thickness shall be measured with a properly calibrated thickness gage in accordance with SSPC-PA 2 - Measurement of Dry Coating Thickness with Magnetic Gages.

If the coating thickness of any paint coat cannot be satisfactorily determined after being applied, a destructive test using a device such as a "Tooke gauge" may be used to measure the DFT. Repair of the destructively tested area shall be performed using a procedure approved by the Engineer, and at no expense to the Department. Mechanical grinding to reduce paint thickness shall not be permitted. Paint thickness that is found to be deficient for any prime, intermediate, or topcoat shall be subject to complete removal of the paint system and recoated.

F2 Stripe Coats

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

Under no circumstances shall the stripe coat requirement on this specification be neglected. The QAI or Engineer shall approve the stripe coat prior to application of the applicable coat.

F3  Prime Coat

After preparing the surfaces as herein specified and after acceptance of the surface preparation by the Engineer, the primer coat shall be applied before there is any evidence of rusting on the surface. The prime coat shall have a minimum DFT of 3.0 mils.

Except as otherwise provided herein, the thickness of the prime coat shall not be less than 3.0 mils for any reading and average not less than 4.0 mils. For excessive thickness readings, final primer thickness shall not exceed the paint manufacturer's written recommendations and/or cause any deleterious conditions (i.e., sagging or mud cracking).

For contact surfaces of bolt splices, the thickness of the prime coat shall not exceed the manufacturer's certified thickness for Class B slip co-efficient.

F4  Intermediate Coat

The color of the epoxy intermediate coat shall present a distinct contrast between the inorganic zinc-rich primer and the polyurethane topcoat.

Prior to application of the intermediate coat, the prime coat shall be fully cured in accordance with the manufacturer's application guide using ASTM D 4752-MEK rub test, to a Resistance Rating of 4.

All unsealed crevices and cavities between contact surfaces shall be filled with primer or caulked with a compatible product recommended by the coating manufacturer. Before applying paint to the caulking compound, the caulk shall be allowed to cure in accordance with the manufacturer's recommendations.

The minimum DFT of the intermediate coat shall be 3.0 mils. The intermediate paint coat shall be applied to all prime coated surfaces that are exposed in the completed structure.

F5  Finish Coats

Finish coat colors shall match the Federal Standard 595 B or Mn/DOT Standard colors and have a semi-gloss finish.

The final coat of paint on surfaces that are readily exposed to view shall be uniform in color, and shall be free of visible lap marks and other blemishes. The minimum DFT of the finish coat shall be 2.0 mils.

F6  Total Paint Thickness

The total paint thickness of the entire paint system shall average not less than 10 mils. In the event that there is a deficiency in the total paint thickness over any part or all of a structure, but not to the extent that the Engineer considers additional paint applications are necessary,
an equitable reduction in payment for the appropriate item of work will be made.

G  Markings for Identification
The Contractor shall stencil the year of painting and the Specification numbers of the prime, intermediate, and top coats in numerals approximately 75 mm (3 inches) high on the interior surface of fascia beams, at the same corner the bridge name plate is displayed and again at the corner that is diagonally opposite that corner.

H  Fasteners
H1  Requirements for Coating
Fasteners shall be free of all organic or other material that would interfere with proper adhesion of the coating. If the contractor requests the use of industrial cleaning solutions for the removal of fastener lubricants, they shall demonstrate to the Engineer that the proposed cleaning solutions will not contaminate or interfere with proper adherence of subsequently applied coating materials. The coating thickness shall not interfere with the proper fit of nuts and bolts.

H2  Paint Thickness Requirements
After installation of fasteners and removal of lubricant and residuals from exposed parts of fasteners, additional primer shall be applied to meet the required primer thickness. Fasteners shall also receive the required thickness of the intermediate and finish coats.

I  Blank

J  Handling, Storage, and Shipping of Painted Steel
Extreme care shall be exercised in handling the painted steel in the shop and field during shipping, erection, and construction of the bridge and components. Painted steel items shall not be moved or handled until the coating is cured in accordance with manufacturer's data sheet. All coated components or products shall be protected during handling and loading by the use of nylon straps, padded hooks, slings, or other non-metallic lifting devices. The steel shall be protected from binding chains by softeners and edge protection devices. Hooks and slings used to hoist the steel shall be padded.

All completed items shall be stored in accordance with 1606 and the following provisions:
(1) All items shall be clearly tagged and/or permanently marked prior to final storage. Identification markings shall include, at a minimum, individual piece marks, bridge and project number(s), fabricator, and applicator job numbers.
(2) The final storage area shall be located out of any "traffic" lanes and in an area that can bear the full weight of the members or items. This area shall be stable enough so the bundles, members or items will not fall below the supporting substrate. All bundles,
members or items shall be inspected and stored in one general location (unless approved by the Engineer) prior to final acceptance.

Individual items, or bundles of coated products, shall be adequately supported in transit in a manner that will prevent damage to the coating(s) and shall not be dropped or dragged. Shipping, bundling, or banding materials shall be padded to protect the components from direct contact with wood, steel or other packaging materials which could scratch, mar or otherwise damage the coated products finish. Softeners and edge protection devices shall be used in conjunction with high-density foam or other acceptable packaging materials at all points of contact.

K Paint Repair

Paint repair procedures shall be submitted, in writing, to the Engineer for approval.

2479.4 METHOD OF MEASUREMENT

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

Painting of the structural steel will be measured by the square meter (foot) based on the area of acceptable paint coverage on non-contact areas, as computed from the dimensions given on the original construction Plans for the structure. Contact areas will not be measured for payment.

2479.5 BASIS OF PAYMENT

A Shop Painting

Payment for item 2479.502, "Inorganic Zinc-Rich Paint System (Shop)", at the Contract price per square meter (square foot) shall be compensation in full for all costs of furnishing paint product for the entire paint system and applying the Primer of an approved system as described above as provided in 2402.

B Field Painting

Payment for item No. 2479.503, "Inorganic Zinc-Rich Paint System (Field)", at the Contract price per square meter (square foot), shall be compensation in full for all costs of applying the intermediate and top coat in the field in accordance with the Specification requirements, as described above.
C  **Shop and Field Painting**

Payment for item No. 2479.504, "Inorganic Zinc-Rich Paint System (Shop and Field)", at the Contract price per square meter (**square foot**), shall be compensation in full for all direct and indirect, costs of surface preparation furnishing and applying shop and field coatings. Paint repairs required to correct damage from field storage or erection shall be considered incidental to the bid price for structural steel.

D  **Payment**

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item/Unit</th>
<th>Item/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2479.502</td>
<td>Inorganic Zinc-Rich Paint System (Shop)</td>
<td>square meter (<strong>square foot</strong>)</td>
</tr>
<tr>
<td>2479.503</td>
<td>Inorganic Zinc-Rich Paint System (Field)</td>
<td>square meter (<strong>square foot</strong>)</td>
</tr>
<tr>
<td>2479.504</td>
<td>Inorganic Zinc-Rich Paint System (Shop and Field)</td>
<td>square meter (<strong>square foot</strong>)</td>
</tr>
</tbody>
</table>

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2481  **Waterproofing**

2481.1  **DESCRIPTION**

This work shall consist of waterproofing joints using one of the following described methods:

2481.2  **MATERIALS**

<table>
<thead>
<tr>
<th>A</th>
<th>Three-Ply System Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Asphalt Primer for Waterproofing Concrete</td>
</tr>
<tr>
<td>A2</td>
<td>Saturated Fabric for Waterproofing</td>
</tr>
<tr>
<td>A3</td>
<td>Asphalt for Mopping Coat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B</th>
<th>Membrane Waterproofing System</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Membrane Waterproofing System</td>
</tr>
</tbody>
</table>

2481.3  **CONSTRUCTION REQUIREMENTS**

A  **General**

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

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

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

A 300 mm (12 inch) wide strip of approved membrane, consisting of rubberized asphalt integrally bonded to polyethylene sheeting, shall be centered on the joint on a surface that has been primed in accordance with the manufacturer's recommendations. The polyethylene sheeting shall have a thickness of 102 µm (4 mils), and the rubberized asphalt shall have a nominal thickness of 1.5 mm (0.06 inch), for a total nominal thickness of 1.6 mm (0.06 inch). The face of the rubberized asphalt opposite that which is bonded to the sheeting shall have a removable covering that shall remain on the membrane until it is ready for placement.

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

C Three-Ply Joint Waterproofing

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

Primers shall be applied cold.

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

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

Joint waterproofing shall precede the application of any surface protection courses required by the Plans or Special Provisions.
2481.4 METHOD OF MEASUREMENT
A Joint Waterproofing
   The Department will measure joint waterproofing by the length of the joints waterproofed.

2481.5 BASIS OF PAYMENT
   The Department will pay for joint waterproofing only when the Contract contains a specific pay item for waterproofing. Otherwise, joint waterproofing will be considered as an incidental expense to the Contract with no direct compensation to the Contractor.
   Payment, when specified in the Contract, will be as follows:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2481.501</td>
<td>Joint Waterproofing</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>
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### 2501.1 DESCRIPTION

This work shall consist 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

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

<table>
<thead>
<tr>
<th>Pipe Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrugated Aluminum (CA)</td>
<td>3225</td>
</tr>
<tr>
<td>Corrugated Steel (CS)</td>
<td>3226</td>
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<tr>
<td>Corrugated Polyethylene (CP)</td>
<td>3247</td>
</tr>
<tr>
<td>Bituminous Coated-Corrugated Steel (BC-CS)</td>
<td>3227</td>
</tr>
<tr>
<td>Aramid Bonded-Corrugated Steel (AB-CS)</td>
<td>3228</td>
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<tr>
<td>Reinforced Concrete (RC)</td>
<td>3236</td>
</tr>
<tr>
<td>Polymeric Coated-Corrugated Steel (PC-CS)</td>
<td>3229</td>
</tr>
<tr>
<td>Corrugated Aluminized Steel (CAS)</td>
<td>3222</td>
</tr>
</tbody>
</table>

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

#### B Structural Plate

<table>
<thead>
<tr>
<th>Plate Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrugated Aluminum (CA)</td>
<td>3233</td>
</tr>
<tr>
<td>Corrugated Steel (CS)</td>
<td>3231</td>
</tr>
</tbody>
</table>

#### C Aprons

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

<table>
<thead>
<tr>
<th>Apron Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Concrete (RC)</td>
<td>3236</td>
</tr>
<tr>
<td>Galvanized Steel (GS)</td>
<td>3226</td>
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<tr>
<td>Aluminum Alloy (AA)</td>
<td>3225C4</td>
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<tr>
<td>Bituminous Coated-Galvanized Steel (BC-GS)</td>
<td>3227</td>
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<tr>
<td>Aluminized Steel</td>
<td>3222</td>
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<tr>
<td>Corrugated Polyethylene (CP)</td>
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</tr>
<tr>
<td>Corrugated Aluminized Steel (CAS)</td>
<td>3222</td>
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</tbody>
</table>
2501.2

D  Flap Gates ............................................................... 3399
E  Anti-seepage Diaphragms ........................................ 3351
F  Pipe Joint Sealer Materials
F1  Preformed Rubber, Type A......................................... 3726
F2  Preformed Plastic, Type B........................................... 3726
F3  Bituminous Mastic....................................................... 3728
G  Granular Materials.................................................... 3149
H  Geotextile, Type II ..................................................... 3733
I  Blank
J  Reinforced Concrete Dissipator Ring ...................... 3236

2501.3 CONSTRUCTION REQUIREMENTS

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

A  General

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

B  Foundations

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

C  Laying Pipe

C1  General

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

Jacking of culverts through the existing earth structure into position may be required by the Plans or permitted by the Engineer. The flow line elevation at the starting point for jacking shall be within 30 mm (0.1 foot) of the staked grade; the flow line shall not be reversed at any point; and the line and grade at any point within the pipe shall not vary by more than 150 mm (½ foot) from the line and grade designated. Metal pipe installed by this method shall have bolted or riveted field connections.

C2  Metal Culvert

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

Metal pipe sections shall be joined by the use of metal connecting bands, centered over the joint, and with the pipe sections as close together as possible. The band shall be tightened sufficiently to ensure a tight joint.
Structural plate culverts shall be assembled according to the instructions of the manufacturer, using approved fasteners. Where bolts are used, the bolts shall be tightened, after assembly, to a torque of 135 to 400 N•m (100 to 300 foot pounds). The Contractor shall furnish a calibrated torque wrench to prove, to the Engineer's satisfaction, the adequacy of the bolt tightening.

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

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

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

Concrete Culvert

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

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

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

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

Extending In-Place Culverts

To the extent feasible, in-place culverts shall be cleared of any obstructions to water flow, before placing the extension pipe. Removal of sediment will only be required to the extent that improved flow is likely to be maintained. This work shall be incidental to the pipe extension, with no direct compensation being made therefor.
Where the pipe ends differ because of changed design, the connection to the in-place culvert shall be made as indicated in the Plans or to the satisfaction of the Engineer.

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

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

**D Culvert Appurtenances**

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

**E Induced Trench Installation**

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

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

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

**F Culvert Cleaning**

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

**2501.4 METHOD OF MEASUREMENT**

**A Culvert Excavation**

When the proposal contains separate items for Culvert excavation under the payment provisions of this Specification, the excavations for culverts will be classified and measured in accordance with the applicable provisions of 2451.
B  Culvert Pipe
Culvert pipe will be measured by length, as determined by summation of the nominal laying lengths of the individual pipe sections incorporated in each structure. Measurements will be separated as to size, type, kind, and strength class, to the extent indicated in the item name.

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

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

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

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

D  Granular Materials
Granular materials for special backfill or bedding will be measured in accordance with 2451.4B.  
2501.5  BASIS OF PAYMENT
Payment for culvert pipe of each size, type, kind, and strength class, at the appropriate Contract prices per unit of measure, will be compensation in full for all costs of furnishing and installing the pipe complete in place as specified, except as otherwise provided herein.

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

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

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

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

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

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

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2501.501</td>
<td>Culvert Excavation, Class (1)</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2501.511</td>
<td>___mm (inch) (2) Pipe Culvert (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.515</td>
<td>___mm (inch) (2) Pipe Apron</td>
<td>each</td>
</tr>
<tr>
<td>2501.517</td>
<td>Anti-seepage Diaphragm for (4) Pipe</td>
<td>each</td>
</tr>
<tr>
<td>2501.519</td>
<td>Flap Gate for (4) Pipe</td>
<td>each</td>
</tr>
<tr>
<td>2501.521</td>
<td>___mm (inch) Span (2) Pipe-Arch Culvert (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.525</td>
<td>___mm (inch) Span (2) Pipe-Arch Apron</td>
<td>each</td>
</tr>
<tr>
<td>2501.527</td>
<td>Anti-seepage Diaphragm for (4) Pipe-Arch</td>
<td>each</td>
</tr>
<tr>
<td>2501.531</td>
<td>___mm (inch) (2) Elliptical Pipe Culvert (5)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.535</td>
<td>___mm (inch) (2) Elliptical Apron</td>
<td>each</td>
</tr>
<tr>
<td>2501.541</td>
<td>___mm (inch) High (2) Cattle Pass Culvert (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.543</td>
<td>___mm (inch) High (2) Cattle Pass Transition Section (3)</td>
<td>each</td>
</tr>
<tr>
<td>2501.545</td>
<td>___mm (inch) High (2) Cattle Pass Apron Culvert (3)</td>
<td>each</td>
</tr>
<tr>
<td>2501.551</td>
<td>___mm (inch) (2) Structural Plate Pipe Culvert (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.555</td>
<td>___mm (inch) Span (2) Structural Plate Pipe-Arch Culvert (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.561</td>
<td>___mm (&quot;) (2) Pipe Culvert, Design (6) (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.565</td>
<td>___mm (inch) Span (2) Pipe-Arch Culvert, Design (6) (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2501.567</td>
<td>___mm (inch) (2) Safety Apron &amp; Grate Design (6)</td>
<td>each</td>
</tr>
<tr>
<td>2501.569</td>
<td>___mm (inch) (2) (7)</td>
<td>each</td>
</tr>
</tbody>
</table>
Subsurface Drains

2502.1 DESCRIPTION
This work shall consist of the construction of subsurface drains, using plant-fabricated pipe and appurtenant materials, installed to:

(a) collect and discharge water infiltrating into the pavement system (pavement edge drain).
(b) collect and discharge water accumulated in the bottom of a granular-backfilled subcut (subcut drain).
(c) cut off or intercept ground water flowing toward the roadway (cut-off drain).

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

Subsurface drains for high bridge abutments, installed to intercept and carry off underground water, shall include all appurtenances, including geotextiles, metal oversleeves with rodent screens, and precast concrete headwalls. The work shall be performed in accordance with applicable provisions of 2502, 3245, 3733, and as detailed in the Plans.

2502.2 MATERIALS
Drain pipe shall be one of the following kinds as specified or permitted as an option. Fittings connecting multiple length of drain pipe shall be of the same material as the pipe. Nonperforated pipe shall be furnished except where the perforated type is specified. Unless higher strength pipe is specified, pipe conforming to the lowest strength class covered in the referenced specification will be acceptable. All discharge pipe, radial connecting pipe, and associated fittings shall be...
nonperforated TP pipe. Special fabrication or jointing details shall be as required by the Plans or as approved by the Engineer.

A  **Drain and Discharge Pipe**
A1 Thermoplastic (TP) ................................................ 3245
A2 Corrugated Polyethylene Drainage Tubing (PE) ........ 3278

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

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

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

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

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

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

**2502.3 CONSTRUCTION REQUIREMENTS**

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

**A  Excavation**

The trench shall be excavated to the designated lines and grades, as shown in the Plans and as necessary to permit placement of the drains in accordance with the provisions hereof. Minimum trench width at the bottom of the excavation shall be the nominal pipe width plus two times the pipe diameter (for example, a 100 mm (4 inch) diameter pipe would be placed in a 300 mm (12 inch) wide trench). Corrugated polyethylene drainage tubing (PE) may be used only when placed in a narrow, controlled-width trench as typically constructed by a chain- or wheel-type trenching machine designed and used for this application. Other types of rigid pipe shall be used for all other uses where compaction is not controlled in a narrow trench. Installation of PE tubing by plowing is not permitted.

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

**B  Laying Drains**

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

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

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

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

C Backfill

Backfilling of drains shall proceed without delay as the installations are made. On all perforated pipe installations, fine filter aggregate shall be placed adjacent to and to a minimum height of 150 mm (6 inches) above the top of the pipe, and to the extent indicated in the Plans. Above that elevation, and on all nonperforated pipe installations, the backfill may be made with suitable material removed from the excavations. In all applications, stones greater than 25 mm (1 inch) shall not be used adjacent to, and for 150 mm (6 inches) above the pipe.

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

D Drain Outlets

D1 Precast Concrete Headwall

Headwall outlets shall be kept 300 mm (12 inches) above ditch grades whenever possible, with the absolute minimum being 150 mm (6 inches). The uppermost point of the headwall shall be placed flush with the in-slope at a minimum downward grade of 2 percent to provide easy water exit. The earthen side slopes adjacent to the headwall shall then be shaped to conform to the sides and toe of the headwall. All soils around and under the concrete headwall outlet shall be compacted to the satisfaction of the Engineer to minimize future movement.
D2  Discharge Pipe
The discharge pipe to the drain outlet shall be constructed concurrently with the drains and be laid at roughly right angles to the roadway centerline. The discharge pipe shall be fully inserted/coupled to the headwall. Connections shall be made with 3A Grout, rubber gasket on the pipe, rubber or plastic gasket cast into the headwall, or by solvent or gasket joint into a TP coupling securely cast into the headwall. The coupling method shall secure the pipe well enough so that small movements of the headwall will not cause separation. The Engineer shall approve the method of coupling. The radial connection between the drain pipe and the discharge pipe shall have a minimum radius of 300 mm (12 inches) and will provide easy access for probes, cleaners, and video cameras. All connections and solvent joints shall be secure to the extent that they will not decouple during backfilling and will prevent soil intrusion. The Engineer shall approve connection and coupling methods.

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

D3  Turf Establishment
The Contractor shall use seed and an erosion control blankets at the drain outlets except when outlets are placed at a location that will normally be sodded under terms of the Contract.

An erosion control blanket, Category 1, meeting 3885, shall be placed to a minimum width of 2 m (6.5 feet) with the headwall centered along the width of the blanket. The blanket shall also extend 1 m (3 feet) above the headwall, and 2 m (6.5 feet) or to the bottom of the ditch which ever is less below the headwall. Anchor staples shall be placed at ½ m (1.5 feet) maximum intervals. When a headwall is placed at a location that will normally be sodded under terms of the Contract, the seed and mulch shall be deleted in favor of sod. Installations shall be watered and maintained in accordance with 2575.3L. Seed installed under the erosion control blanket shall be the same mixture and rate as that designated in the Plan for the immediate surrounding area. In the absence of a seed mixture specified in the Plan, seed mixture 250 shall be placed at the rate of 1 kg/m² (2 pounds per square yard) before anchoring the blanket.
D4  Marking Outlet Locations
The Contractor shall permanently mark the location of all outlets with a 150 by 450 mm (6 by 18 inch) strip of white marking tape according to 3354. The Contractor shall place the tape at the outside edge of the bituminous shoulder, at right angles to the roadway, and roll the tape into the shoulder while the bituminous is still hot. When two runs of drain pipe come together at a low point and discharge via a "Y" to a single outlet, the Contractor shall place two markings side-by-side with a 150 mm (6 inch) spacing. If there is no bituminous shoulder, the Contractor shall place the tape on the bituminous pavement or spray a white paint strip on concrete pavements. If paint or tape marking is not appropriate, the Engineer may approve alternate methods. The furnishing of, and placement of the tape or paint, is incidental work.

D5  Inspection and Cleanout
It shall be the responsibility of the Contractor to ensure that once installed, the discharge pipe and headwalls remain clean and operative so that water is not trapped in the pipe, and also to make a final inspection, with the Engineer, of all discharge pipes and headwalls to ensure that they have the proper grade, are clean, properly landscaped, erosion control has been properly installed and maintained, and are generally in satisfactory operating condition.

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

2502.4 METHOD OF MEASUREMENT
A  Subsurface Drains
Drains will be measured by installed length along the centerline of the pipe. Terminal points of measurement will be the pipe end at free outlets; the point of junction with in-place pipe; or the center of structures, catch basins, or multiple junction points as they apply.

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

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

Measurement on the basis of compacted volume will be limited to the minimum dimensions shown in the Plans.
2502.4

C Precast Concrete Headwalls

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

2502.5 BASIS OF PAYMENT

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

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

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

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

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

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

Unless its existence is shown in the Plans, the removal of ledge rock or rocks larger than 0.4 m³ (½ cubic yard) volume from the excavation will be paid for as Extra Work.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2502.501</td>
<td>___mm (inch) Precast Concrete Headwall</td>
<td>each</td>
</tr>
<tr>
<td>2502.502</td>
<td>Drainage System Type</td>
<td>lump sum</td>
</tr>
<tr>
<td>2502.521</td>
<td>___mm (inch) (1) Pipe Drain (2)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2502.541</td>
<td>___mm (inch) Perforated (1) Pipe Drain (2)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2502.571</td>
<td>___mm (inch) Install (3)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2502.573</td>
<td>___mm (inch) Install (3)</td>
<td>each</td>
</tr>
</tbody>
</table>

NOTE: (1) Specify Kind—See 2502.2B
(2) Specify Strength Class, if other than minimum requirement.
(3) Specify item name.
2503

Pipe Sewers

2503.1 DESCRIPTION

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

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

2503.2 MATERIALS

A  Pipe

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

A1  Nonreinforced Concrete (NC) ........................................ 3253
A2  Reinforced Concrete (RC) ........................................... 3236
A3  Corrugated Aluminum (CA) ....................................... 3225
A4  Corrugated Steel (CS) ............................................. 3226
A5  Corrugated Aluminized Steel (CAS) ........................... 3222
A6  Bituminous Coated-Corrugated Steel (BC-CS) .............. 3227
A7  Aramid Bonded-Corrugated Steel (AB-CS) .................. 3228
A8  Blank
A9  Corrugated Polyethylene (CP) .................................... 3247
A10 Plastic Truss (PT) .................................................. 3241
A11 Vitrified Clay (VC) ................................................ 3251
A12 Polymeric Coated-Corrugated Steel (PC-CS) .............. 3229

Coating Type shall be as specified in the Contract.

A13 Thermoplastic .................................................... 3245

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

C  Pipe Joint Sealer Materials

C1  Hot-Poured Sealing Compound ................................. 3724
C2  Preformed Rubber, Type A .................................... 3726
C3  Preformed Plastic, Type B .................................. 3726
C4  Bituminous Mastic .............................................. 3728

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

2503.3 CONSTRUCTION REQUIREMENTS

A  General

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

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

B Excavation

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

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

If the trench is excavated to a greater width than that authorized according to the above tabulation, the Engineer may direct the Contractor to provide a higher class of bedding, a higher strength pipe, or both, than that required by the Contract; without additional compensation therefor; as the Engineer deems necessary to satisfy the design requirements.

C Laying Pipe

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

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

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

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

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

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

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

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

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

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

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

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

D Backfill

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

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

E Installation by Jacking

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

F Cleanout

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

2503.4 METHOD OF MEASUREMENT

A Excavation

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

B Sewer Pipe

Each pipe, as classified by Proposal item, will be measured separately by length along the line of the sewer. Terminal points of measurement will be the pipe end at free outlets; the point of junction
2503.4

with in-place pipe; or the center of manholes, catch basins or multiple
junction points as they apply.

Pipe transition sections will be measured as the larger size pipe.
Sections of metal pipe at the outlets of clay or concrete sewers will
be considered as metal sewers.
Sewer materials that are furnished by the Department for installation
under the Contract will be measured as length of installed sewer,
separated as to type but without regard to size.

C  Sewer Appurtenances

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

D  Granular Materials

Granular materials for special backfill and bedding will be measured
in accordance with 2451.4B.
Measurement on the basis of compacted volume will be limited in
width to the maximum trench widths allowed under 2503.3, Excavation.

2503.5  BASIS OF PAYMENT

Payment for sewer pipe of each size, type, kind, and strength class,
at the appropriate Contract prices per unit of measure, will be
compensation in full for all costs of furnishing and installing the pipe
complete in place as specified, except as otherwise provided herein.
For elbow, tee or wye sections and the necessary additional
connectors that are ordered by the Engineer but that are not indicated in
the Plans, additional compensation will be made in the amount of the
actual invoice cost of the materials involved.
Payment for installing sewer materials provided by the Department
will be made under the applicable installation item indicated in the
Proposal and, except for Extra Work or work designated under other
items, will be considered as full compensation for all the work and
additional materials used in installing the sewer complete in place.
Granular materials for special bedding or backfill will be paid for
separately in accordance with 2451.5.
Where installation by jacking is permitted, in the absence of a
specific pay item therefor, payment will be made on the same basis as
if the sewer were installed by the trenching method.
Payment for flap gates at the Contract price per unit will be
compensation in full for furnishing and installing the gates complete in
place as specified.
Any aprons required in connection with the sewer construction will
be paid for separately in accordance with 2501.5.
Any required excavation more than 300 mm (1 foot) below the bottom of the pipe, as shown in the Plans, will be paid for as Extra Work.

Unless its existence is shown in the Plans, the removal of ledge rock or rocks larger than 0.4 m³ (½ cubic yard) in volume from the excavation will be paid for as Extra Work.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2503.511</td>
<td>__mm (inch) (1) Pipe Sewer (2)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2503.519</td>
<td>Flap Gate for (3) Pipe</td>
<td>each</td>
</tr>
<tr>
<td>2503.521</td>
<td>__mm (inch) Span (1) Pipe-Arch Sewer (2)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2503.531</td>
<td>__mm (inch) (1) Elliptical Pipe Sewer (4)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2503.541</td>
<td>__mm (inch) (1) Pipe Sewer, Design (5) (2)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2503.571</td>
<td>Install (6)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2503.573</td>
<td>Install (6)</td>
<td>each</td>
</tr>
</tbody>
</table>

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

2506

Manholes and Catch Basins

2506.1 DESCRIPTION

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

For the purposes of this Specification, precast concrete median drains will be considered to be casting assemblies.
2506.2 MATERIALS
A Concrete ...................................................................... 2461
3B42 concrete shall be used for cast-in-place structures of Designs A, C, F, or G; and for drop inlet surface block.
3Y43 concrete shall be used in all other cast-in-place structures.
B Mortar
Mortar shall conform to ASTM C 270. The cement shall be either Type S masonry cement or 2 to 4 parts of Portland cement to 1 part of Type S hydrated lime. Mortar sand shall have a volume equal to 2.25 to 3 times the total of the volume of cement and lime. Sufficient water shall be added for proper consistency.
The cement and lime shall be air-entrained unless approved otherwise by the Concrete Engineer. The entrained air content of the mortar shall be within the range of 7-10 percent.
B1 Portland Cement .......................................................... 3101
B2 Hydrated Lime (Type S) ............................................... 3106
B3 Masonry Cement (Type S) .......................................... 3107
B4 Mortar Sand .................................................................... 3128
C Clay Brick .................................................................. 3612
D Concrete Brick ........................................................... 3616
E Concrete Masonry Units ........................................... 3621
F Sectional Concrete Manhole/Catch Basin Units ....... 3622
G Clay Pipe, Standard Strength ............................... 3251
H Nonreinforced Concrete Pipe ................................. 3253
I Blank
J Reinforced Concrete Pipe ............................................. 3236
K Corrugated Steel Pipe .................................................. 3226
L Metal Drainage Castings ............................................ 3321
M Concrete Drainage Castings .................................. 3622
N Granular Materials ....................................................... 3149
O Blank
P Corrugated Aluminum Pipe ......................................... 3225
Q Corrugated Aluminized Steel (CAS) ....................... 3222
2506.3 CONSTRUCTION REQUIREMENTS
A General
A1 Combination Construction
The Engineer may permit a combination of cast-in-place and prefabricated concrete construction for those structures where a type of construction is not specified and where structural strength and continuity is maintained.
A2 Intercepting Existing Facilities
Where the new structure will intercept an existing underground facility, the existing facility shall be incorporated into the structure to the extent required, including any necessary removal, replacement, or
special connections, without detriment to the planned function of the facility.

A3  Abandoned Pipes
Any abandoned pipes that enter a structure that will not be abandoned shall be detached from the structure and the wall opening shall be permanently plugged with concrete or masonry. The upgrade end of the abandoned pipes shall also be plugged with concrete or masonry.

A4  Excavation, Bedding, and Backfill
Excavation, bedding, and backfill construction requirements shall be as indicated in 2451.

A5  Inspection Before Construction
Mortar shall not be placed in any unit or section of work, until the Engineer has inspected and approved the required foundation preparations, materials, and provisions for cold weather protection.

A6  Temperature Restrictions
A6a  Mortar shall not be placed on a frozen foundation or against any surface with a temperature below freezing.
A6b  Concrete or mortar production shall not commence or continue when the air temperature at the construction site in the shade or away from artificial heat is below 2°C (36°F):
   (1) Unless authorized by the Engineer when the air temperature is rising and has reached 1°C (34°F).
   (2) Unless provisions satisfactory to the Engineer have been made in advance for cold weather protection.
A6c  Masonry units or aggregate whose temperature is 0°C (32°F), or less, shall not be used except under direct supervision of the Engineer.
A6d  All concrete or mortar mixes shall have a temperature of not less than 10°C (50°F) nor more than 32°C (90°F). The mix shall be maintained within this temperature range until it is deposited in the work.
A6e  The Engineer may approve heating of masonry units, mix materials, or mortar by an approved heating system operated in an acceptable manner. Spot heating of such materials by means of steam jets or direct application of combustion heating devices, as the work progresses, will not be permitted.

B  Cast-In-Place Concrete .............................................. 2411

C  Masonry
The following requirements shall apply when part or all of the structure is constructed using clay brick or concrete masonry units. The term, "unit", as applied herein, shall refer to either the brick or concrete block unless otherwise qualified.
Concrete masonry units shall not be moistened prior to placement in the work, but all other types of masonry units shall be moistened before being laid.

Units shall be laid in a full mortar bed, in horizontal courses, using the "shove joint" method. All joints shall be filled with mortar. Joints on the inside of the structure shall be no more than 13 mm (½ inch) wide and shall be struck. The outside of the structure shall be plastered with mortar to a smooth surface.

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

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

1. In circular type structures, the bricks shall be laid flat and radially, with the ends exposed on the inside of the structure. Where the thickness of the wall is greater than the length of one brick, the outside bricks may be laid circumferentially, using full header construction in at least each sixth course.

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

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

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

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

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

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

G Adjusting Frame or Ring Castings
Vertical adjustment of access castings shall be made to the planned elevation on the existing structure, based on the criteria that full support for the casting is obtained above the cone section and that the structure construction above the cone does not exceed 600 mm (2 feet). Where these criteria cannot be maintained in the adjustment work, the structure shall be reconstructed.

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

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

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

I Blank

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

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

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

Excavated materials not required for backfill shall be disposed of as directed by the Engineer, within a haul distance of 1 km (½ mile).

2506.4 METHOD OF MEASUREMENT
Manholes and catch basins will be measured as drainage structures.
A  Constructing Drainage Structures

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

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

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

B  Reconstruction

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

C  Castings

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

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

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

D  Adjusting Castings

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

2506.5  BASIS OF PAYMENT

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

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

(a) Any excavation that is in ledge rock and the removal of boulders or detached rocks each having a volume of more than 0.4 m³ (½ cubic yard) will, unless the existence of such rock is shown in the Plans, be paid for as Extra Work.
(b) Payment for reconstructing drainage structures includes removal of the existing casting but does not include placement of a casting on the reconstructed structure.

(c) Payment will be made for the removal and replacement of concrete base or concrete pavement when, except for the structure construction, the surface would not otherwise have been disturbed. Payment will be at the appropriate unit prices on the basis of the area, to the nearest 0.1 m² (1/10 square yard), within a rectangle having sides that lie ½ m (1 ½ feet) outside of the structure limits. No direct compensation will be made for removing and replacing any pavement outside of these limits or for replacing any other type of surfacing.

(d) Payment for drainage structure construction by the structure as individual units complete in place will be compensation for furnishing and installing any castings required.

(e) No direct payment will be made for removal and replacement of concrete surfacing in connection with the item of adjust frame and ring castings.

(f) Granular materials for special bedding or backfill will be paid for in accordance with 2451.5.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2506.501</td>
<td>Construct Drainage Structure, ................</td>
<td>Design _____ meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(linear foot)</td>
</tr>
<tr>
<td>2506.502</td>
<td>Construct Drainage Structure, Design _____</td>
<td>each</td>
</tr>
<tr>
<td>2506.503</td>
<td>Reconstruct Drainage Structure ............</td>
<td>each</td>
</tr>
<tr>
<td>2506.516</td>
<td>Casting Assembly ................................</td>
<td>each</td>
</tr>
<tr>
<td>2506.521</td>
<td>Install Casting .................................</td>
<td>each</td>
</tr>
<tr>
<td>2506.522</td>
<td>Adjust Frame and Ring Casting................</td>
<td>each</td>
</tr>
</tbody>
</table>
2511

2511
Riprap

2511.1 DESCRIPTION
This work shall consist of furnishing and placing stone riprap, with or without grouting as specified, at the locations shown in the Plans or ordered by the Engineer, as a protective covering on earth slopes, piers, abutments, walls, or other structures, where the soil is susceptible to erosion.

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

2511.2 MATERIALS
A Riprap Materials ........................................................ 3601
B Filter Materials
B1 Granular Filter .............................................................. 3601
B2 Geotextile Filter ........................................................... 3733
C 3A-Grout ..................................................................... 2461

2511.3 CONSTRUCTION REQUIREMENTS
A General
The foundation for the riprap, with or without filter material, shall be excavated and shaped to the cross-sections indicated in the Plans, unless otherwise directed by the Engineer. All loose foundation material shall be thoroughly compacted before placement of the riprap or filter material.

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

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

B1 Granular Filter
When granular filter is used, the thickness shall be 150 mm (6 inches) unless other dimensions are specified.

Granular filter materials shall be spread to uniform thickness over the prepared foundation. Granular material placed under water shall be deposited directly on the foundation by means of a bucket or similar container. Discharging the granular material above the water surface will not be permitted.
Wherever geotextile filter material is placed, the Contractor shall ensure that:

(a) The foundation surface is relatively smooth and free of stones, sticks, and other debris or irregularities that might puncture the fabric.

(b) Placing material or conducting construction operations do not tear, puncture, or shift the fabric.

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

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

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

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

C Riprap Stone

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

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

Before placement of riprap stone on geotextile, the Engineer may require the Contractor to demonstrate that the placement methods will not damage the fabric. The Engineer may order the removal of at least 3 m² (4 square yards) of riprap to inspect for fabric damage, subject to 1511.
C1  Random Riprap
Random riprap shall be positioned in a manner that will provide uniform distribution of the various sizes of stone and produce a dense, well-keyed layer of stones with the least practical quantity of void space. The surface shall be leveled as necessary, to produce a reasonably uniform appearance and the required thickness.

C2  Hand-Placed Riprap
The stones for hand-placed riprap shall be firmly embedded in the foundation material, with the axis of the stone that most nearly approximates the specified thickness of riprap laid perpendicular to the foundation slope. Stones shall be laid with minimum practicable quantity of space between them and positioned to stagger the joints up the slope. Each stone shall be so placed that its mass is carried by the foundation material as well as adjacent stones.

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

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

C3  Quarry-run Riprap
Quarry-run riprap shall be placed as specified for random riprap.

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

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

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

2511.4 METHOD OF MEASUREMENT
A  Riprap
Riprap of each type and class measured by volume will be computed on the basis of actual surface dimensions as staked and the specified thickness.

Riprap of each type and class measured by mass will be based upon scale tickets of materials delivered and placed within the staked areas.
B  Filter Materials
Filter materials measured by mass will be based upon scale tickets of material delivered and placed within the staked areas.
Filter materials measured by volume will be computed on the basis of actual surface dimensions as staked and the specified thickness.
Geotextile filter material measured by area will be computed on the basis of actual surface dimensions as staked, with no allowance for overlaps or seams.

2511.5  BASIS OF PAYMENT
The Contractor will accept payment for riprap of each type and class at the Contract price per unit of measure as compensation in full for all costs of furnishing the required materials; excavating and preparing the foundations; and placing the riprap stone, grouting, and filter materials as specified. The Contractor will receive separate compensation for filter materials only when the Contract contains the appropriate pay items.
Payment will be as follows:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2511.501</td>
<td>Random Riprap, Class ___ ……..</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2511.502</td>
<td>Random Riprap, Class ___ ……..</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2511.503</td>
<td>Quarry-run Riprap ……..</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2511.504</td>
<td>Quarry-run Riprap ……..</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2511.505</td>
<td>Hand-placed Riprap ……..</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2511.507</td>
<td>Grouted Riprap ……..</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2511.511</td>
<td>Granular Filter ……..</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2511.513</td>
<td>Granular Filter Material ……..</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2511.515</td>
<td>Geotextile Filter, Type ___ ……..</td>
<td>square meter (square yard)</td>
</tr>
</tbody>
</table>

2512  Gabions and Revet Mattresses

2512.1  DESCRIPTION
Furnish and construct gabions and revet mattresses (placing stone in wire baskets) at the locations shown in the Plans or ordered by the Engineer.

2512.2  MATERIALS

A  Riprap Materials ……………………………………… 3601
B  Filter Materials
B1  Granular Filter ……………………………………… 3601
B2  Geotextile Filter ……………………………………… 3733
C  Gabions ………………………………………………… 3602
D  Revet Mattresses ……………………………………… 3602
2512.3 CONSTRUCTION REQUIREMENTS

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

The Contractor shall:

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

B Filter Material

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

B1 Granular Filter ......................................................... 2511.3
B2 Geotextile Filter ....................................................... 2511.3

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

C Baskets and Fasteners

C1 Documentation

The Contractor shall provide:

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

C2 Construction

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

The Contractor shall:

(a) Assemble the baskets according to the manufacturer’s recommendations unless the following requirements, 3602, or the Plan state otherwise.
(b) Place and fasten the diaphragms in the baskets to the side and bottom mesh so that cell dimensions are not more than 1 m (3 feet).
(c) Fasten adjoining empty baskets together at their perimeters.
(d) Place stones in the cells of baskets in a manner that will minimize voids, does not allow sharp edges to protrude through the mesh, and maintains the basket in the dimensions shown in the Plans. This will require some stones to be hand-placed.
(e) Generally fill cells in 300 mm (12 inch) lifts. Fill cells of up to 300 mm (12 inches) in one lift. Fill cells of up to 450 mm (18 inches) in two equal lifts. Do not fill cells more than 300 mm (12 inches) higher than stone layers in adjacent cells or baskets.
(f) For twisted wire gabions place horizontal connecting wires on top of the stone layer in both directions where there is not a supporting basket, to prevent the sides from bulging. For welded wire gabions install preformed stiffeners across the corners of the gabions before filling. Two rows of stiffeners (4 per cell) are required for the front face and the side faces. A single row of stiffeners (2 per cell) is required on the back face. No stiffeners are required in interior cells. Preformed stiffeners shall have a nominal length of 450 mm (18 inches). The stiffeners should be hooked at crossing wires. Lacing wire may be used as a stiffener.

(g) Fold the top of baskets shut and fasten to the ends, sides, diaphragms, and adjacent baskets, after the basket is filled.

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

(i) Blank

(j) Stagger the vertical joints between the baskets of adjacent rows and layers unless otherwise shown in the Contract.

(k) Blank

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

C3 Fasteners

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

C3a Lacing Wire

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

C3b Alternative Fastener

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

D Acceptance

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

2512.4 METHOD OF MEASUREMENT

A Gabion and Revet Mattress

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

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

2512.5 BASIS OF PAYMENT

The Department will make payment for gabions and revet mattresses at the Contract price per unit of measure as full
2512.5

compensation for all costs of furnishing the required materials, excavating and preparing the foundations, furnishing and installing filter materials, and constructing and filling the gabions and revet mattresses as specified.

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

The Department will pay as follows:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2512.517</td>
<td>Gabion</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2512.519</td>
<td>Revet Mattress</td>
<td>cubic meter (cubic yard)</td>
</tr>
</tbody>
</table>
2514 Slope Paving

2514.1 DESCRIPTION
This work shall consist of paving embankment slopes and waterways with Portland cement concrete or crushed aggregate, as specified, to provide erosion protection.

2514.2 MATERIALS
A Concrete ................................................................. 2461
Unless otherwise specified, the concrete shall meet the requirements for Mix Designation 3A34, except that the slump requirement may be adjusted as approved by the Engineer to achieve the desired results.
B Reinforcement Bars ............................................. 3301
Reinforcement shall be either Grade 300 or Grade 420 (Grade 40 or Grade 60) deformed billet Steel, of ASTM A 615/A 615M.
C Preformed Joint Filler ............................................. 3702
D Bituminous Material .............................................. 3151
Bituminous material for stabilizing aggregate slope paving shall be Liquid Asphalt, Grade MC-250, MC-800, or Emulsified Asphalt, Grade CSS-1, CSS-1H, RS-1, or CRS-2.
E Aggregate
The material for aggregate slope paving shall conform to 3137 for gradation class CA-1, CA-2, or CA-3, except that the fourth paragraph of 3137.2E (multiple fraction requirement) shall not apply.

2514.3 CONSTRUCTION REQUIREMENTS
A Foundation Preparations
The foundation upon which the paving material is to be placed shall be prepared as necessary to achieve the specified paving dimensions and surface elevations as indicated in the Plans or directed by the Engineer. Foundation preparations shall include the excavating of high spots and the filling and compacting of low spots until the foundation conforms to the required elevation and slope and is of uniform density.
In the event the rough grading was performed by others under another contract and the Engineer determines that there is either a shortage or excess of material to construct to the planned foundation elevations, the Engineer may make such minor adjustments in grade to balance out the available material or may order the placement of additional material from other sources or the removal and outside disposal of excess material, as may be required to achieve acceptable foundation elevations. The furnishing and placing of additional material and the removal and outside disposal of excess material by order of the Engineer will be compensated for as Extra Work to the extent that loading and hauling of the material is necessary. Excess material disposed of on areas adjoining the slope paving as directed by
the Engineer, without loading and hauling, will not be compensated for separately as Extra Work but will be considered as being incidental to the slope paving item.

B  Aggregate Slope Paving

The aggregate shall be deposited, spread, consolidated, and shaped by mechanical or hand methods that will provide uniform depth and density and produce uniform surface appearance. Liquid asphalt shall be applied when ambient air temperature is not less than 5°C (40°F), at an approximate rate of 8 L/m² (1.8 gallons per square yard). Emulsified asphalt shall be applied when ambient air temperature is not less than 10°C (50°F), at an approximate rate of 11 L/m² (2.5 gallons per square yard). Bituminous materials shall penetrate to a depth of not less than one-half the required thickness of the aggregate slope paving. Adjacent structure surfaces shall be protected against bituminous splatter.

C  Concrete Slope Paving

Construction shall be in accordance with the applicable provisions of 2401. The concrete shall be placed, consolidated, struck-off, and hand floated as will secure dense pavement relatively free of voids and cavities and produce uniform surface appearance. Side forms shall be so set and supported and the concrete so finished as to result in surfaces that do not deviate from a true plane and the prescribed grade by more than plus or minus 13 mm (½ inch). Metal reinforcement and preformed filler material shall be placed as required by the Plans and shall be suitably supported to maintain correct position during concrete placement.

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

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

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

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

2514.4 METHOD OF MEASUREMENT
Slope paving of each type will be measured separately by area of top surface, bounded by the outside edges of abutment faces, toe walls, side walls or timber planks, as constructed and accepted for payment.

2514.5 BASIS OF PAYMENT
Payment for slope paving of each type specified at the Contract price per unit of measure of surface area will be compensation in full for all costs of constructing the work complete in place as specified.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2514.501</td>
<td>Concrete Slope Paving</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2514.503</td>
<td>Aggregate Slope Paving</td>
<td>square meter (square yard)</td>
</tr>
</tbody>
</table>

2520
Lean Mix Backfill

2520.1 DESCRIPTION
This work shall consist of placing a lean cementitious backfill into utility and culvert trenches, or other such excavations, where the use of conventional compacting equipment is deemed inappropriate or impractical. It is neither a low strength concrete nor a soil cement, but is a controlled-density backfill material.

2520.2 MATERIALS

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

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

| E | Water                        | 3906                        |
| F | Admixtures                   | 3113                        |

2520.3 MIX REQUIREMENTS

| A | Mix Design and Control       |

Lean mix backfill design shall be governed by the absolute volume relationships; and basic mix proportions set forth herein for the control of cement, fly ash, water, and aggregate content; and the degree of workability necessary for proper placement.
A1 Tentative Material Proportioning

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

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

The remaining volume* will consist of:
- Fine Aggregate ......................................................... 50%
- Coarse Aggregate ....................................................... 50%

Gradation Range 6 as shown in 2461.3B4

*Up to 30% of the aggregate by volume may be replaced by pre-formed foam. The foaming agent shall comply with ASTM C-869 when tested in accordance with ASTM C-796. Other admixtures may be used when specifically approved by the mix designer and Mn/DOT's Concrete Engineer.

A2 Mix Requirements

- Slump 250 mm ± 25 mm (10 inch ± 1 inch)
- Unconfined Compressive Strength:
  - Minimum desirable: 500 kPa (75 psi) at 28 days
  - Maximum desirable: 2750 kPa (400 psi) at 28 days

A3 Job Mix Proportions

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

A4 Mix Adjustments

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

B Production Controls

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

C Batching and Mixing Requirements

C1 Proportioning Methods

Lean mix batch materials shall be proportioned by mass (weight) except where volumetric proportioning is authorized in writing by the Engineer.
C2 Other Batching and Mixing Requirements

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

D Ready-Mixed Lean Mix Backfill

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

E Construction Requirements

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

E1 Curing and Protection

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

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

2520.4 METHOD OF MEASUREMENT

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

2520.5 BASIS OF PAYMENT

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

Should the Department determine a need exists for such a pay item, it will be shown in the Plans. Payment will be made at the Contract price per unit of measure. This will be compensation in full for all costs of producing and furnishing the lean mix backfill and for all costs of forming, plugging, placing, venting, protecting as required except for such costs that are specifically compensated for under other Contract items.
### Item No. Item Unit
2520.501 Lean Mix Backfill cubic meter (cubic yard)

#### 2521 Walks

**2521.1 DESCRIPTION**
This work shall consist of bituminous or concrete walkway construction in accordance with these Specifications and close conformity with the lines and grades indicated in the Plans or established by the Engineer.

**2521.2 MATERIALS**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Concrete, Mix No. 3A32</td>
<td>2461</td>
</tr>
<tr>
<td></td>
<td>Concrete, Mix No. 3A36</td>
<td>2461</td>
</tr>
<tr>
<td>B</td>
<td>Preformed Joint Filler</td>
<td>3702</td>
</tr>
<tr>
<td>C</td>
<td>Blank</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Concrete Treating Oil</td>
<td>3917</td>
</tr>
<tr>
<td>E</td>
<td>Bituminous Mixture, Type as Specified</td>
<td>2360</td>
</tr>
<tr>
<td>F</td>
<td>Curing Materials</td>
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</tr>
<tr>
<td></td>
<td>Curing Paper</td>
<td>3752</td>
</tr>
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<td></td>
<td>Plastic Sheeting</td>
<td>3756</td>
</tr>
<tr>
<td></td>
<td>Membrane Curing Compound</td>
<td>3754</td>
</tr>
<tr>
<td></td>
<td>Extreme Service Membrane Cure</td>
<td>3755</td>
</tr>
<tr>
<td>G</td>
<td>Granular Materials</td>
<td>3149</td>
</tr>
</tbody>
</table>

**2521.3 CONSTRUCTION REQUIREMENTS**

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

**A1 Sawing Concrete Walk**
This work shall consist of sawing existing concrete walk to produce a neat line from which to extend the new work.

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

**C Concrete**

**C1 Placing and Finishing Concrete**
The foundation and forms shall be thoroughly wetted immediately prior to the placing of the concrete. The concrete shall be placed,
consolidated to fill all voids, struck off to the required grade, and floated smooth. After the water sheen has disappeared, the joints shall be edged and the surface lightly brushed to a uniform texture.

The surface shall not vary more than 5 mm (3/16 inch) from a 3 m (10 foot) straight edge, and the formed concrete shall be within 13 mm (½ inch) of the required location.

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

C1a Exposed Aggregate Finish

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

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

Apply retardant coating as soon after the concrete surface has been screeded, edged, and jointed. Retardant shall be applied in accordance with the manufacturer's instructions to produce a 6 mm (± 2 mm) (1/4 inch (± 1/8 inch) etch of mortar removal after final set.

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

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

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

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

C2 Joint Construction

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

Joints shall be vertical and straight, and be parallel with or at right angles to the walk centerline where possible. The joints shall align with
like joints in adjoining work unless the work is isolated by 13 mm (½ inch) preformed joint filler.

All joints and edges of the walk shall be rounded with a 6 mm (¼ inch) radius edging tool.

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

Expansion joints shall be 13 mm (½ inch) wide and shall be equal in depth to the full thickness of the walk.

Joint construction at locations where a fixed object or structure extends through the walk shall be modified to the extent deemed necessary by the Engineer. Preformed joint filler material, 13 mm (½ inch) thick, shall be placed adjacent to all fixed objects so as to separate the object from the abutting concrete edges.

C3 Concrete Curing and Protection

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

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

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

C3a Blanket Curing Method

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

C3b Membrane and Extreme Service Membrane Curing Method

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

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

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

D Bituminous

The bituminous mixture shall be placed on the compacted foundation material in one or more courses as indicated in the Plans, so as to give the required thickness.

E Backfilling

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

2521.4 METHOD OF MEASUREMENT

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

Measurement for sawing concrete walk will be made by the length of concrete walk sawed.

2521.5 BASIS OF PAYMENT

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

Concrete and Bituminous walk construction will be paid for on the basis of the following schedule:
2521.5

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2521.501</td>
<td>___mm (___inch) Concrete Walk</td>
<td>___________________________ square meter (square foot)</td>
</tr>
<tr>
<td>2521.503</td>
<td>___mm (inch) Concrete Terrace</td>
<td>___________________________ square meter (square foot)</td>
</tr>
<tr>
<td>2521.511</td>
<td>___mm (inch) Bituminous Walk</td>
<td>___________________________ square meter (square foot)</td>
</tr>
<tr>
<td>2521.513</td>
<td>___mm (inch) Bituminous Terrace</td>
<td>___________________________ square meter (square foot)</td>
</tr>
<tr>
<td>2521.515</td>
<td>____Sawing Concrete Walk .......... meter (linear foot)</td>
<td></td>
</tr>
</tbody>
</table>

2531

Concrete Curbing

2531.1 DESCRIPTION
This work shall consist 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
Mix designations shall be as given below for the method of placement:
A1 Manual Placement ............................................... Mix No. 3A32
A2 Slip-form Placement ........................................... Mix No. 3A22
B Reinforcement Bars ............................................. 3301
C Steel Fabric .......................................................... 3303
D Preformed Joint Filler ......................................... 3702
E Blank
F Concrete Treating Oil ........................................... 3917
G Curing Materials
G1 Curing Paper ...................................................... 3752
G2 Plastic Sheeting ................................................. 3756
G3 Membrane Curing Compound ................................... 3754
G4 Extreme Service Membrane Cure ............................ 3755
H Granular Materials ................................................ 3149

2531.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations
The foundation shall be excavated, shaped, and compacted to a firm, uniform bearing surface, conforming to the planned section and established grade. Unsuitable subgrade soils shall be removed and replaced as directed. Granular material, as specified and where required by the Plans, shall be furnished, placed and compacted thoroughly to the required depth.
B  Forms
Forms shall be of metal, wood, or other suitable material, and shall be capable of sustaining the concrete in its proper position until set. Face forms for curbing shall conform to the required shape and design. Side forms shall have a depth at least equal to the edge thickness of the concrete being formed. The forms shall be fully supported on the foundation and be adequately restrained at the proper line and grade. Approved flexible or curved forms of proper radius shall be used on curves having a radius of 45 m (150 feet) or less.

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

C  Joint Construction
Transverse expansion joints, filled with 13 mm (½ inch) preformed joint filler material, shall be placed at the ends of all curved sections; and at the ends of the curved portions of entrance and street returns. Longitudinal expansion joints shall be placed as shown in the Plans. Expansion joints with filler material shall also be placed at locations where the concrete surrounds or adjoins any existing fixed objects such as fire hydrants, building foundations, and other rigid structures.

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

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

Longitudinal construction joints between a concrete median or gutter section and a concrete pavement shall have a surface groove, either formed or sawed, that is approximately 10 mm (3/8 inch) wide and at least 13 mm (½ inch) in depth.

D  Metal Reinforcement
Metal reinforcement shall be provided and placed as required by the Plans and in conformance with the applicable provisions of 2472.
E  Placing and Finishing Concrete

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

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

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

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

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

F  Slipform Machine Placement

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

G  Concrete Curing and Protection

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

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

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

G1  Blanket Curing Method
The concrete shall be covered with waterproof paper or plastic sheeting as soon as possible (without marring the concrete) after completion of the finishing operations. The curing blankets shall be in such condition and be utilized in such manner as to envelop the exposed concrete and prevent loss of water vapor.

G2  Membrane and Extreme Service Membrane Curing Method
All surfaces exposed to air at the time of cure shall be coated with membrane curing compound within 1 hour after finishing the concrete surfaces. The compound shall be applied by an approved airless spraying machine at the approximate rate of 1 L/4 m² (1 gallon per 150 square feet) surface curing area.

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

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

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

All surplus excavated materials shall be disposed of by the Contractor in a manner satisfactory to the Engineer.
K Workmanship and Finish
The complete concrete work shall give the appearance of uniformity in surface contour and texture, and shall be accurately constructed to line and grade.

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

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

Unacceptable work shall be removed and be replaced with acceptable work as ordered by the Engineer. In the absence of an order to remove and replace, the Contractor shall have the option of so doing or may elect to leave the unacceptable work in place and accept the following price reductions:

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

2531.4 METHOD OF MEASUREMENT
The construction provided for herein will be measured, as indicated in the Proposal, by the length, area, or volume. No deductions will be made for any castings or minor fixtures encompassed in the work.

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

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

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

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

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

D  Pedestrian Curb Ramps
Measurement for pedestrian curb ramps will be made by the number of pedestrian curb ramps constructed as specified.

Measurement for pedestrian curb ramps Type will be made by the top surface area. The measurement will be taken from the outer most edge of the concrete walk, curb, or curb and gutter.

2531.5  BASIS OF PAYMENT
Payment for the concrete construction provided for herein, at the Contract prices per unit of measure, will be compensation in full for all costs of furnishing the materials and constructing the work complete in place as specified, except that any granular materials furnished and placed by order of the Engineer in the absence of specific Plan requirements will be paid for separately under 2451.5.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2531.501</td>
<td>Concrete Curb and Gutter, Design</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2531.502</td>
<td>Concrete Curb, Design</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2531.503</td>
<td>Concrete Median</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2531.505</td>
<td>Concrete Median</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2531.507</td>
<td>___mm (inch) Concrete Driveway Pavement</td>
<td>( \text{square meter (square yard)} )</td>
</tr>
<tr>
<td>2531.511</td>
<td>Concrete (Type of Structure)</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2531.521</td>
<td>Structural Concrete</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2531.530</td>
<td>Concrete Entrance Nose, Design 7107</td>
<td>each</td>
</tr>
<tr>
<td>2531.531</td>
<td>Concrete Entrance Nose, Design 7108</td>
<td>each</td>
</tr>
<tr>
<td>2531.532</td>
<td>Pedestrian Curb Ramp (Type ___)</td>
<td>each</td>
</tr>
</tbody>
</table>
2531.5

2531.533 Pedestrian Curb Ramp (Type ___) ..............................................square meter (square yard)

2533

Concrete Median Barriers

2533.1 DESCRIPTION

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

2533.2 MATERIALS

A Concrete .................................................................................. 2461
A1 3Y32 concrete shall be used for all fixed form cast-in-place concrete median barriers.
A2 3Y12 concrete shall be used for all slipform concrete median barriers.
A3 3Y32 concrete shall be used for all precast concrete median barriers.

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

C Precast Concrete Median Barrier .................. 3630

2533.3 CONSTRUCTION REQUIREMENTS

A General

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

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

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

B Cast-In-Place Fixed Form Construction

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

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

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

C  Cast-In-Place Slipform Construction

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

D  Surface Finishes

D1  Cast-In-Place

Cast-In-Place concrete median barriers shall receive an Ordinary Surface Finish as specified in 2401.3. The ordinary surface finish shall start immediately after the removal of the forms and shall be carried on continuously to completion. As the ordinary surface finish progress, it shall be followed by immediately rubbing the surface with a cork float or fine carborundum stone (depending on the set of the concrete) to produce a paste on the surface and to expose and fill all depressions and all surface cavities. The paste shall be floated to a smooth surface free of coarse texture, swirls, and ridges and before it is set, shall be brushed lightly with a fine bristled brush until all cement films present are removed and the surface has a uniform, fine grained sanded texture.

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

D2  Precast

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

The Contractor shall not apply the special surface finish on the precast concrete median barrier until the barrier is placed in its final location and the Engineer has approved the surface condition of the barrier.
2533.3

**E  Concrete Curing and Protection**

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

**F  Workmanship and Finish**

Irregularities in any 3 m (10 feet) length of the finished concrete median barrier shall not exceed 6 mm (¼ inch) (horizontal and vertical). Surfaces and edges not meeting this tolerance shall be considered to be Unacceptable Work. Unacceptable Work shall be removed and replaced with acceptable work when so ordered by the Engineer. Extensive areas with deviations greater than 13 mm (½ inch) shall be removed and replaced. In the absence of an order to remove and replace, the Unacceptable Work may be left in place with the following price adjustments:

1. For 8 to 13 mm (5/16 to ½ inch) deviations, payment at 75 percent of the Contract price.
2. For minor areas with deviations over 13 mm (½ inch), payment at 50 percent of Contract price.

**2533.4 METHOD OF MEASUREMENT**

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

**2533.5 BASIS OF PAYMENT**

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

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2533.501</td>
<td>Concrete Median Barrier, Design (1) Type (2)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2533.506</td>
<td>Concrete Median Barrier &amp; Glare Screen, Design (1)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2533.507</td>
<td>Portable Precast Concrete Barrier, Design (1)</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>
2533.5

2533.508 Relocate Portable Precast Concrete Barrier, Design (1)...............................meter (linear foot)

(1) Current Standard Plate
(2) Type A, AA, AL, Transition, A Step, or AA Step
2535

Bituminous Curb

2535.1 DESCRIPTION
This work shall consist of constructing bituminous curbing composed of a mixture of aggregate and bituminous material.

2535.2 MATERIALS
The bituminous mixture for the curb shall be produced in accordance with the requirements for wearing course mixtures as provided in 2360, subject to the following provisions:
(a) The mixture shall be of the same type as that used in the wearing course upon which the curb is to be constructed, unless the use of another type is specified or approved by the Engineer.
(b) The bitumen content of the mixture may be increased if necessary, at the discretion of the Engineer. The Engineer may require the substitution of a lower penetration asphalt cement for the specified grade.

2535.3 CONSTRUCTION REQUIREMENTS
Bituminous curb shall be placed under the same restrictions as those that apply to the wearing course construction 2360. If so directed by the Engineer, a tack coat shall be applied to the area on which the curb is to be constructed, as provided for in 2357. The bituminous mixture shall be placed by an approved automatic curb machine that shapes and compacts the mixture to the specified cross section. The use of manual methods of placement will only be permitted where machine placement is not feasible, and then in a manner approved by the Engineer.

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

2535.4 METHOD OF MEASUREMENT
Bituminous curb will be measured by length along the face of the curb at the gutter line.

2535.5 BASIS OF PAYMENT
Payment for bituminous curb at the Contract price per unit of measure will be compensation in full for all costs of its construction, including the costs of producing and furnishing the bituminous mixture.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2535.501</td>
<td>Bituminous Curb</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>
2545

Electric Lighting Systems

2545.1 DESCRIPTION

A  General

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

B  Definitions

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

C  Electrical Distribution System

The distribution circuits of the electric lighting system shall be of the multiple type consisting of three conductors plus equipment ground. The three conductors shall constitute two photoelectric controlled 120 volt or 240 volt circuits as indicated in the Plan. Both lighting circuits and the equipment ground shall be installed complete to each standard.

The Power Company requires that the cabinet be opened for visual inspection before making the service connection. The Contractor's electrician shall be present when the Power Company makes the visual inspection.

2545.2 MATERIALS

A  General

A1  Regulations and Code

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

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

A2  Materials and Electrical Equipment........................... 2565.2

A3  Material Samples for Testing..................................... 2565.2

A4  Tests .......................................................................... 2565.2

A5  Warranties, Guarantees, and Instruction Sheets

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

(b) The Contractor shall warrant and guarantee satisfactory in-service operation of all materials and electrical equipment for a period of one (1) year. The one (1) year in-service warranty period shall begin with the "turn-on" of the electric lighting system. "Turn-on" shall be defined as the time when the complete and operational electric lighting system meets all installation, operational and testing requirements of the
Contract. The in-service warranty is in addition to individual warranties provided by product Manufacturers.

**B Hardware**

All ferrous metal hardware, except stainless steel, shall be galvanized according to 3392.

B1 Fasteners .......................................................... 3391

B2 Anchor Rods .......................................................... 3385

B2a Lighting Service Cabinet Anchorages

High strength bolts, nuts and washers for lighting service cabinet installation shall be in accordance with 3391; shall be galvanized in accordance with 3392; and shall be sized in accordance with 3850.

B2b Lighting Unit Anchorages

Anchor rods, nuts and washers for lighting unit installation on concrete foundations shall be in accordance with 3385; Type A – Carbon Steel Anchor Rods; shall be galvanized the top 300 mm (1 foot) of the anchor rod and nuts; and shall be sized as specified in the Contract.

Threaded studs and nuts for lighting unit installation on steel screw-in foundations shall be in accordance with 3391; shall be galvanized in accordance with 3392; and shall be sized as specified in the Contract.

B2c Rust Inhibitor

Threaded portions of all anchor rods above concrete foundations shall be coated with a rust inhibitor before installation of lighting service cabinets, lighting units, or other type cabinets on the anchor rods.

B3 Cap Screws, Set Screws, and Tap Bolts

Cap screws, set screws, and tap bolts shall be made of commercial brass or bronze. Washers shall be made of galvanized steel or commercial brass.

**C Conduit and Accessories**

C1 Rigid Steel Conduit (RSC) ........................................ 3801

C2 Intermediate Metal Conduit (IMC).............................. 3802

C3 Non-metallic Conduit (NMC)................................. 3803

C4 Conduit Fixtures

Fixtures for metal conduit, where required, shall be made of cast or malleable iron, galvanized according to 3394, and shall have threaded connections. All access covers shall be made of the same material as the fixture and shall provide a watertight fit.

Fixtures for NMC shall be non-metallic intended for use with the type of conduit used.

C5 Expansion Fittings .................................................. 3839
D  Electrical Cables and Conductors
Conductors for main circuits shall be No. 8 or larger, and those for single lamp branch circuit shall be No. 10 or larger.
D1  Armored Underground Cable, Polyethylene .................. 3815
D2  Electrical Conductors .................................................. 3815
D3  Overhead Light Cable................................................... 3815
E  Light Standards .......................................................... 3811
Light standards shall be of the style and type specified in the Contract.
F  Light Fixtures
Light fixtures shall be of the style and type specified below or in the Contract.
F1  Roadway Lighting Luminaires ..................................... 3810
F2  Sign Lighting Fixtures................................................. 3810
F3  Underpass Lighting Fixtures......................................... 3810
F4  Lamps ........................................................................... 3810
Lamps for the luminaires or fixtures shall be the wattage and type specified in the Contract, and shall be universal or base-down to horizontal burning type.
G  Concrete ................................................................. 2461
G1  General
Concrete for light standard foundations shall be Mix. No. 3Y43.
Concrete for equipment pad foundations shall be Mix. No. 3A32.
Concrete meeting the requirements for Type 3, Grade A shall be furnished where use of a specific mix designation is not specified in the Contract.
Concrete pavement or base removed because of trenching or construction operations shall be constructed or replaced with Mix. No. 3Y43 high early strength concrete.
G2  Reinforcement Bars ..................................................... 3301
H  Service Equipment...................................................... 3837
I  Blank
J  Lighting Service Cabinet............................................... 3850
K  Electrical Junction Boxes ........................................... 3838
L  Wood Poles .................................................................. 3840
M  Handholes
Handholes shall be of the type specified in the Contract.
N  Photoelectric Control .................................................. 3812
O  Blank
P  Miscellaneous Materials
Materials and electrical equipment for which no requirements are included in the Contract shall be in accordance with the best standard
practices and workmanship. All materials and electrical equipment shall be approved by the Engineer before installation.

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

R  Lighting Units
   Lighting Units shall be of the style and type specified below or in the Contract.
   Lighting units shall consist of a light standard, mast arm(s), 50 mm (2 inch) slipfitters, luminaire(s), lamps, wire holder, and all miscellaneous equipment required for a complete lighting unit installation.
   Lighting units shall be as specified in the Contract, and conform to the requirements of 3810, 3811, and 3812.

Within 15 days after the Contract approval notice mailing date, the Contractor shall furnish evidence to the Engineer, in writing, that orders have been placed for all components of the lighting units required on the project.

2545.3 CONSTRUCTION REQUIREMENTS

A  General
   The locations of component parts, as indicated in the Contract, are approximate only. The exact locations will be established at the job site by the Engineer.
   The Contractor shall perform no work on the job site until all underground utilities are located in accordance with 1507. Electrical cable damaged, due to Contractor’s negligence, shall be replaced between handholes and light poles within 24 hours at no expense to the Department. Damaged electrical cable shall not be spliced underground.
   Highways, streets, and roads shall be kept open to traffic during construction, subject to 1404. Any openings or uncompleted work that may, after working hours or during construction, cause a hazard to vehicle or pedestrian traffic shall be suitably protected to the satisfaction of the Engineer.

A1  Compliance with Electrical Codes and Standards ..... 2565.3
A2  Permits and Inspections .............................................. 2565.3
A3  Utility Property And Service .................................... 2565.3
B  Existing Electrical Systems ........................................... 2565.3
C  Excavation and Backfill ............................................. 2565.3
D  Conduit and Fitting Installation .................................. 2565.3
E  Handhole Installation .................................................. 2565.3
2545.3

**F** Concrete Foundation Installation

**F1** General

Light foundations (light bases and equipment pads) shall be constructed in accordance with 2565.3, as specified in the Contract, and the following:

**F2** Light Bases

Light bases shall contain one 50 mm (2 inch) NMC 90 degree elbow for each direct buried cable that enters the base, and one spare 50 mm (2 inch) NMC 90 degree elbow, capped at each end, for expansion of the lighting system. These conduit elbows are in addition to extra conduit elbows called for in the Contract.

Where light bases are located in a cut section or a fill section, the Contractor shall 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, a 25 mm (1 inch) NMC elbow having bushings at each end shall be installed to carry the grounding wire. The electrode shall be 75 to 150 mm (3 to 6 inches) below the ground line, within 300 mm (1 foot) of the foundation.

Where ground rod electrodes are installed in concrete foundations, the top of the ground rod electrode shall extend not more than 75 mm (3 inches) nor less than 50 mm (2 inches) above the foundation.

**F3** Equipment Pad

Where the required ground rods are separated from the equipment pad, NMC elbows of the size indicated in the Contract, having threads and bushings at each end shall be installed to carry the grounding wire.

The electrode shall be 75 to 150 mm (3 to 6 inches) below the ground line within 300 mm (1 foot) of the foundation.

Where ground rod electrodes are installed in concrete foundations, the top of the ground rod electrode shall extend not more than 75 mm (3 inches) nor less than 50 mm (2 inches) above the foundation.

**G** Wiring and Conductor Installation

**G1** General

The installation of wiring and conductors shall be in accordance with the applicable provisions of 2565.3, and the following:

Service conductors shall be run in a separate conduit system from all other conductors.

Separate lighting branch circuits may be placed in a single conduit but shall be electrically independent. All conductors of a lighting branch circuit shall be run in a single conduit.
G2 Underground Wiring

Armored cable shall be installed by trenching or plowing methods and shall be installed at a depth of not less than 610 mm (2 feet). Where solid rock or other obstructions are encountered, installation of the cable shall be permitted at a depth of not less than 460 mm (18 inches) provided a 50 mm (2 inch) thick concrete slab is placed in the trench over the cable. Installation of the cable shall be permitted at a depth of not less than 153 mm (6 inches) provided the cable is run through rigid steel conduit and a 50 mm (2 inch) thick concrete slab is placed above the cable and conduit.

Armored cable shall be installed at the same distance behind the bituminous shoulder or back of curb as the light bases. An additional 600 mm (2 feet) of slack armored cable shall be installed near the light base before the cable enters the base conduit.

Armored cable shall extend at least 600 mm (2 feet) above the light base foundation with a minimum of 100 mm (4 inches) of the outer jacket extending above the conduit.

Wiring in conduit shall be installed with sufficient slack to allow for contraction.

An independent grounding wire shall be run through all non-metallic conduit systems and electrically connected to all metal fixtures and equipment along the run.

For all expansion sleeves in metallic conduit, a No. 8 grounding jumper shall be installed internally between conduit sections.

All pulling of wires through conduit or raceways shall be done by hand and without damage to the wires or their covering. The conduit shall be clean and dry at the time the wiring is installed. The cable or conductors shall be dry and clean, except powdered graphite or soapstone that may be used to ease the pulling.

G3 Above Ground Wiring

Within roadway lighting standards, unless otherwise specified, the wires connecting the luminaire to the underground cable or base mounted ballast shall be 14-2 UF cable with ground and a 6 A cartridge type fuse. The fuse shall be mounted in an inline molded fuse connector/holder with casing that shall be located at the level of the handhole. Fuses in breakaway poles shall be of the breakaway type. Sufficient excess conductor length shall be provided to allow withdrawal of the connected fuse holder. The neutral and grounding wires shall not be fused.

Neutral-supported aluminum cable, conforming to 3815 may be used to provide temporary power distribution through aerial lines. The overhead cable shall be attached to the poles in a manner acceptable to
the Engineer. Overhead light cable shall not be supported by the luminaires.

G4 Splices ................................................................. 2565.3

No underground splices will be permitted that are not called for in the Contract or authorized in writing by the Engineer. When underground splices are permitted, the underground splices shall be the type as specified in the Contract.

G5 Terminal Blocks....................................................... 2565.3

H Lighting Standard Installation

Light standards with balanced fixtures or luminaires shall be set plumb. Standards with unbalanced fixtures or bracket arms, or standards that act as supports for overhead wires or guy lines, shall be set with a rake sufficient to counterbalance lateral deflection.

Standards shall be adjusted to the proper position by shims or double nuts before being anchored in position.

Damage to the lighting standard, mast arm, brackets, or other appurtenances to the light standard shall be repaired and restored to the satisfaction of the Engineer.

I Blank

J Sign Lighting Installation

J1 General

Construction of sign lighting shall be as specified in the Contract and the applicable sections of this Specification.

Power distribution to the sign structure shall, unless otherwise required, be by trench laid cable.

J2 Safety Switch

Install the safety switch in a vertical upright position.

J3 Safety Switch Wiring

Install No. 12 conductors in 21 mm (¾ inch) RSC between the switch and the fixtures. All splicing shall be accomplished with a wire nut and waterproof coating. All conduit connections shall be rain tight.

Install a No. 12 green conductor in 21 mm (¾ inch) RSC between safety switch and fixtures, to provide ground. The No. 12 conductor shall be connected to the grounding lug attached to the safety switch enclosure (enclosure isolated from the neutral terminal) and the grounding screw attached to each fixture housing.

Wiring installed between the sign post and the safety switch shall be run in 21 mm (¾ inch) RSC. 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 detailed in the Contract. The splices shall be insulated to the level of insulation of the power conductors and shall be waterproofed. The splices shall be
dressed in the center of the post and up from the base plate with sufficient excess conductor length provided to permit withdrawal of the splices through the handhole.

Upon completion of new or modified sign lighting system(s) for each feed point, a burn test shall be performed as specified in 2545.3K2.

J4 Feed Point Identification Plate

Furnish and install a feed point identification plate for each new lighted overhead sign in accordance with the details shown in the Contract. The plate shall incorporate the feed point identification number appearing in parenthesis directly below or along side the sign number in the Contract.

Strap mount the plate to the overhead sign post in accordance with the details in the Contract. The plate shall be installed on the right post when looking in the direction of traffic flow. When signs face both directions of travel on a single structure, two plates will be required. The plate shall be installed at a height of approximately 2.2 m (7 feet) above the base plate elevation and facing traffic.

For bridge mounted signs, the feed point identification plate shall be installed on a 3 kg/m (2 pound per foot) delineator post in accordance with 3401. The feed point identification plate and post should be installed as close to the bridge as possible and behind the guardrail, if present. If no guardrail is in place, the feed point identification plate and post shall be installed at least 3.7 m (12 feet) outside the edge of the shoulder or face of curb. The bottom of the FPID plate shall be approximately 2.2 m (7 feet) above the edge of the pavement.

J5 Safety Cable

The Contractor shall furnish and install brackets, aircraft cable and all necessary hardware, in accordance with the applicable provisions of 2564, to assemble and attach a safety cable as detailed in the Plan.

K Electrical System Testing and Acceptance

Before completion of the work, the Contractor shall test the entire system for unwanted grounds and conduct a 12-hour burn test for each feed point.

K1 Megohm meter test (Test for unwanted grounds)

A megohm meter test, at 500 VDC, indicating the insulation resistance of each circuit shall be made. The megohm tester shall be energized for 15 s on the circuits to check if any break down of the circuits occurs. The Contractor shall furnish the Engineer with a written report of the megohm meter readings for the permanent record. The report shall contain the following information:

(a) PROJECT NUMBER AND LOCATION
(b) FEEDPOINT NUMBER - As indicated in the Plans.
(c) BRANCH CIRCUIT - Identify each lighting branch circuit being tested by indicating the number of the first light connected to that circuit, as indicated in the Plans.

(d) PHASE CONDUCTOR INSULATION RESISTANCE - Measure the resistance between the phase conductors, and the resistance between each phase conductor and the equipment ground bar in the service cabinet with the fuses removed from the inline fuse connectors in the lighting poles. The resistance shall not be less than 100 MΩ.

(e) NEUTRAL CONDUCTOR INSULATION RESISTANCE - Measure the resistance between each neutral conductor and the equipment ground bar in the service cabinet with the fuses removed from the inline fuse connectors in the lighting poles. The resistance shall not be less than 100 MΩ.

(f) CIRCUIT INSULATION RESISTANCE - Measure the resistance between each phase conductor and the equipment ground bar in the service cabinet with all fuses in place in the lighting poles. The resistance shall not be less than 100 MΩ.

The Contractor shall make sure that the circuit's conductors are connected to the circuit breaker of the opposite phases (some manufacturers alternate every other breaker with opposite phases, and other manufacturers split the top and bottom halves of the circuit breaker with opposite phases).

All tests shall be made at the service cabinet, in the presence of the Engineer, with all grounding connections in place. The phase and neutral conductors shall be disconnected at the service cabinet for the insulation resistance tests.

Where test results indicate faulty insulation or a faulty connection within the circuit, all necessary corrections shall be made and the circuit retested, all at no expense to the Department. No additional payment will be made for replacing any part of or the entire circuit as required to make the circuits meet the test requirements.

K2 12-Hour Burn Test

Upon completion of a feed point and before no more than 90 percent of the feed point cost is paid, the service cabinet must be energized and the entire electrical system must operate successfully without interruption for 12 hours, during daylight hours only. The Contractor shall pay all power costs incurred and all such costs shall be incidental to the cost of the Project.

L Lighting Service Cabinet Installation

Pad mounted lighting service cabinets shall be securely bolted to the concrete foundation.
All components of the lighting service cabinet shall be installed in a workable first class condition and shall include all miscellaneous hardware required for a complete lighting service cabinet installation. The Contractor shall coordinate with the power company for connection of power to the lighting service cabinet.

M  Painting

Painting of all nongalvanized ferrous metalwork, except for stainless steel, shall be in accordance with the applicable requirements of 2478.

Painting of all galvanized ferrous metalwork, shall be in accordance with 2478.

For steel lighting service cabinets, unless otherwise specified in the Contract, the finish coats shall be two field coats of Dark Green Acrolon 218, or approved equivalent polyurethane finish coat matching Color Number 14062 of the Federal Standard 595B.

The finish coats shall be applied by brush or spray application. The inside of light standard shafts need not be painted.

Aluminum service cabinets, unless otherwise specified, shall be anodized to match Duranodic finish #311.

If a manufacturer's shop coat paint is accepted or specified in the Contract, the Contractor shall make every effort during erection of a painted pole to protect the factory applied finish. The collar used for handling the pole shall be lined with a felt pad and the protective wrapping on the pole shall be left on at the lift point area to protect the finish of the pole. Any nicks, scratches, paint chips or other damage to the finish shall be repaired and restored to the satisfaction of the Engineer.

N  Restoration and Cleanup ........................................ 2565.3

O  Blank

P  Light Standard, Light Fixture, and Lighting Service Cabinet Numbering

The Contractor shall number the light standards or light units (underpass luminaires, tunnel luminaires, high mast luminaires, special luminaires, etc.) and the outside of lighting service cabinets with decals in accordance with the numbering shown in the Plans.

Pole numbering shall consist of the feed point numbers and letters placed immediately above the pole number at a height of 1.8 m (6 feet) above the concrete base at an angle of 45 degrees facing oncoming traffic.

Each letter and number shall be black, 50 mm (2 inches) high on a 38 x 64 mm (1 ½ x 2 ½ inches) gray background.

Decals shall be self-sticking acrylic with optical lens elements, 127 µm (5 mil) low temperature permanent acrylic adhesive with a
2545.3

-23°C (-10°F) rating, and a service temperature rating of -48°C (-55°F)
to +34°C (94°F).

A sample decal shall be submitted to the Engineer for approval before the decals are installed.

The pole shaft shall be "lightly sanded" to remove oxidation, and wiped with isopropyl alcohol before applying numbers and letters.

Wood pole lighting standards shall be numbered to the satisfaction of the Engineer.

Underpass lighting units shall be numbered with the last letter of the feed point and with the luminaire number.

Branch circuit breakers on the interior of the lighting service cabinets shall be labeled indicating the color of the circuit conductor (Red or Black) and the luminaire number. The Contractor shall ensure that the type of labeling used is legible and has sufficient durability to withstand the environment involved.

Q  Luminaire Installation

The Contractor shall install and level luminaires in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer.

Place a level on the area provided on the top of the luminaire, and level in a side to side and front to back direction. Adjust the luminaire as required to completely level the luminaire.

R  Bonding and Grounding

All bonding, grounding, ground rod electrodes, grounding electrode conductors, and grounding connections shall be in accordance with the applicable provisions of 2565.3, the NEC and the following:

All metal poles, conduit, service cabinets, service equipment, and other non-current-carrying metal surfaces shall be made mechanically and electrically secure to form a continuous, bonded, grounded system and to provide a low impedance path from any exposed metal surface to the system ground at the service cabinet or service equipment.

Any equipment grounding conductor in the armored cable, bronze tape armor of the armored cable, equipment grounding conductor in conduit, rigid steel conduit, the grounding lug of the light standard or sign post, and ACSR equipment ground messenger of overhead light cable indicated in the Plans shall be bonded together and used as the equipment ground. The bonding and grounding jumper shall be a copper conductor no less than No. 6. The neutral conductor shall be grounded only at the feedpoint.

The grounding and bonding jumper shall be connected to the bronze tape armor with a bronze or copper lug type connector or bolt. Other attachments of the grounding and bonding jumper shall be by means of
cast clamps or grounding bushings with a bronze or integral lug to accommodate the jumper.

Where indicated in the Contract, a supplemental ground rod electrode shall be installed. Ground rods used for this purpose shall be copper coated, have a minimum diameter of 16 mm (5/8 inch) and be 3 m (10 feet) in length.

Ground rod electrodes shall be provided at every other light base and the light base located at both ends of a run, unless otherwise indicated in the Contract.

All main switch cabinets, control cabinets, or service cabinets shall have a direct grounding connection to a ground rod. When installed on bridges or buildings, each cabinet or metal structure shall be bonded to the bridge or building grounding system. Grounding conductor runs shall be as short as possible.

S  Service Equipment Installation .............................................. 2565.3
T  Existing Materials and Electrical Equipment
Existing materials and electrical equipment required by the Contract or as directed by the Engineer to be removed, salvaged, reinstall, or stockpiled shall be in accordance with 2565.3.
U  Wood Pole Installation .......................................................... 2565.3
V  Lighting Units
All components of lighting units shall be installed in a workable first class condition and shall include all miscellaneous hardware required for a complete lighting unit installation.

2545.4 METHOD OF MEASUREMENT
A  Complete Systems
When separate items are listed in the Contract for various types of complete electrical systems, each separate system will be measured in accordance with the following:
A1  Electric Lighting System
Each separate electric lighting system will be measured as a single unit, complete in place.
A2  Electric Power System
Each separate electric power system will be measured as a single unit, complete in place.
A3  Sign Lighting System - ___ Fixtures
Each separate sign lighting system - ___ fixtures, will be measured as an integral unit, complete in place.
A4  Sign Lighting System Bridge Mounted - ___ Fixtures
Each separate sign lighting system bridge mounted - ___ fixtures, will be measured as an integral unit, complete in place.
A5 Conduit System
Each separate conduit system will be measured as an integral unit, complete in place.

B Electrical System Components
When separate Items are listed in the Contract for the various component parts of an electrical system, they will be measured in accordance with the following:
B1 Lighting Units
Lighting units of each type of mounting and fixture design will be measured separately by the number of units of each type, complete in place.
B2 Luminaires
Luminaires of each type and wattage will be measured separately by the number of luminaires complete in place.
B3 Light Bases
Concrete bases of each design for lighting units will be measured separately as integral units, complete in place.
B4 Conduit
Conduit of each kind and diameter will be measured separately by the length between end terminals along the centerline of the conduit as actually installed.
B5 Underground Wire
Underground wire of each kind and size will be measured separately by the length between end terminals along the centerline of the wire as actually installed.
B6 Armored Cable
Armored cable of each kind and size will be measured separately by the length between end terminals along the centerline of the cable as actually installed.
B7 Overhead Light Cable
Overhead light cable of each kind and size will be measured separately by the length between end terminals along the centerline of the wire as actually installed.
B8 Service Cabinets
Service cabinets of each type will be measured separately by the number of cabinets, complete in place.
B9 Equipment Pads
Equipment pads of each type will be measured separately by the number of equipment pads complete in place.
B10 Junction Boxes
Junction boxes will be measured by the number of junction boxes complete in place.
B11 Handholes
Handholes of each design will be measured separately by the number of handholes complete in place.

B12 Underpass Lighting Fixtures
Underpass lighting fixtures of each design will be measured separately by the number of underpass lighting units complete in place.

B13 Wood Poles
Wood poles will be measured by the number of wood poles complete in place.

2545.5 BASIS OF PAYMENT
Payment for lighting systems, power systems, sign lighting systems, modify sign lighting systems, and conduit systems at the appropriate Contract price per system will be compensation in full for all costs of furnishing and installing the complete system as specified.

Payment for lighting units of each type at the Contract price per unit will be compensation in full for furnishing and installing the lighting unit as specified, including lamps, luminaire, ballast, pole base, pole and bracket, inline fuse, wiring between pole base and fixtures, luminaire wire holder, splice to power circuit, numbering of the light standard, and all other miscellaneous items required for a complete installation.

Payment for luminaires of each type and wattage at the Contract price per luminaire will be compensation in full for furnishing and installing the luminaire as specified, including the housing, reflector, glassware, lamp, ballast, mounting, mounting hardware, wiring, connections, numbering of the luminaire if not installed on a light standard, and all other miscellaneous items required for a complete installation.

Payment for light bases of each design at the Contract price per base will be compensation in full for furnishing and installing the light base as specified, including excavation, concrete, reinforcement, anchor rods, ground rod, ground lead, grounding connections, conduit elbows and bushings, and all other miscellaneous items required for a complete installation.

Payment for conduit of each kind and diameter at the Contract price per unit of measure will be compensation in full for furnishing and installing the conduit as specified, including the conduit, trenching, jacking, augering, conduit sleeves, couplings, weatherheads, elbows, bushings, sealing around the conduit where it enters a pull box, sealing conduit ends in concrete foundations and in pull boxes, grounding and bonding of conduit, backfilling and restoring sod, sidewalks, pavements, and the like, and all other miscellaneous items required for a complete installation of the conduit.
Payment for underground wire of each kind and size at the Contract price per unit of measure will be compensation in full for furnishing and installing the wire as specified, including the wire, pulling, splicing, terminals, making required connections, testing, and all other miscellaneous items required for complete installation of the wire.

Payment for armored cable of each kind and size at the Contract price per unit of measure will be compensation in full for furnishing and installing the cable as specified, including the cable, trenching, armor grounding, connections, fittings, fastenings, hangers, backfilling and surface restoration, testing, and all other miscellaneous items required for a complete installation of the cable.

Payment for overhead light cable of each kind and size at the Contract price per unit of measure will be compensation in full for furnishing and installing the cable as specified, including the cable, grounding of the messenger wire, connections, fastenings, hangars, testing, and all other miscellaneous items required for a complete installation of the cable.

Payment for service cabinet of each type at the Contract price per cabinet will be compensation in full for furnishing and installing the lighting service cabinet as specified, including panelboard enclosure, circuit breakers, switches, relays, photoelectric control, 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 all miscellaneous items required for a complete installation.

Payment for equipment pads of each type at the Contract price per equipment pad will be compensation in full for furnishing and installing the equipment pads as specified, including excavation, concrete, reinforcement, anchoring hardware within the pad, conduits within the pad, ground rods, grounding connections, mounting brackets, mounting hardware, surface restoration, and all other miscellaneous items required for a complete equipment pad installation.

Payment for junction boxes at the Contract price per box will be compensation in full for furnishing and installing the boxes as specified, including the junction box, bushings, covers, gaskets, and all appurtenances required for a complete installation.

Payment for handholes of each design at the Contract price per handhole will be compensation in full for furnishing and installing the handholes as specified, including the handhole, metal frame and cover, excavation, aggregate drain bed, backfilling, sealing conduit entrances, surface restoration, and all miscellaneous items required for a complete installation.
Payment for underpass lighting fixtures of each type and wattage at
the Contract price per unit will be compensation in full for furnishing
and installing the underpass lighting unit as specified, including the
housing, reflector, glassware, lamp, ballast, mounting, mounting
hardware, wiring, connections, numbering of the lighting fixtures, and
all other miscellaneous items required for a complete installation.

Payment of wood poles at the Contract price per wood pole will be
compensation in full for furnishing and installing wood poles as
specified, including class of wood pole, surface restoration, and all
other miscellaneous items required for a complete installation.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
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<tbody>
<tr>
<td>2545.501</td>
<td>Electric Light System</td>
<td>lump sum</td>
</tr>
<tr>
<td>2545.503</td>
<td>Electric Power System</td>
<td>lump sum</td>
</tr>
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<td>2545.505</td>
<td>Sign Lighting System - ____ Fixtures</td>
<td>system</td>
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<td>2545.506</td>
<td>Sign Lighting System Bridge</td>
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</tr>
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<td>Mounted - ____ Fixtures</td>
<td>system</td>
</tr>
<tr>
<td>2545.509</td>
<td>Conduit System</td>
<td>lump sum</td>
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<tr>
<td>2545.511</td>
<td>Lighting Unit, Type ____</td>
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</tr>
<tr>
<td>2545.513</td>
<td>Luminaire</td>
<td>each</td>
</tr>
<tr>
<td>2545.514</td>
<td>Underpass Lighting Fixture, Type ____</td>
<td>each</td>
</tr>
<tr>
<td>2545.515</td>
<td>Light Base, Design ____</td>
<td>each</td>
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<tr>
<td>2545.521</td>
<td>mm (inch) Rigid Steel Conduit</td>
<td>meter (linear foot)</td>
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<tr>
<td>2545.522</td>
<td>mm (inch) Intermediate Metal Conduit</td>
<td>meter (linear foot)</td>
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<tr>
<td>2545.523</td>
<td>mm (inch) Nonmetallic Conduit</td>
<td>meter (linear foot)</td>
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<td>2545.531</td>
<td>Underground Wire, ___ Conductor No. ___</td>
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<td>2545.533</td>
<td>Armored Cable, ___ Conductor No. ___</td>
<td>meter (linear foot)</td>
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<td>2545.537</td>
<td>Overhead Light Cable, ___ Conductor No. ___</td>
<td>meter (linear foot)</td>
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<tr>
<td>2545.541</td>
<td>Service Cabinet, ___ Type ____</td>
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<td>2545.542</td>
<td>m (__ foot) Wood Pole, Class ____</td>
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<td>2545.545</td>
<td>Equipment Pad</td>
<td>each</td>
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<tr>
<td>2545.551</td>
<td>Junction Box</td>
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<tr>
<td>2545.553</td>
<td>Handhole</td>
<td>each</td>
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</tbody>
</table>
Traffic Management System

2550.1 SCOPE

This work includes furnishing and installing Traffic Management System (TMS) components including communications system components, traffic control system components, surveillance system components and motorist information system components.

Communication system components include the cable plant (fiber optic cables, electronic/telephone cables), conduit, hand holes, splice cabinets, equipment cabinets, equipment shelters, fiber distribution equipment (splice panels, patch panels, and fiber distribution frame), fiber optic cable pulling vaults, fiber optic splice vaults, and outdoor fiber splice enclosures.

Traffic control system components include ramp meters, lane control signals, control cabinets, control cable and power cable.

Surveillance system components include CCTV system hardware and vehicle detection devices. CCTV system hardware includes the folding television standard (pole), lightning protection, video cable, control cable, power cable, pole-mounted control cabinet, and junction box. Vehicle detection devices include detector loops (preformed and saw cut), lead-in cable, and loop/lead splice encapsulator.

Motorist information system components include variable message signs and guide signs.

Electrical service is also provided for TMS components.

Each bidder shall submit a written statement with the bid. The statement shall comply with 1201 and shall identify all subcontractors.

Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>BD-4</td>
<td>TWP Distribution Pedestal (Splice Cabinet)</td>
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<tr>
<td>BD-7</td>
<td>TWP Distribution Pedestal (Splice Cabinet)</td>
</tr>
<tr>
<td>C-C</td>
<td>Center to Center</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Drafting</td>
</tr>
<tr>
<td>CMS</td>
<td>Changeable Message Sign</td>
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<tr>
<td>CTS</td>
<td>Clear To Send</td>
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<tr>
<td>DIP</td>
<td>Dual In-line Package</td>
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<td>DSX</td>
<td>Digital Signal Crossconnect</td>
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<td>EIA</td>
<td>Electronics Industry Association</td>
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<td>FC-PC</td>
<td>Fiber Connector</td>
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<td>FDF</td>
<td>Fiber Distribution Frame</td>
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<td>FNBT</td>
<td>Facing NSEW Bound Traffic</td>
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<td>FO</td>
<td>Fiberoptic</td>
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<td>HD</td>
<td>Heavy Duty</td>
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<tr>
<td>JB</td>
<td>Junction Box</td>
</tr>
<tr>
<td>LD</td>
<td>Light Duty</td>
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</tbody>
</table>
A  General

All materials, work methods, and equipment shall comply with the standards of the National Electrical Manufacturers Association; the Electronic Industries Association; the Underwriters Laboratory, Inc; the National Electrical Code; local codes and ordinances; these specifications; and with the requirements of the Contract.

Each component is designed for 10 years of industrial use. The Contractor warranties all materials and workmanship for 6 months after completion and acceptance of the Contract. The warranty period begins on the date all construction obligations of the Contractor are completed as documented by the final completion date on the change in construction status report.

During the warranty period the Contractor shall, at no cost to the Department, make repairs to all equipment and devices furnished and installed during the Project. The Engineer will notify the Contractor that a warranted item needs repair. The Contractor will acknowledge the notification within 24 hours and furnish the repair with 48 hours. The repair must satisfy the Engineer.

B  Foundations ................................................................. 3951

C  Conduit and Accessories ............................................. 3952
C1  Conduit .............................................................. 3952
C2  Handhole ............................................................. 3952
C3  Junction Box ....................................................... 3838
C4  Locator Ball ......................................................... 3952
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<td>C6</td>
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<td>Outdoor Fiber Splice Enclosure</td>
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<td>D11</td>
<td>Optical Pigtails and Patch Cord</td>
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<td>E</td>
<td><strong>Fiberoptic Cables</strong></td>
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<td>E1</td>
<td>Trunk Cables</td>
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<td>E2</td>
<td>MM Pig Tails</td>
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<td>MM Patch Cord</td>
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<td>Armored Pigtails</td>
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<td><strong>Cabinets</strong></td>
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<td>F1</td>
<td>334Z Series Cabinet</td>
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<td>F2</td>
<td>336 Series Cabinet</td>
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<td>F3</td>
<td>Shelter Cabinet</td>
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<td>480 mm (19 inch) EIA Cabinet</td>
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<td>F6</td>
<td>Splice Cabinet (BD-4 and BD-7)</td>
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<td><strong>Ramp Control Signal and Advance Flasher</strong></td>
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<td>Signal Pedestal</td>
<td>3832/Plan</td>
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<td>Signal Face</td>
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<td>H3</td>
<td>Lane Control Signal</td>
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<td>H4</td>
<td>Advance Flasher</td>
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<td>J</td>
<td><strong>Closed Circuit Television Assembly</strong></td>
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<td>K</td>
<td><strong>Changeable Message Sign</strong></td>
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<td>L</td>
<td><strong>Buried Cable Sign</strong></td>
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<td>M</td>
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<td>Fiber Distribution Frame</td>
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<td><strong>System Integration</strong></td>
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<td><strong>Loop Detector</strong></td>
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<td>Loop Detector</td>
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<tr>
<td>P2</td>
<td>Loop Detector Splice</td>
<td>3967</td>
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</tbody>
</table>
2550.3 CONSTRUCTION REQUIREMENTS

The Contractor shall do the work, or ensure that the work is completed as follows.

A  Cable Installation

The Contractor shall place conduit and direct buried cables in the same trench only when the cable is installed 900 mm (36 inches) deep, 150 mm (6 inches) of fill is added, and the conduit is installed on the fill.

Install direct burial cable by trenching or by plowing, as far from the paved portion of the roadway as practical. Install direct burial cable under bituminous or concrete surfaces in conduit.

Permanently secure 6 mm (¼ inch) character labels to each cable in each handhole and in each cabinet. The Department will provide the cable identifiers.

A1  Cable Installed In Conduit

The Contractor shall pull cable into conduit by hand or machine. Use a limiting device to prevent exceeding the pulling tension specified by the manufacturer.

The Contractor shall: apply a material compatible, industry accepted lubricant to the cables to reduce pulling tension; install each cable with enough slack to compensate for contraction; and permanently secure 6 mm (¼ inch) character labels to the cable(s) in each handhole and cabinet with the identification provided by the Department. Damaged cable is not acceptable. Remove abandoned cable(s) from each conduit. The operating TMS must remain active while the cables are removed.

A2  Direct Buried Cables

Trench or plow direct buried cables at a minimum of 900 mm (36 inches) deep. Locate the cable route as far from the paved portion of the roadway as practical.

Install an 80 mm (3.15 inches) wide, stretchable, orange, warning tape, between 460 mm (18 inches) above the cable and 300 mm (12 inches) below the surface. The tape bears the permanent legend "CAUTION: Mn/DOT CABLE BELOW".

Place buried cable warning signs, described in 3973, at less than 150 m (500 foot) intervals, offset 1 m (3 feet), along the cable route.

Install an orange-colored plastic resin sheath to enhance the visibility of buried cable signposts. The plastic resin sheath is:

(a) Triangular in shape, having a wall thickness of 2.03 ± 0.25 mm (0.08 ± 0.01 inches) with a 84.07 ± 0.51 mm (3.31 ± 0.02 inch) width of each side;

(b) Temperature stable from -40 °C (-40 °F) to 65 °C (150 °F);

(c) UV resistant;
A3 Copper Cable Installation

The Contractor has full and immediate responsibility to repair every existing TMS cable damaged by Contractor activity. The repair includes everything needed for a complete repair. The quality of the repair must satisfy the project Engineer.

(a) Replace damaged radio frequency (RF) transmission cable with new cable between the existing terminations. Splices in RF transmission cable or telephone cable are not allowed between existing terminations. Below ground splices are never allowed.

(b) Terminate RF transmission cables (COAX and telephone cables) No. 19 in above ground cabinets to amplifiers, or with connectors designed for use with that specific cable.

(c) Install the cables inside CCTV standards to the cable supports.

(d) Test power cables in accordance with 2545.

(e) Splice telephone cables in BD-4 and BD-7 cabinets with a weather resistant, crimp connector designed to splice three No. 19 conductors.

A4 Fiberoptic Cable Installation

The Contractor shall submit a plan detailing each fiberoptic cable installation, the installation method, and the calculated pulling tension. The cable is taken up at intermediate pulling points with a device made for that purpose. The cable pulls are continuous and steady between pull points.

The Contractor shall:

(a) Accomplish direction changes of fiberoptic cable before entering a handhole or other conduit access point. Do not change the direction of fiberoptic cables in handholes.

(b) Install fiberoptic cable in split conduit through the handholes. Extend the conduit 50 mm (2 inches) beyond the wall of each handhole and seal the conduit to the handhole with duct seal.

(c) Splice optical fibers only in outdoor fiber splice enclosures and fiber splice panels. Splices between cabinets and splice vaults are not allowed.

(d) Continuously monitor the tensile load on the cable. The fiberoptic cable route is pre-ripped to prevent harm to plowed-in cable.

(e) Place 150 mm (6 inches) of aggregate that complies with 3149.2G, beneath cables placed in a trench before backfilling the trench. The backfilling shall comply with 2451.

(f) Provide a smooth transition from one elevation to the other when installing fiberoptic cable in existing conduits, that are in existing
handholes. This may require re-installing existing conduits and is incidental to the cable installation.

(g) Label the destination of each trunk cable onto the cable in each vault. The Contractor shall label the fiberoptic patchcords and pigtails at terminations with their source, destination, and cable function. The labels are permanent and have 6 mm (¼ inch) characters.

B Cabinet Installation
B1 Cabinet Labels
Label each control cabinet with permanent 40 mm (1.6 inch) high characters, using the cabinet name provided by the Department.

B2 Two Days Notice
The Contractor shall notify the TMC Operations Supervisor 2 days before removing an active cabinet from service.

B3 Secure and Seal
Secure the cabinets to the concrete foundation with anchor rods, nuts and washers.

B4 Conduit
Install conduits at the center of the cabinet base and 80 mm (3.15 inches) above the foundation.

C Changeable Message Signs (CMS)
The changeable message sign structures and mounting hardware shall comply with 2564.

The electrical equipment located on the sign structure shall not protrude over the walkway, shall not interfere with moving the walkway safety rail or with opening the sign door.

The Contractor installs 120/240 VAC to the sign within 1 week after installation to enable operating the ventilation units.

D Lane Control Signals (LCS)
Make the clearance between the bottom of the lane control signal and the pavement at least 5.3 m (17 feet). The mounting hardware complies with 2564.

E Restore Shrubs and Bushes
The Contractor shall restore all shrubs and bushes damaged by Contractor activities, in accordance with 1712.

F Handholes (HH)
Make all openings in the side of handholes water tight with a material compatible compound.

Cast the Light Duty metal cover frame and the heavy duty metal cover frame in concrete.
2550.3

Fill Handholes abandoned in sodded areas, with tamped granular material that complies with 3149.2E. Salvage useable handhole covers from abandoned Handholes, to Department’s Electrical Services Section.

Secure the HH ball to an eye bolt with a 6 mm (¼ inch) wide wire wrap. The HH ball is located within 0.3 m (1 foot) of the HH cover.

G  Ramp Control Signal (RCS)
Cover each installed RCS and keep it covered until the beginning of the system operational test.

H  Conduit
Conduit installation complies with 2565.3D and the following additions.

H1  Conduit on Bridges
Conceal conduit on bridges behind the facia girder, in a location not readily visible to motorists. Install deflecting expansion joints, as per NEC requirements.

H2  Factory Bends
Factory bends in 76 mm (3 inches) and larger conduit are greater than 900 mm (36 inch) radius.

H3  Foundation Locations
The Contract foundation locations are approximate. The Engineer stakes the actual locations, outside the clear zone, as far from the paved portion of the roadways as practical.

I  Blank

J  Bonding and Grounding ........................................2565.3J

J1  Insulated Cable
Insulated cable may be used instead of bare ground cable if 300 mm (12 inches) of the cable is wrapped with green electrical tape in the cabinet and in each handhole through which the cable passes.

J2  Shield Continuity
Maintain the electrical continuity of the cable shields while terminating and splicing cables. The shield bonding conforms to REA splicing Standard PC-2, Section 3.3. The bonding connectors comply with REA Specification PE-33 for Cable Shield Connectors. Bond and ground the cable sheaths to a 4.6 m (15 feet) long x 16 mm (5/8 inch) diameter ground rod.

K  Loop Detector Installation
Loop Detector Installation complies with the Contract detail and these requirements.

K1  Loop Detector Conductors
Loop Detector Conductors end in the near handhole. Splice the conductors to the lead-in cable with a soldered butt splice. Wrap the
splice with one wrap of electrical tape before placing it into the splice encapsulator device.

K2 Detector Test
Test all detectors in the presence of a Department inspector and furnish all items required for the test. Use copies of the Loop Detector Test Report, detailed in the Contract, when recording the Loop Detector values.

L Fiberoptic System
The system integrator proves the fiberoptic system functions as specified before the operations test begins.

L1 Blank
L2 Blank
L3 Ensure that each outdoor fiber splice enclosure:
(a) Is bonded to the cable armor by a cable clamp;
(b) Is bonded to the closest ground rod by a 1/C No. 6 ground wire and clamp;
(c) Has non-oxidizing coating on all connections.

L4 Fiber Splice Panel
Mount the fiber splice panel where indicated in the Contract. Secure the fiberoptic cable(s) and pigtail(s) to the panel. Bond the shields to the splice panel ground lug.

L5 Fiberoptic Splice Vault
Place the fiberoptic splice vault on 300 mm (12 inches) of filter aggregate complying with 3149.2H. Seal and flash test the vault as per the manufacturer recommendations.
Coil 18 m (60 feet) of cable in each vault containing splices. This allows moving the splice enclosure to the splicing vehicle.

L6 Optical Link Attenuation Test
The test equipment includes a light source emitting light at the required wavelength and an optical power meter. Calibrate the light source and the power meter at the beginning of each day of testing and after every 20 measurements. Design the light source and power meter to couple to an optical fiber through an ST or FC-PC connector, or through a bare fiber adapter to fibers that have no connector.

To calculate the attenuation, subtract the difference in the received power from the light source before and after measurement through the link.

Record these values during the Optical Link Attenuation tests:
(a) The length of the link.
(b) The attenuation of each splice (0.3 dB maximum).
(c) The mean attenuation of each splice in the link.
(d) The attenuation of each MM link at 1300 nm.
(e) The attenuation of each SM link at 1550 nm.
Label optical links with the identifier, the source, and the destination of each cable.

**CCTV Assembly Installation**

Do not degrade the existing CCTV signals during CCTV Assembly installation.

Orient the environmental housing lightning protection away from the road at approximately 90 degrees to centerline. Install the horizontal lockout for the pan and tilt unit over the lightning rod support and set the vertical lockout to 30 degrees above horizontal. The housing mounting bolts do not hit the pan and tilt unit cover in any tilt position.

**METHOD OF MEASUREMENT**

The Engineer will only measure items for payment that are completed and accepted.

**A Complete Systems**

Measure ________ system separately by the number of systems installed.

**B Traffic Management System Components**

The Engineer will measure the various system components by the units of measure listed in the Contract.

**BASIS OF PAYMENT**

The Department will:

(a) Retain 10 percent of the amounts payable on each partial estimate, in accord with 1906.

(b) Pay for material on hand.

(c) Pay the remaining percentage retained upon completion of the work to the Engineer's satisfaction.

The Department will make payment according to the following:

Payment for _______ system, at the Contract price, is compensation in full for all costs incidental to furnishing and installing the system specified, complete in place.

Payment for system integration at the Contract price, is full compensation for all costs incidental to incorporating the work and material of the Contract, into the existing system. Payment is based on the percent of the Contract completed, as indicated on the project progress chart. When the chart indicates 10 percent of the Contract has been completed, 10 percent of the systems integration item bid price is paid.

Payment for _______ foundation, at the appropriate Contract price per unit of measure, includes all work materials and costs involved in furnishing and installing the foundation specified.
When the cabinet foundation is part of a larger pad, the cabinet foundation includes the concrete and conduit under and adjacent to the cabinet.

When the service foundation is part of a larger pad, the service foundation includes the concrete, conduit and conductors under and adjacent to the service equipment.

Payment for each of the pay items at the appropriate Contract price per unit, is compensation in full for all costs incidental to furnishing and installing that item.

Payment for TMS is made on the basis of this schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
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<tbody>
<tr>
<td>2550.501</td>
<td>System</td>
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<tr>
<td>2550.509</td>
<td>Systems Integration</td>
<td>lump sum</td>
</tr>
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<td>Foundation</td>
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<td>2550.513</td>
<td>Junction Box</td>
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<td>2550.514</td>
<td>Fiberoptic Splice Vault</td>
<td>each</td>
</tr>
<tr>
<td>2550.515</td>
<td>Outdoor Fiber Splice Enclosure</td>
<td>each</td>
</tr>
<tr>
<td>2550.516</td>
<td>Buried Cable Sign</td>
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</tr>
<tr>
<td>2550.519</td>
<td>Truck Pad</td>
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<td>2550.521</td>
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<td>(\text{mm (in)}) Non metallic Conduit</td>
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<tr>
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<td>(\text{mm (in)}) Pushed Conduit</td>
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<td>2550.532</td>
<td>Cable Conductor No.</td>
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<td>Fiberoptic Trunk Cable SM</td>
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<td>Armoured Fiberoptic Pigtail</td>
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<td>(\text{m (ft)} \times \text{m (ft)}) Loop Detector, Design</td>
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<td>2550.542</td>
<td>Loop Detector Splice</td>
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<td>2550.551</td>
<td>Ramp Control Signal, Design</td>
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<td>2550.552</td>
<td>Flasher Signal</td>
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<td>2550.553</td>
<td>Lane Control Signal</td>
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<tr>
<td>2550.561</td>
<td>Closed Circuit Television Assembly</td>
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<tr>
<td>2550.562</td>
<td>Changeable Message Sign, Design</td>
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<td>2550.571</td>
<td>Cabinet</td>
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<td>Service</td>
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<tr>
<td>2550.581</td>
<td>Loop Detector Module</td>
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</tr>
</tbody>
</table>
2554

Traffic Barriers

2554.1 DESCRIPTION
This work shall consist of the installation of guardrail, barrier, end treatments, barrier fencing, permanent barricades, and similar devices that protect or prohibit traffic at the locations indicated in the Plans or as directed by the Engineer. It shall also include the installation of posts, guide posts, and the resetting of existing barriers.

2554.2 MATERIALS

A  Metal Posts
A1  Flanged Channel Sign Post ............................................. 3401
A2  Structural Metal Posts ............................................. 3406
B  Blank
C  Wood Posts .................................................................. 3412
D  Timber Plank, S4S ..................................................... 3426
E  Wire Rope ................................................................. 3381
F  Steel Beams
F1  Steel Plate Beams ......................................................... 3382
F2  Rub Rail ................................................................. 3306
G  Hardware and Fittings ............................................. 3381, 3382
H  Paints, as specified in the Contract
I  Blank
J  Concrete ...................................................................... 2461

Concrete for anchor blocks and bearing blocks shall develop a compressive strength of not less than 19 MPa (2750 psi) at 14 days. No air entrainment will be required.

K  Anchorage Rods ......................................................... 3385

2554.3 CONSTRUCTION REQUIREMENTS

A  Excavation and Foundations
Post holes may be dug by hand or mechanical methods. The depth of each excavation shall be that required to place the rail elements at the specified height above the ground surface and meet the requirements for post top and side alignment. Anchorage excavations shall be made in a manner that will provide bearing on firm, undisturbed earth at the proper depth.

The foundation of line, guide, and permanent barricade posts shall be the natural soil at the bottom of the excavation, tamped to provide firm bearing. End posts and posts at intermediate guardrail anchorages shall be founded on concrete bearing blocks of the dimensions shown in the Plans, which shall be installed firmly on a properly prepared foundation.
B Installing Posts

Posts of the required size and type shall be installed at the intervals indicated in the Plans and to the staked lines. Post tops shall be within 10 mm (3/8 inch) of the required elevation and grade.

Type A guide posts shall be 140 mm (5 ½ inch) nominal diameter (120 to 160 mm (4 ¾ to 6 ¼ inch) by 1.8 m (6 feet) long, treated wood conforming to 3412, and installed with the top of the post 760 mm (30 inches) above the shoulder P.I. elevation, unless otherwise indicated.

Type B guide posts (culvert markers) shall be flanged channel steel posts with a mass of 3.0 kg/m (2 pounds per foot) of length conforming to 3401 and shall be installed as shown in the Plans.

Mechanical driving of posts, where required or permitted, shall be accomplished by means that will give the necessary accuracy of placement without damage.

Required backfill materials shall be installed and consolidated thoroughly in a manner that will maintain the post plumb and in the correct position.

C Installing Barriers

Traffic barriers of the required design shall be installed as shown in the Plans. Proprietary barrier items shall be installed per manufacturers specifications.

Holes drilled in wood posts shall be the same diameter as the bolts or fittings to be accommodated. In metal posts, drilled holes for bolts or other fittings shall have a diameter no more than 1.6 mm (1/16 inch) greater than that of the bolt or fitting. Field cuts in treated wood shall be given two applications of copper naphthenate or another compatible preservative material meeting AWPA Standard M4, with a minimum time lapse of 2 hours between applications. Field bored holes may be left untreated.

Bolt length shall not be any longer than necessary to allow full nut contact after tightening at the overall nominal depth of the assembled parts, plus reasonable allowance for oversize components. Wherever vehicle contact is possible, bolt end projections beyond the rail contact face shall be avoided, or the excess length shall be cut off within 15 mm (9/16 inch) of the nut head.

C1 Wire Rope Installations

Except where cable clips are permitted, free ends of wire rope shall be wire wrapped to prevent unraveling.

At intermediate anchorages, the cables shall be properly spaced to prevent contact between the separate cables.
C2  Steel Plate Beam Barriers
When offset blocks are required, the blocks shall be of treated timber or other material on the approved list on file with the Materials Engineer. The Contractor shall treat field cuts on treated wood according to 2554.3C. Rail and end sections shall overlap the adjacent section in the direction of traffic. End treatments shall be installed in accordance with the details as shown in the Plans and as staked in the field. Proprietary end treatments shall be installed per manufacturer's specifications. Installation of the required guardrail end treatments shall be done concurrently with the installation of the guardrail.

C3  Chain Link Fence Barriers
Installation shall be in accordance with the Plans. Tension on the fence shall be that which will allow no visible sag of the fence between supports.

C4  Permanent Barricades
Permanent barricades shall be fabricated as shown in the Plans.

D  Painting and Field Repairs
Steel that is not coated according to 3406 and is above the ground shall be given two coats of paint as shown in the Plans and in accordance with the applicable provisions of 2479. The Contractor shall make other field repairs according to the manufacturer's recommendations.

E  Disposal of Surplus Excavated Material
All surplus excavated material shall be disposed of by the Contractor, at no expense to the Department, and in a manner satisfactory to the Engineer.

2554.4 METHOD OF MEASUREMENT
A  Traffic Barriers
Traffic barriers of each design designation will be measured by length, to the nearest 0.3 m (1 foot), between the centers of end posts in each continuous section, with no deduction for expansion assemblies.

B  Permanent Barricades
Permanent Barricades will be measured by length, to the nearest 0.3 m (1 foot), from end to end of the planks of each unit.

C  Guide Posts
Guide posts will be measured by the number of posts placed. Each type, as indicated in the Plans, will be measured separately.

D  Anchorage Assemblies
Anchorage assemblies will be measured by the number of assemblies installed. Each assembly shall consist of the anchor and the fittings required to connect it to the end post.
### End Treatments

End treatments will be measured by the number of units of each type installed complete-in-place.

#### 2554.5 BASIS OF PAYMENT

Payment for the installation of traffic barriers at the Contract price per unit of measure for each design specified will be compensation in full for furnishing all required materials and installing the barrier as specified, except that anchorage assemblies will be paid for as separate items, complete as shown in the Plans.

Payment for the installation of end treatments of each type at the Contract price per unit of measure will be compensation in full for furnishing and installing steel plate beam rail, all necessary posts, appropriate anchorage, offset blocks, hardware, and required materials as specified.

Payment for the installation of guide posts at the Contract price per unit of measure for each type specified will be compensation in full for all costs of furnishing and installing the posts as specified.

Payment for the installation of traffic barriers or guide posts at the Contract price per unit of measure will be compensation in full for all costs of installing the work as specified, using materials furnished by the Department.

Payment for permanent barricades at the Contract price per unit of measure will be compensation in full for all costs of furnishing the required materials and installing the barricades complete-in-place as specified.

Payment for traffic barriers and barricades will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2554.501</td>
<td>Traffic Barrier, Design ___</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2554.505</td>
<td>Permanent Barricades</td>
<td>meter (linear foot)</td>
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<td>2554.509</td>
<td>Guide Post, Type ___</td>
<td>each</td>
</tr>
<tr>
<td>2554.511</td>
<td>Install Traffic Barrier, Design ___</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2554.515</td>
<td>Install Guide Post, Type ___</td>
<td>each</td>
</tr>
<tr>
<td>2554.521</td>
<td>Anchorage Assembly</td>
<td>each</td>
</tr>
<tr>
<td>2554.523</td>
<td>End Treatment - ___</td>
<td>each</td>
</tr>
</tbody>
</table>
2557

Fencing

2557.1 DESCRIPTION

This work consists of constructing fences.

2557.2 MATERIALS

If the type of material for metal products is not specified in the Contract, the Contractor may select the type of material. The Contractor shall use the same type of metal fence components on the entire Project.

All tubular metal posts shall be capped.

When coated metal posts are indicated in the Contract, the Contractor shall use the same coating on posts, post supports, rails, gate frames, expansion sleeves, and other hardware items or fittings. The Contractor shall use:
(a) Zinc coating with zinc coated fence fabric.
(b) Aluminum or zinc coating with aluminum coated steel fabric.
(c) Vinyl coating with vinyl coated fence fabric. The vinyl coated posts, hardware, and fabric shall be black with a low to medium gloss, unless otherwise stated.

The Contractor shall use aluminum alloy posts, rails, frames, and other hardware items with aluminum alloy fence fabric.

A  Fence Wire ................................................................. 3376
B  Fence Gates ............................................................... 3379
C  Fence Posts
C1  Rolled Steel Posts ....................................................... 3403
C2  Structural Metal Posts ............................................... 3406
C3  Blank
C4  Treated Wood Posts .................................................. 3413
D  Hardware and Fittings ............................................... 3406
E  Concrete

Concrete shall meet the requirements for Grade B, Type 3 concrete as specified in 2461.

2557.3 CONSTRUCTION REQUIREMENTS

A  General

All brush, trees, and other obstructions that interfere with construction of the fence shall be removed and disposed of according to the applicable provisions of 1405, 2101, and 2104.3C. A smooth ground profile shall be provided at the fence line. The work necessary to accomplish these purposes shall, unless the Contract specifically provides payment for any part or all of the work, be incidental to fence construction and no direct compensation will be made therefor.

In general, the bottom of the fence shall follow the contour of the ground. At small stream crossings, drainage ditches, and other
locations where it is impractical to conform the fence to the ground contour the fence shall span the depression and, unless the Plans or the Engineer require otherwise, the space below the bottom of the fence shall be closed with extra fabric or wire as the Engineer directs. If extra length posts are needed at such locations, the Contractor shall furnish and install the longer posts in lieu of the standard length posts, together with any intermediate posts, stakes, braces, extra fabric, or wires as may be required. All such work and materials will be incidental to fence construction and no direct compensation will be made therefore except where the Contract specifically provides payment for any part or all of such work under separate items.

The Contractor shall make field repairs according to the manufacturer’s recommendations.

B  Installing Posts, Rails and Braces
B1  General

Posts shall be set plumb except at locations where the Engineer deems it more practical for the posts to be set perpendicular to the slope of the ground.

Corner posts, pull posts, end posts, and gate posts shall be installed at locations shown in the Plans or designated by the Engineer. In general, corner post assemblies will be required at all horizontal angle points where the deflection exceeds 20 degrees. Where practical, pull posts shall be spaced to provide a braced post at all points where:
(a) The vertical alignment deflects by more than 20 degrees.
(b) The post anchorage is necessary to counteract wire uplift.
(c) An abrupt grade change on short runs cannot be avoided by shaping the ground to a uniform contour.

When fence posts are driven, the post top shall be protected against damage. All posts that are damaged during installation shall be removed and replaced.

When posts are placed on concrete walls, curbs or other concrete structures, methods and materials used for anchoring posts shall be as specified in the Plans.

If solid rock is encountered above the required elevation of the bottom of a post, the post shall be set at least 300 mm (12 inches) into the rock or with its bottom at the required elevation, whichever requires the lesser excavation into the rock. In such cases, the post shall be cut off at the bottom to provide the required height above the ground surface. Holes in rock shall provide a minimum clearance of 25 mm (1 inch) around the post, and shall be filled around the post with grout consisting of one part Portland cement, 0.1 part hydrated lime (if desired) and 2 parts mortar sand, with sufficient water to give the proper consistency.
Concrete for setting posts and braces shall be thoroughly compacted around the posts and allowed to cure for not less than 3 days before the fence wire is installed.

The concrete may be poured into prebored holes without forming, provided the earth is firm enough to permit satisfactory placement and care is taken to prevent contamination of the concrete during placement.

Except as otherwise required for posts and braces set in rock or concrete, the annular space around all posts set in prebored holes shall be backfilled in layers using selected material from the excavation (unless special material is provided), with each layer thoroughly compacted to produce a rigid post setting.

All surplus excavated material shall be disposed of in low areas along the fence line, or as directed by the Engineer, and the adjacent area shall be finished neatly.

B2  Metal Post Installations

All posts for chain-link fabric fencing shall be set in concrete as provided for in the Plans, except that line posts may be driven provided that posts of sufficient extra length are furnished to allow drive setting at least 1.2 m (4 feet) into the ground.

Rolled steel line posts shall be driven.

Rolled steel end posts, corner posts and pull posts (together with the required braces) may be provided with anchor plates and brace plates and set in dug holes, or the anchor and brace plates may be omitted and the posts and braces set in concrete. All excavations around the posts and braces shall be backfilled, using the excavated material, and the backfill shall be thoroughly compacted.

Rolled steel gate posts shall be set in concrete.

At those locations where the Plans require the use of metal post extensions, the Contractor shall furnish and install posts of such extra length as may be directed by the Engineer. Where post splicing is necessary, the pipe ends at the splice shall be threaded and joined, employing a standard thread with coupling of the same material. Splices in the exposed upper portion of the post shall be avoided where practicable. A suitable plug shall be provided in the bottom end of each extended post.

B3  Wood Post Installations

Wood posts may be driven or set in prebored holes. In either case the larger end of the post shall be placed in the ground. When posts are driven, the end placed in the ground may be cut square or pointed. Except for holes in rock, the diameter of post holes shall be sufficiently large to provide a clearance of at least 75 mm (3 inches) around the post so as to permit proper backfill and compaction.
Wood braces shall conform to 3413, so far as they are applicable. The diameters of wood braces as shown in the Plans shall be construed to be the minimum permissible diameter at the small end, but the diameter at the small end shall be no greater than the top diameter of the smaller adjacent post.

C Installing Fence Wire

All fence wire shall be installed and pulled tight in accordance with standard practice and the recommendations of the manufacturer.

C1 Chain Link Fabric

Chain link fabric shall be placed in continuous runs between corner, end, and gate posts. The fabric shall be installed on the side of line posts that face away from the main road; except when the Engineer directs otherwise because of snow plowing or other concerns. Impacts from snow plowing should stress the posts rather than the fasteners.

At all ends of chain link fabric, a stretcher bar shall be threaded through the fabric loops and fastened to the posts by means of clamps as shown in the Plans.

Splices in the chain link fabric shall be made by weaving in a pre-bent wire of the same kind as that in the fabric.

C2 Barbed Wire and Woven Wire

Unless otherwise directed by the Engineer, barbed wire and woven wire to be installed on tangent alignment or on curves of 1 degree or less shall be placed on the side of line posts that faces away from the main roadbed. Where the fence is placed on horizontal curves exceeding 1 degree, the wire shall be placed on the side of line posts that is on the outside of the curve. At all corners the post shall be offset to the inside so that the wire will bear against the post.

Fence wire shall be fastened to end, corner, gate, or pull posts before being fastened to intermediate line posts. Woven wire shall be stretched until all longitudinal wires are taut and approximately 30 percent of the factory fabricated fence crimp (tension curves) has been removed.

At all major vertical grade changes, woven wire shall be cut and spliced at the pull post as may be necessary to obtain and maintain uniform tension in all horizontal wires. To the extent feasible, tension curves may be increased in number or depth, by use of a wire crimping tool, so as to accomplish the same objective.

Wires shall be fastened to metal line posts by means of approved wire clips or clamps and to wood posts by means of galvanized staples. Where the wire is looped around end, corner, or pull posts, the wire shall be wrapped around itself not less than 4 complete turns.

Wire staples of the U-shaped type shall be at least 45 mm (1 ½ inches) long when used in pine posts and at least 50 mm
L-shaped staples (with serrated, barbed or ring shanks) may be of a length not less than 38 mm (1 ½ inches). U-shaped staples shall be driven diagonally across the wood grain so that both points do not enter between the same grain. Staples shall be sloped slightly upward, against the pull of the wire, in depressions where wire up-lift occurs, and shall be sloped slightly downward on level ground and over knolls. Wires shall be stapled tightly at corner, end, and pull posts, but on line posts the staples shall not be driven so tightly as to prevent movement of the wire. In no case shall staples be driven so tight as to damage the wire.

Splicing of wire at locations between posts shall be accomplished with approved type of splicing sleeve or by wrapping each wire end around the other wire a sufficient number of turns to ensure a lasting connection. From 4 to 6 turns will be required, depending on the splicing method used, the type of wire, and the quality of workmanship. The Engineer will require that a splicing tool be used to obtain uniformly tight wraps where hand wrapping is not satisfactory.

Where splicing sleeves are used on woven wire, the horizontal distance between vertical wires shall be maintained approximately the same as that in the wire as fabricated. When woven wire is spliced by the wrap method, the two end stay wires shall abut each other and be enclosed within the wrap.

D  Installing Gates

Where the Plans require gates, each gate shall be equipped with a "padlock keeper" of a design that will permit locking the gate with a padlock. The padlock will be furnished by the Department.

E  Electrical Grounds

Electrical grounds consisting of copper coated steel rods having a nominal diameter of 15 mm (5/8 inch) or more and a minimum length of 2.4 m (8 feet) shall be installed along each fence line at the staked locations.

Ground rods shall be driven to an elevation approximately flush with the ground surface, at points directly below or adjacent to the fence wire, and each ground rod shall be connected to the fence with a solid No. 6 copper wire. The ground wire shall be attached to the ground rod and to the fence wires with approved type metal clamps in such a manner that each longitudinal fence wire is electrically grounded. No more than one connection will be required on woven wire and chain link fabric, that being near the bottom at each ground rod.

Electrical grounds are to be installed at locations established in accordance with the following requirements:
An electrical ground shall be installed on each fence line at the approximate point of crossing of each electric power line, and two grounds shall be installed at each pedestrian gate, one on each side of the gate opening and as close to the gate post as practicable.

Additional grounds shall be installed on each fence line as necessary to maintain a desired maximum spacing between grounds of 450 m (1500 feet) on fences where metal posts are used and 300 m (1000 feet) on fences where wood posts are used.

A minimum of one electrical ground shall be installed on each separate section of fence. A separate section of fence shall be defined as a run on which the electrical continuity has not been broken by gates, terminal posts, etc.

On each separate section of fence, the spacing of electrical grounds shall be as uniform as practicable and such that a ground will be located within a distance from each end not greater than one-half the desired maximum spacing interval.

### 2557.4 METHOD OF MEASUREMENT

#### A  Wire Fence
Fence of each design will be measured separately, by length along the bottom of the fence, from center to center of end posts, exclusive of the lengths of gates as measured between gate posts.

#### B  Brace Assemblies
Brace assemblies of each kind (wood or metal) will be measured separately by the number of each kind constructed complete-in-place, regardless of length, design, or anchorage. A brace assembly shall consist of a single wood or metal brace, installed as either a leg brace or as a horizontal brace between two consecutive posts (brace assemblies for chain link fences shall consist of two brace bars and a truss rod), together with the required brace plate or concrete anchor, post anchorages, and guy wires or truss rods.

#### C  Electrical Grounds
Measurement will be by the number of ground rods and connections furnished and installed complete-in-place.

#### D  Gates
Measurement will be by the number of individual units constructed complete-in-place.

#### E  Metal Post Extensions
Metal post extensions will be measured by length of extensions, determined as the difference between the standard driven post length and the actual post length as installed.

### 2557.5 BASIS OF PAYMENT
Payment for fence of each design at the Contract price per unit of measure will be compensation in full for all costs of the installation and...
materials except those that the Contract specifically designates as having been included for payment under separate items.

Payment for brace assemblies of each kind at the Contract price per unit of measure will be compensation in full for furnishing and installing the braces as specified, including the required brace plate or concrete anchor, post anchorages, and all guy wires or truss rods.

Payment for electrical grounds at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing the ground rods as specified, complete with ground wire and connectors.

Payment for gates of each kind at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing the complete gate assembly as specified.

Payment for furnishing and installing metal fence post extensions as directed by the Engineer, at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing the post extensions as specified.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2557.501</td>
<td>Wire Fence, Design ___</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2557.516</td>
<td>Pedestrian Gate</td>
<td>each</td>
</tr>
<tr>
<td>2557.517</td>
<td>Vehicular Gate</td>
<td>each</td>
</tr>
<tr>
<td>2557.519</td>
<td>Metal Post Extensions</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2557.521</td>
<td>Wood Brace Assembly</td>
<td>each</td>
</tr>
<tr>
<td>2557.522</td>
<td>Metal Brace Assembly</td>
<td>each</td>
</tr>
<tr>
<td>2557.523</td>
<td>Metal Brace Assembly (Chain Link Fence)</td>
<td>each</td>
</tr>
<tr>
<td>2557.527</td>
<td>Electrical Ground</td>
<td>each</td>
</tr>
</tbody>
</table>

2560
Highway-Railroad Grade Crossing Signals

2560.1 DESCRIPTION
This work shall consist of furnishing materials for and installing electrically operated highway-railroad grade crossing signals of the flashing light type, together with crossing gates and cantilever type signals if so required by the Contract.

2560.2 MATERIALS
A General Requirements
All materials and signal parts furnished by the Contractor shall meet the applicable requirements of the Association of American Railroads, the Railroad on whose line the signal will be installed, and the Rules and Specifications for Signs and Signals for Installations at Highway-Railroad Crossings contained within Chapter 8830 of
Minnesota Rules, as last issued prior to the date of advertisement for
bids.
A1 Manufacturer's Drawings, Details, Catalog References and
Specifications
The bidder shall furnish, with the Proposal, manufacturer's
drawings, catalog references, and specifications for any and all
materials and apparatus that may be required to furnish but that are not
covered by these Specifications or the Plans. Materials and apparatus
covered by such drawings, catalog references or specifications shall not
be used unless approved, in writing, by the Engineer. No change or
changes shall be made in any approved manufacturer's drawings
without the written consent of the Engineer.
After award of the Contract, the Contractor shall furnish the
Engineer 5 sets of all such drawings as have
been approved. Any work
done before the approval of these drawings will be done at the
Contractor's own risk and expense. The Contractor shall not substitute
any materials or apparatus for those specified herein without the written
approval of the Engineer.
A2 Tests
The Contractor shall make, at the Contractor's expense, such tests as
may be necessary to demonstrate to the satisfaction of the Department
and the Railroad Company that the materials, apparatus and installation
will meet the requirements of the Specifications.
The Contractor shall provide, without separate compensation
therefore, such instruments, apparatus, tools, and labor as may be
necessary to make the required tests. The instruments and apparatus
shall remain the property of the Contractor.

2560.3 CONSTRUCTION REQUIREMENTS
A General
The location for the signal as shown in the Plans shall be considered
as being approximate only. The exact location will be determined at the
site, and shall be such that the clearance distances for the several units
will conform to the rules and regulations established therefore.
A1 Inspection of Material, Apparatus and Workmanship
The Railroad Company on whose line the signal system is to be
installed, although not a party to the Contract, shall be permitted,
through its accredited representative, to inspect any or all of the
materials, the apparatus and workmanship of installation, at any time
during the construction or installation.
A2 Work by Railroad Company
Under a special agreement with the Department, the Railroad
Company will, without cost to the Contractor, perform so much of the
work described hereafter (in paragraphs A2a to A2f inclusive) as is
specified in the Special Provisions and will furnish all labor and tools required therefore. However, the Contractor shall furnish all materials and apparatus shown in the Plans as being necessary to complete such work.

A2a Place switch rod insulation and insulated joints in the tracks, as shown in the Plans.

A2b Make such rearrangements of existing wiring systems as may become necessary because of the signal installation.

A2c Make such relocation of any existing signal apparatus or device as may become necessary because of the signal installation, as shown in the Plans.

A2d Make all connections between the new signal installation and any existing signal system.

A2e Remove and replace crossings if necessary for bonding the rails or installing underground cables.

A2f Insulate metal crossings where necessary because of the signal installation.


Any information concerning traffic movements on the Railroad that the Contractor may need will be furnished at the Contractor's request by the Railroad Company's Dispatcher.

During construction operations when it becomes necessary for the Contractor to perform work that may interfere with traffic on the Railroad, the Contractor shall notify the Railroad Company through its Signal Engineer, Superintendent of Signals, or other authorized official, at least 48 hours in advance of starting such work. Such work shall not be started, however, until authorized by the Railroad Company.

The Contractor shall not place a colored glass signal light so that it will face an approaching train. Open flame torches shall be used in lieu of flashing lights in all places where such lights might confuse the crews of approaching trains.

Any or all openings or uncompleted work that may, after working hours, cause a hazard or unnecessary inconvenience to traffic, shall be suitably and substantially covered by the Contractor to protect traffic on either the Railroad or the highway.

The Contractor shall properly cover the signal or screen it from view, immediately after it is mounted, and shall maintain this covering or screening until authority is given to place the installation in service.

A4 Final Inspection of Installation

The final inspection, as provided for in 1516, shall be made in the company of the Department's Director of Railroad Administration and the Signal Engineer of the Railroad Company or their authorized
representatives. Final acceptance will not be made until the Contractor has complied with 2560.3A5.

A5 Placing in Service

The Contractor shall place the system in service when authorized to do so by the Engineer, and it shall be placed in charge of competent attendants for a period of not less than 24 hours after being placed in service.

2560.4 METHOD OF MEASUREMENT

The signal system (including crossing gates if required by the Contract) and the advance warning signs will be measured as an integral unit complete in place.

2560.5 BASIS OF PAYMENT

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2560.501</td>
<td>Highway-Railroad Grade Crossing Signal System</td>
<td>lump sum</td>
</tr>
</tbody>
</table>

2564 Traffic Signs and Devices

2564.1 DESCRIPTION

This work includes the fabrication, packaging, and delivery or installation of traffic signs and devices.

2564.2 MATERIALS

A General

Electrical materials and equipment shall conform to 2545.2. Where a particular material (fixture, device, or component) is specified, an alternate material, equal to or better than the material specified, may be used provided the Contractor obtains the written approval of the Engineer before incorporating such alternate material into the work.

B Structural Steel

All structural steel posts and trusses shall be fabricated from steel conforming to 3306, unless otherwise specified in the Contract.

Structural bolts, nuts, and washers shall conform to 3391.2B and 3392.

Bolt anchorages shall be as specified in the Contract or, if not so specified, as approved by the Engineer.

C Concrete (Mix 3Y43) ................................................ 2461

D Reinforcement Bars .................................................. 3301

All reinforcement bars, except spiral bars, shall be as indicated in the Contract and shall be epoxy coated.

E Spiral Reinforcement ................................................ 3305

F Signs and Markers .................................................. 3352
All sign panels shall be fabricated in accordance with the following, unless otherwise specified in the Contract. Types of sign panels, route markers, and overlays contained in this Specification are referenced in the Mn/DOT Traffic Engineering Manual or the Mn/DOT Standard Signs Manual, or both.

**F1** Sign base material for sign panels Type C, Type D, Type Overlay, delineators, markers and Type OH sign panels on sign supports shall be sheet aluminum in accordance with 3352.2A1a except the sign base material for cylinder style delineators shall be non-reflectorized lexon black flexible plastic.

**F2** Sign base material for sign panels Type A, Type EA, Type EO and Type OH sign panels on panel mounting posts shall be extruded aluminum in accordance with 3352.2A1b and covered with 1600 µm (0.063 inch) sheet aluminum conforming to Mn/DOT 3352.2A1a covering the extruded panel. Fasteners to attach the sheet aluminum to the extruded panel shall be 5 mm (3/16 inch) aluminum alloy pull through rivets. The sheet aluminum shall be butted tightly vertically and riveted to the extruded panel on 300 mm (12 inch) centers maximum vertically and horizontally. All edges and corners of each sheet shall be riveted. Rivets shall not be placed within 25 mm (1 inch) of the extruded panel joints. After being attached, the sheet aluminum shall be substantially free of any waviness.

**F3** Sign face material for all sign panels, delineators and markers shall be reflective sheeting conforming to 3352.2A2e(a) (Type IX), except as specified below:

- Sign face material for standard sign I-X1 shall be reflective sheeting conforming to 3352.2A2b(a) (Type III).
- Sign face material for standard signs W1-8 and W14-3 and X4-2 Hazard Markers, X4-3 Culvert Markers and X4-4 Clearance Markers shall be reflective sheeting conforming to 3352.2A2e(b) (Type IX FL Fluorescent yellow).
- Sign face material for standard signs W11-1, W11-2, S1-1, S4-3 and S5-1 shall be reflective sheeting conforming to 3352.2A2e(b) (Type IX FL Fluorescent yellow-green). Sign face material for standard signs W16-7p, W16-9p, W20-100P, and W13-1, when used with the aforementioned signs, shall be reflective sheeting conforming to 3352.2A2e(b) (Type IX FL Fluorescent yellow-green).

For the sign face material on the M1-5A Route Marker and the M1-5B Type Overlay, the gold color shall be obtained by means of screen processed color using a transparent gold paint. The blue color shall be obtained by means of screen processed color using a transparent blue paint. The overlap of the blue and gold screen processed colors shall not exceed 3 mm (3/32 inch).
Sign face material for sign panels with brown background shall be white reflective sheeting conforming to 3352.2A2e(a) (Type IX).

Yellow sign face material for cylinder style delineators, reboundable drums, and channelizers shall be reflective sheeting conforming to 3352.2A2b(c) (Type III MD).

Orange and white sign face material for cylinder style delineators, reboundable drums, and channelizers shall be reflective sheeting conforming to 3352.2A2d(b) (Type VII MD).

Sign face material for X4-2 Hazard Markers shall be non-reflectorized black or non-reflectorized yellow as specified in the Contract.

Sign face material for X4-11 End of Roadway Markers shall be non-reflectorized red or non-reflectorized black as specified in the Contract.

Sign face material for traffic cones shall be reflective sheeting conforming to 3352.2A2b(b) (Type III MC).

Sign face material for tubular markers shall be reflective sheeting conforming to 3352.2A2b(d) (Type III MT).

Sign face material for roll up signs shall be reflective material conforming to 3352.2A2c (Type VI).

Sign face material for all rigid work zone signs shall be reflective sheeting conforming to 3352.2A2d(a) (Type VII) except as specified below:

Sign face material for standard signs W20-7a, G20-4, W21-X4, W21-X4a, W21-X7 (SLOW side), M4-8, M4-8a, M4-9, M4-10, all signs for paint striping operations, and any other sign requiring extraordinary emphasis, as determined by the District Work Zone Coordinator, shall be reflective sheeting conforming to 3352.2A2d(c) (Type VII MF).

F4 Sign legend material for all sign panels, the numerals on M1-5A Route Markers and M1-5B Type Overlays, delineators and markers, and colors other than yellow on warning signs, shall be reflective sheeting conforming to 3352.2A2e(a) (Type IX), except as specified below:

The sign legend material on sign panels with brown sheeting shall be brown (1179) electronic cuttable (EC) film produced by the same manufacturer that fabricates the reflective sheeting conforming to 3352.2A2e(a) (Type IX). If applying brown EC film on sign panels requires splicing, splices shall be vertical, butt spliced and spaced so that splices do not occur through letters or arrows.

The sign legend material for colors other than black may be screened in accordance with 3352.2A5c.
The sign legend material for black legend shall be in accordance with 3352.2A4c or 3352.2A4d.

**G Anchor Rods** ............................................................... 3385

**H Flanged Channel Sign Posts** ........................................... 3401

### 2564.3 CONSTRUCTION REQUIREMENTS

**A General**

Fabrication and installation of traffic signs and devices shall conform to the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) for Streets and Highways and to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

The Contractor shall not perform work on the job site until all underground utilities are located in compliance with 1507. Electrical cable damaged due to the negligence of the Contractor shall be replaced at no expense to the Department. Damaged electrical cable shall be replaced, by the Contractor, from terminal point to terminal point.

Construction of any kind or type of electrical system or conduit system for the conveyance of electrical cables and conductors, or the required portions thereof, as specified in the Contract, shall conform to 1702 and 2545.3.

Sign locations and post lengths indicated in the Contract are approximate. Final determination of sign locations will be made in the field by the Engineer. The required post lengths for Type A and Type OH Signs will be determined by the Engineer. The required post lengths for all other signs shall be determined by the Contractor.

If the legend on an existing sign is pertinent to traffic and the sign is to be refurbished, down time for the sign shall not extend beyond the 8-hour period from 8:00 a.m. to 4:00 p.m., unless a suitable replacement sign is provided by the Contractor at no expense to the Department.

If, in the opinion of the Engineer, the message on a sign panel is not pertinent to existing traffic, the Contractor shall delay installation of that sign panel until such time as the message does become pertinent or, in lieu thereof, the sign panel may be installed provided an effective covering is placed over the non-pertinent message. The cover shall be opaque, and shall prevent moisture from being held against the sign face. Burlap will not be accepted as an effective covering for reflective signs. The Contractor shall install the sign panel with the required covering and the Department will assume the responsibility for maintaining and removing the cover after acceptance of the work. Unless the Contractor has arranged to reclaim the covering material, it shall become the property of the Department upon final acceptance of the work. The covering, maintaining, and uncovering of sign panels
with non-pertinent messages shall be done by the Contractor with no
direct compensation.

The removal and replacement of any existing guardrail solely for
the convenience of the Contractor shall be considered as being
incidental work.

The Contractor shall replace all topsoil, sodded, and seeded areas
disturbed by the operations and dispose of any excess excavated
materials in a manner satisfactory to the Engineer.

B  Concrete Structures

Concrete for footings shall be produced in accordance with 2461
and meet the requirements for Grade Y, Type 3 Concrete as specified
therein.

All exposed concrete surfaces shall be given a rubbed surface finish.

The Contractor shall not install sign posts on concrete footings until
after a minimum 7 days of curing period has elapsed.

B1  Concrete Footings

The Contractor may substitute spread footings for drilled shaft
footings or vice versa, subject to the approval of the Engineer.

Footings shall be constructed in accordance with the Contract
requirements and there shall be no adjustment in Contract quantities and
prices.

If the Contract specifies drilled shaft footings, the Contractor may
submit, for approval by the Engineer, an alternate design in lieu of
detailed in the Contract. If approved by the Engineer, the Contractor
may elect to construct the shaft footing accordingly without adjustment
of any Contract quantities and prices. Design details shall be in
accordance with either of the following:

(a) Use a constant diameter shaft at least 153 mm (6 inches) greater
than the diagonal dimension of the column base plate. Use the
planned longitudinal reinforcement bars without bending. Either
spiral reinforcement or tie bars spaced at 153 mm (6 inches) centers
may be used for the full length of the shaft, or

(b) Install a horizontal construction joint at the bottom of the tapered
section of the shaft [about 1.8 m (6 feet) below the top]. Before
placing new concrete above the construction joint, the surface of the
in place concrete shall be coated with an approved bonding agent.
Vertical reinforcement bars shall be lapped 40 bar diameters.

The footings shall be constructed in accordance with 2401.3 except
as modified by the following:

The Contractor may use undisturbed earth as the form for concrete
placement, provided the earth is firm enough to permit satisfactory
placement of the concrete and precautions are taken to prevent
contamination of the concrete.
B2 Median Barrier Footing
The Contractor shall provide NMC conduit and fittings to connect to the non-metallic conduit in adjacent median barrier as required.
The surface finish and color shall match that of adjacent median barrier.

C Sign Support
The Contractor shall furnish and install a sign support in accordance with the Contract, current AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" and the following:
The concrete footings shall be as specified in the Contract. The Contractor shall determine the reinforcement steel and the anchor rods in accordance with the details in the Contract.
The Contractor shall furnish and install an Overhead Sign Identification Plate in accordance with 2564.3P.

D Overhead Sign Structure Repair
The Contractor shall repair an existing overhead sign structure in accordance with the applicable provisions of 2123 and the following:
The Contractor shall contact the Department's Structural Metals Inspection Unit (DSMIU) to schedule inspection of sign structures. This inspection shall be completed before removal of the sign structure from storage, or after the Contractor's salvage of the structure.
The following conditions, if encountered, shall be corrected as determined by the DSMIU: rusted or missing nuts, bolts or washers, defective shop and field splices on main chord angles, missing welds, cracking of welds or structural elements, section loss on post base plate, flame gouges on base plate or at bolt holes, cracks around post handhole, zinc coating loss or deterioration, and rusting. All repairs shall be performed in accordance with 2471.
The Contractor shall verify that each locking pin will completely fit into the locking pin hole in the handrail hinge with the handrail in the raised position. For locking pins that do not fit, the Contractor shall drill out the handrail hinge to make a proper fit. Damage to galvanized surfaces shall be repaired in accordance with 2471.3L1.
The Contractor shall obtain reinspection by the DSMIU after the repair has been completed and before installation.

E Structural Steel
The manufacture and fabrication of structural metals shall conform to 2471, subject to the following additional requirements and limitations:
Shop drawings for overhead sign structures and for Type A sign structures shall be furnished in accordance with 2471.3B.
Steel trusses shall be constructed true to dimensions and shall be uniform in appearance. The truss sections and posts shall be assembled in the shop before galvanizing; shall be checked for straightness, alignment and dimensions; and any variations shall be corrected. Warpage from galvanizing shall be corrected before installation of structural steel will be permitted.

All main chord angles for overhead sign structures 13 mm (½ inch) or greater in thickness shall meet a Charpy V-notch impact strength requirement of 20 N•m (15 foot•pounds) at 5 °C (40 °F).

The overhead sign post base plate anchor rod holes shall be made by use of a drill or other mechanical cutting tool of proper size.

The Contractor shall lubricate the threads of nuts before installation. The following minimum torque values shall be used:

<table>
<thead>
<tr>
<th>ANCHOR ROD DIAMETER</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 mm (2 inches)</td>
<td>400 N•m (300 foot•pounds)</td>
</tr>
<tr>
<td>57 mm (2 ¼ inches)</td>
<td>500 N•m (375 foot•pounds)</td>
</tr>
<tr>
<td>64 mm (2 ½ inches)</td>
<td>600 N•m (450 foot•pounds)</td>
</tr>
<tr>
<td>70 mm (2 ¾ inches)</td>
<td>750 N•m (550 foot•pounds)</td>
</tr>
<tr>
<td>76 mm (3 inches)</td>
<td>950 N•m (700 foot•pounds)</td>
</tr>
</tbody>
</table>

The Contractor shall mark the threads of the anchor bolts in accordance with 2402.3H.

The Contractor shall furnish and install galvanized structural steel posts (H-Pile) as footings for Type A signs, unless otherwise specified in the Contract, in accordance with the applicable provisions of 2452, 2471, and the following:

The footing shall be constructed in accordance with the details in the Contract. A 4.3 m (14 foot) H-Pile post may be utilized instead of welding a 0.6 m (2 foot) stub post to the 3.7 m (12 foot) H-Pile. The required 107-125 kN (12-14 ton) bearing capacity for each H-Pile shall be obtained in accordance with 2452. If the required bearing capacity is not obtained after driving the length of H-Pile specified in the Contract, the Contractor shall splice additional length of H-Pile in accordance with 2452 and drive to the required bearing capacity. All damage to galvanized surfaces shall be repaired in accordance with 2471 before back filling.

F Flanged Channel Sign Posts

F1 Furnish Flanged Channel Sign Post

The Contractor shall fabricate, package, and deliver flanged channel sign posts in accordance with 2564, 3352, and 3401.

(a) Posts of the same mass and length shall be banded together, with suitable banding materials, in lots of no more than 20 posts per bundle. Each bundle shall be plainly labeled with the post mass per
meter, the name of the Contractor, the Project number, source of the material and the supplier’s name.

(b) The posts shall be delivered to the Department as specified in the Contract. The Contractor shall give at least 3 working days notice to the Engineer.

(c) Posts shall be deposited where and as directed by Department personnel. All damage detected during unloading shall be cause for immediate rejection of damaged materials. Final inspection and acceptance of the posts will be made by the Department within 14 days of the delivery date.

F2 Furnish and Install Flanged Channel Sign Posts

The Contractor shall install the posts plumb above ground and located and oriented as directed by the Engineer. Any post that is bent or otherwise damaged to the extent that, in the opinion of the Engineer, it is not acceptable, shall be removed from the site and replaced by the Contractor at no expense to the Department.

Posts shall be firm in the ground. After driving, the top of the post shall have the same cross-sectional dimensions as the body of the post.

When mounting a delineator on a bridge rail, a bracket as shown in the Contract shall be furnished and installed by the Contractor in lieu of a conventional steel post.

All costs and work of installing posts in surfaced medians or sidewalks shall be considered incidental to the installation.

G Modify Post

Splices will not be permitted in the lower 1.5 m (5 feet) of Type A sign posts.

The Contractor shall extend Type A sign posts located above the friction fuse, and panel mounting posts, by welding a section (new or salvaged under this Contract of the same size) to an existing post in accordance with the applicable provisions of 2471. Only S100 x 11 (S4x7.7) panel mounting posts may be extended by bolt splicing in accordance with the details in the Contract and with the applicable provisions of 2471. Post extensions shall be galvanized in accordance with 2471.

When shortening a post, the removed section of post shall be disposed of in accordance with 2104.

Thermal cutting will be permitted in accordance with 2471. Galvanized areas marred due to cutting or welding shall be repaired in accordance with 2471.

H Sign Panels

Type Overlays are separate panels mounted on the face of signs to form a part of the legend. Type Overlays shall be attached to the sign panels with rivets spaced on 300 mm (12 inch) centers except the edges
of each Type Overlay shall be attached with rivets spaced on 150 mm (6 inch) centers maximum. No rivets are to be installed within 25 mm (1 inch) of extruded panel joints.

The Contractor shall fabricate the sign panels in accordance with the standard sign drawings contained in the Mn/DOT Standard Signs Manual or as detailed in the Contract. For sign panels detailed in the Contract, sign panel layouts are dimensioned as follows:

**Vertical dimensioning**
The dimension given is for the legend component having the largest vertical dimension in the particular line of copy. Other legend components are centered on the larger legend component unless indicated otherwise.

**Horizontal dimensioning**
The horizontal dimensions given within the sign panel are to the tenth of an inch and are cumulative representing the distance from the left edge of panel to the extreme left edge of the legend component.

**Sign Panel Recap**
The position of an arrow is measured in degrees counterclockwise from a right horizontal reference line. The abbreviation MOD used in the sign panel recap = Modified.

The Contractor shall screen a fabrication sticker with the following information: Company name and address, the twelve months of the year in numeric order (1 through 12) and the current and following 4 years (last two digits of each year). The Contractor shall affix the sticker to the backside of each new Type C (single post installations only) and Type D sign panels in the lower right corner (when facing the back of the sign panel). On installations of two or more posts for Type C sign panels, the Contractor shall install the sticker in the center at the bottom of the sign panel. The Contractor may indicate the month and year of fabrication of the sign panel on the sticker by either of the following methods:

Punch out the month and year of fabrication of the sign panel on the completed sticker.

Block out the month and year of fabrication on the screen prior to applying the black ink so that the month and year of fabrication will not be displayed.

The Contractor shall provide a full size mockup (75 mm x 40 mm) (3 inches x 1 ½ inches) of the sticker (black legend on a white reflectorized background) to the Department for approval.

The Contractor shall attach all extruded sign panels to sign posts or panel mounting posts with new post clips. Each post clip shall be
torqued to 16 to 19 N•m (12 to 14 footpounds) when attaching all extruded sign panels to posts.

The Contractor shall package, deliver, store, and install sign panels in accordance with 1607, 3352, and the retroreflective sheeting manufacturer's recommended practices and procedures.

For signs or sign panels being furnished and installed, the Contractor shall affix a Department furnished warning sticker to the backside of each sign panel directly above the fabrication sticker. Warning stickers are available at the Department's Transportation District Office specified in the Contract. The Transportation District's contact person and phone number are specified in the Contract. Thirty calendar days advance notice shall be given prior to picking up the stickers.

For sign panels being furnished only, the Contractor shall group all sign panels by type (e.g. R1-2) and then by size. Each package shall contain only those sign panels destined for a specific location and no more than 20 sign panels per package. Each package shall be plainly labeled with the Sign Number (e.g. Sign R1-2), name of the Contractor, the Project number, source of the material, the supplier's name, quantity of sign panels, and the delivery location as specified in the Contract.

The Contractor shall give at least 3 working days notice to sign shop personnel before delivery of sign panels to the Department.

Sign panels shall be deposited where and as directed by Department personnel. Any damage detected during unloading shall be cause for immediate rejection of the damaged materials. Final inspection and acceptance of the sign panels will be made by the Department within 14 days of the delivery date.

I  Blank
J  Saw Sign Panels

The Contractor shall saw cut extruded aluminum sign panels straight and the resulting panel edge shall be smooth. Excess material shall be disposed of in accordance with 2104.

K  Sign Panel Overlay Type __

The Contractor shall furnish and install overlay panels on existing extruded aluminum sign panels, including legend. Fasteners to attach the overlay sheets to the extruded panel shall be 5 mm (1/16 inch) aluminum alloy pull through rivets.

The sign base material for overlay sheets shall be 1600 µm (0.063 inch) aluminum conforming to 3352.2A1a. The sign face material shall be reflective sheeting conforming to 3352.2A2e(a) (Type IX). The sign legend material shall be reflective sheeting conforming to 3352.2A2e(a) (Type IX), except where black legend is specified the
sign legend material shall be Direct Applied conforming to 3352.2A4c or 3352.2A4d.

The Contractor shall remove the demountable legend conforming to 3352.2A2e(a) (Type IX) on the existing sign panel and dispose of in accordance with 2104.

The Contractor shall butt the overlay sheets tightly vertically and rivet them to the existing panel on 300 mm (12 inch) centers maximum vertically and horizontally. All edges and corners of each overlay sheet shall be riveted. Rivets shall not be within 25 mm (1 inch) of the extruded panel joints. The overlay sheets after being attached to the existing panel shall be substantially free of any waviness.

L  Install Sign Panel Type __

The Contractor shall install a sign panel (either salvaged or Department furnished) of the type specified in the Contract in accordance with the details in the Contract and the following:

Type A and Type OH sign panels shall be installed using new post clips. Type EA and Type EO sign panels shall be installed with new flanged channel posts and post clips. The Contractor shall torque each post clip to 16 to 19 N•m (12 to 14 footpounds) when attaching all extruded sign panels to posts.

Type C and Type D sign panels shall be installed with new nuts, bolts and washers.

Type OH sign panels, being installed on sign supports, shall include new sign bracket assemblies in accordance with the details in the Plan.

M  Install Sign Type __

The Contractor shall install Type A signs on breakaway supports at the locations indicated in the Contract. Salvaged or Department furnished Type A sign panels shall be installed using new post clips. The Contractor shall torque each post clip to 16 to 19 N•m (12 to 14 footpounds) when attaching all extruded sign panels to posts. Completed installations shall be in accordance with Contract requirements and details. A new friction fuse (includes friction fuse plate and hinge plate) new bolts, nuts and washers shall be furnished and installed on each post. Damage to galvanized surfaces shall be repaired in accordance with 2471.

The Contractor shall furnish and install a new sign structure for Type C and Type D signs and install the salvaged sign panel(s) in accordance with the details in the Contract using new nuts, bolts, and washers. The salvaged sign panel(s) shall be installed to the mounting height requirements specified in the Contract.

The Contractor shall install each mast arm mounted Type D sign at the location indicated in the Plan, to the satisfaction of Engineer, and as follows:
2564.3

The Structural Details For Signal Mast Arm Mounted Signs are specified in the Mn/DOT Standard Signs Manual, Page No. 105A. Each mast arm mounted Type D sign panel shall be provided with a mounting system approved by the Department. Approval shall be obtained by submitting product specifications and strength calculations, demonstrating compliance with the current AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals". Submittal shall be made to Fabrication Methods Engineer, Mn/DOT Office of Bridges and Structures, Mail Stop 610, 3485 Hadley Avenue North, Oakdale, Minnesota 55128.

The Contractor shall furnish new flanged channel posts for Type EA and Type EO sign panel(s), and install the salvaged sign panel(s) with new post clips in accordance with details in the Contract. The Contractor shall torque each post clip to 16-19 N•m (12-14 foot-pounds).

The Contractor shall install the Type OH sign structure (either salvaged or from storage) on new concrete footing(s) in accordance with the torque requirements under 2564.3E and with the details in the Contract.

The Contractor shall remove the following and furnish and install new: safety chains and components of safety chain snap assemblies, safety rail locking pins, and chains welded to the locking pin heads (one chain/locking pin). This work shall be incidental to the installation of the sign structure. Items removed shall be disposed of in accordance with 2104.

The Contractor shall verify that each locking pin will completely fit into the locking pin hole in the handrail hinge with the handrail in the raised position. For locking pins that do not fit, the Contractor shall drill out the handrail hinge to make a proper fit. Damage to galvanized surfaces shall be repaired in accordance with 2471.3L1.

Sign Legend Revision

The Contractor shall revise the sign legend of existing sign panels in accordance with the details in the Contract and the following:

Clean the sign faces with a mild detergent and water solution before installing the new sign legend.

New sign legend for Type A, Type EA, Type EO and Type OH sign panels shall be reflective sheeting conforming to 3352.2A2e(a) (Type IX), except where black legend is specified the sign legend material shall be direct applied non-reflectorized conforming to the 3352.2A4c or 3352.2A4d.

Blank
P  Overhead Sign Identification Plate
The Contractor shall furnish and install an overhead sign identification plate for each overhead sign being installed under the Contract. The plate shall incorporate the overhead sign number appearing directly below the sign panel on the Plan layout and shall comply with the details in the Contract.
For post mounted signs, the plate shall be strap mounted to the overhead sign post in accordance with the details shown in the Contract. The plate shall be installed on the right post when looking in the direction of traffic flow. When signs face both directions of travel on a single structure, two plates will be required. The plate shall be installed at a height of 1.8 m (6 feet) above the base plate elevation and facing traffic.
For bridge mounted Type OH signs with sign lighting, the overhead sign identification plate shall be installed at a mounting height of approximately 1.9 m (6 feet) above the edge of the pavement on the feed point identification plate delineator post specified in 2545.3.4. For bridge mounted Type OH signs with no sign lighting, the plate shall be installed on a 3 kg/m (2 pounds per foot) delineator post in accordance with 3401. The plate and post should be installed as close to the bridge as possible and behind the guardrail, if present. If no guardrail is in place, the plate and post shall be installed at least 3.7 m (12 feet) outside the edge of shoulder or face of curb. The bottom of the plate shall be approximately 1.8 m (6 feet) above the edge of pavement.

Q  Extend Walkway Support
The Contractor shall extend each walkway support on existing Type OH sign structures in accordance with the details in the Contract.

R  Friction Fuse
The Contractor shall furnish and install a friction fuse on each sign post of existing Type A sign installations in accordance with the details in the Contract and the following:
Remove the in place friction fuse (friction fuse plate, hinge plate, and all in place mounting hardware) and dispose of in accordance with 2104.
Furnish and install a new friction fuse (includes friction fuse plate and hinge plate), new bolts, nuts and washers on each post in accordance with the details in the Contract. Damage to galvanized surfaces shall be repaired in accordance with 2471.3L1.

S  Keeper Plate
The Contractor shall furnish and install a keeper plate on each sign post of existing Type A sign installations in accordance with the details in the Contract.
The Contractor shall verify the sign post dimensions in the field. Immediately before installing the keeper plates, the base connection plate shall be cleaned and be free of grit, dirt, etc. The post shall be reinstalled in accordance with the base connection bolting procedure. Missing, damaged or rusty bolts, nuts and washers shall be replaced by the Contractor.

**T Traffic Control**

This work shall consist of furnishing, installing, maintaining, and removing traffic control devices.

All signs shall conform to the Mn/DOT Standard Signs Manual. All barricades shall conform to current Mn/DOT Standard Plate 8000. All other traffic control devices shall conform to the MN MUTCD. Nylon washer spacers shall be installed between the temporary traffic construction sign panel(s) and the in place sign panel.

The Contractor shall provide all necessary traffic control devices (TCD's) as required by the Contract and the MN MUTCD.

The Contractor shall install all TCD's where required, before the beginning of any work. The Contractor shall maintain all TCD's and remove them when not required.

**U Scheduling of Work**

The Contractor shall schedule the work in compliance with the following requirements:

1. One of the following signs shall be in service at all times for each exit:
   - The Exit sign in the gore, or
   - The Exit direction sign just in advance of the gore.

2. One directional sign shall be in service at all times for each exit. This may be the Advance guide sign or the exit directional sign.

3. Sign structures shall not be removed until permitted by the Engineer. The Engineer’s approval for removing an existing sign is contingent upon Item 1 and 2 above and upon a satisfactory replacement being constructed and functional.

**V Delineators and Markers**

The Contractor shall fabricate delineators and markers in accordance with the standard sign drawings contained in the Mn/DOT Standard Signs Manual, Mn/DOT Traffic Engineering Manual or as detailed in the Contract. The Contractor shall furnish and install the tubular or flanged channel sign post, mounting bracket or strap mounting hardware, and attach the delineator or marker with mounting hardware as detailed in the Contract.

**W Safety Cable**

For Type OH signs with walkway and no sign lighting, the Contractor shall furnish and install brackets, aircraft cable and all
necessary hardware, in accordance with the applicable provisions of 2564, to assemble and attach a safety cable as detailed in the Plan.

2564.4 METHOD OF MEASUREMENT

A  General
- Items modify post, install sign panel Type __, sign legend revision, overhead sign identification plate, extend walkway support, friction fuse, and keeper plate will individually be measured by the each.

B  Concrete Structures
- All necessary excavation for a concrete structure will be considered as being incidental to construction of the structure and no measurement will be made thereof except under the following conditions:
  1. Excavation required 300 mm (12 inches) below the bottom of the concrete structure will be measured as actual material removed within the limitations set forth in 2451.4A and the volume will be paid for as Extra Work.
  2. Payment as Extra Work will be made where Class R excavation is encountered and cannot be avoided by adjustment of the concrete structure location.
  3. All reinforcement bars in concrete structures will be incidental to the construction and with no measurement being made.

B1  Concrete Footings
- Concrete footings for Type OH signs will be measured separately by volume, based on specified dimensions in the Contract with no deductions for the volume of metal reinforcement, anchorages, conduit, etc., except that the anchorage assemblies will be measured separately.

B2  Median Barrier Footing
- Median barrier footing will be measured separately by the unit based on specified dimensions in the Contract with no deductions for the volume of metal reinforcement, anchorages, conduit, etc., except that the anchorage assembly will be measured separately.

C  Sign Support
- The sign support will be measured as a complete unit including the concrete footing(s) and overhead sign identification plate.

D  Overhead Sign Structure Repair
- Overhead sign structure repair will be measured by the actual number of hours required to complete the repair, including use and operation of equipment, travel time within the Project limits, and work and materials involved. However, crane work and materials required to position and block the truss up off the ground shall be paid for under install sign type OH, with no additional compensation. Overhead sign structure repair is exempt from 1903 as no unit price adjustments will be made in the event of a quantity underrun of overrun.
E  Structural Steel

The structural steel items: trusses for overhead signs (Design A); posts for overhead signs (Design A); trusses for overhead signs (Design B); posts for overhead signs (Design B); walkway supports for overhead signs (Design B); walkway grating for overhead signs (Design B); panel mounting posts for overhead signs (Design B); trusses for overhead signs (Bridge Mounted); and posts and H-piles for Type A signs will be measured separately by computed mass (weight) of structural steel incorporated in each item in accordance with the measurement provisions of 2402.4A, subject to the following:

1. The mass (weight) measurement for trusses for overhead signs (Design A) will include the structural members of the truss, the lower chord juncture plate, cap plates, tie plates, collar, panel mounting posts, walkway grating, walkway supports, safety rail, and fixture mounting channel.

2. The mass (weight) measurement for posts for overhead signs (Design A) will include the posts, the base juncture plate, lower chord juncture post plate, gusset plates, baseplate, overhead sign identification plate, and the anchorage assembly.

3. The mass (weight) measurement for trusses for overhead signs (Bridge Mounted) will include the structural members of the truss, the panel mounting posts, walkway grating, walkway supports, safety rail, and fixture mounting channels.

(2) The computed mass (weight) will be based on the quantity tables included in the Contract.

(3) No measurement will be made of any bolts, nuts, rivets, washers, and shims used in the fabrication and erection of signs. The provisions of 2402.4A providing a percentage increase in mass (weight) therefore will not apply.

F  Flanged Channel Sign Posts

Flanged channel sign posts will be measured by computed mass (weight) for each size of post being furnished.

G  Sign Panels

Sign panels of each type will be measured separately by area based on the nominal dimensions of the sign panels. All signs will be considered as being rectangular for the purpose of measurement except that, for triangular shaped sign panels, the measurement will be the actual area of the triangle. No deduction will be made for rounding of corners.

H  Saw Sign Panels

Sawing of extruded sign panels will be measured by the length of the saw cut.
I  Sign Panel Overlay Type __
Sign panel overlays will be measured separately by the area and type of sign panel(s) overlaid.

J  Install Sign Type __
Signs of each type will be measured by the number of complete units in place as specified under 2564.3M, except that the posts and concrete footings or H-Pile footings for Type A signs, and the footings for Type OH signs, will be paid for separately.

K  Delineators and Markers
Delineators and markers of each type will be measured by the number of complete units furnished and installed. A complete unit will consist of the delineator or marker panel, tubular or flanged channel sign post, mounting bracket or strap mounting hardware, and delineator or marker panel mounting hardware as specified in the Mn/DOT Standard Signs Manual, Mn/DOT Traffic Engineering Manual, or as detailed in the Contract.

2564.5 BASIS OF PAYMENT
The Department will pay for traffic signs and devices at the Contract price per unit of measure. The Contractor will accept the payment as compensation in full for all costs relating to furnishing and installing or furnishing the item except those costs that the Contract specifically designates as included for payment under a separate item.

Payment for concrete footings at the Contract price per cubic meter (cubic yard) will be compensation in full for all costs of constructing the footings and will include replacing all topsoil and sodded areas disturbed by the operations and disposal of any excess excavated materials in a manner satisfactory to the Engineer, except that anchorage assemblies will be paid for under Structural Steel - Post for OH Signs (Design __).

Payment for median barrier footing at the Contract price per unit of measure will be compensation in full for all costs of constructing the footing in place as specified, except that the anchorage assembly will be paid for under Structural Steel-Posts for OH signs (Design __).

Payment for sign support at the Contract price per unit of measure will be compensation in full for furnishing and installing the sign support (including the concrete footings) and overhead sign identification plate.

Payment for overhead sign structure repair at the Contract price per hour will include compensation in full for all costs involved in performing the work as specified in the Contract, except that the crane work and materials required to position and block the truss up off the ground shall be paid for under install sign type OH.
Payment for structural steel items by weight at the Contract price per mass (weight) of steel will be compensation in full for all costs of fabricating and erecting the structural steel items as specified in the Contract.

Payment for modify post at the Contract price per unit of measure will be compensation in full for all costs of modifying each post as specified in the Contract.

Payment for flanged channel sign posts at the Contract price per kilogram (pound) will be made under structural steel, and will be compensation in full for all costs involved in manufacturing, packaging and delivering the posts as specified in the Contract.

Payment for furnishing and installing sign panels of each type separately at the Contract price per square meter (square foot) will be compensation in full for all costs of fabricating and erecting panels as specified, except for those components that are specifically noted as Type Overlays. Payment for Type C and Type D sign panels will include compensation for furnishing and installing the tubular or flanged channel sign posts, stringers, brackets, and attachment angles or strap mounting hardware on which the sign panels are attached. Payment for Type EA and Type EO sign panels will include compensation for furnishing and installing the flanged channel sign posts. Payment for Type A Sign Panels will include compensation for the hardware required to assemble the panel sections and attach the assembled sign panels to the sign posts. Payment for Type OH Sign Panels will include compensation for the hardware required to assemble the panel sections and attach the assembled sign panels to the panel mountings posts or the sign support. Torquing post clips will be incidental to furnishing and installing extruded sign panels. Screening and installing fabrication stickers and installing warning stickers will be incidental to furnishing and installing Type C and Type D sign panels.

Payment for furnishing sign panels of each type separately at the Contract price per square meter (square foot) will be compensation in full for fabricating packaging, and delivering the sign panels as specified in the Contract.

Payment for saw sign panels at the Contract price per unit of measure will be compensation in full for all costs of sawing sign panels as specified in the Contract.

Payment for sign panel overlay Type __ at the Contract price per square meter (square foot) will be compensation in full for all costs involved in performing the work as specified in the Contract, including the removal and reinstallation of the existing sign panel, if necessary, except that furnishing and installing new Type Overlays will be paid for as sign panels Type Overlay.
Payment for install sign panel Type __ at the Contract price per unit of measure will be compensation in full for all costs of installing each sign panel as specified in the Contract.

Payment for install sign Type __ at the Contract price per unit of measure will be compensation in full for all costs of installing each sign as specified in the Contract, except that the posts and H-Files for Type A signs will be paid for under Structural Steel Posts for Type A signs; the anchorage assembly(ies) will be paid for under Structural Steel Posts for Type OH Signs (Design _) and concrete footing(s) for Type OH signs will be paid for under Concrete Footings (Type Spread or Shaft) or median barrier footing(s).

Payment for sign legend revision at the Contract price per unit of measure will be compensation in full for all costs of revising each sign panel as specified in the Contract.

Payment for overhead sign identification plate at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing each overhead sign identification plate as specified in the Contract.

Payment for extend walkway support at the Contract price per unit of measure will be compensation in full for all costs of extending each walkway support as specified in the Contract.

Payment for friction fuse at the Contract price per unit of measure will be compensation in full for all costs of removing an in place and furnishing and installing a new friction fuse as specified in the Contract.

Payment for keeper plate at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing a new keeper plate as specified in the Contract.

Payment for delineators and markers at the Contract price per unit of measure will be compensation in full for all costs of furnishing and installing each delineators and marker as specified in the Contract.

Payment for traffic signs and devices will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
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<td>2564.511</td>
<td>Concrete Footings-Type</td>
<td>cubic meter (cubic yard)</td>
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<tr>
<td>2564.513</td>
<td>Median Barrier Footing</td>
<td>each</td>
</tr>
<tr>
<td>2564.515</td>
<td>Sign Support</td>
<td>each</td>
</tr>
<tr>
<td>2564.518</td>
<td>Overhead Sign Structure Repair</td>
<td>man-hour</td>
</tr>
<tr>
<td>2564.522</td>
<td>Structural Steel --- (Specify Item &amp; Use)</td>
<td>kilogram (pound)</td>
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<td>2564.524</td>
<td>Modify Post</td>
<td>each</td>
</tr>
<tr>
<td>2564.531</td>
<td>Sign Panels Type ___</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2564.533</td>
<td>Furnish Sign Panels Type ___</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2564.534</td>
<td>Saw Sign Panel Type ___</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>
2564.5

2564.535 Sign Panel Overlay Type ______ square meter (square foot)
2564.536 Install Sign Panel Type .................................................. each
2564.537 Install Sign Type .......................................................... each
2564.538 Sign Legend Revision ...................................................... each
2564.539 Overhead Sign Identification Plate .................................. each
2564.540 Extend Walkway Support ................................................ each
2564.541 Friction Fuse ................................................................. each
2564.542 Keeper Plate ................................................................. each
2564.550 Delineator, Type .............................................................. each
2564.551 Reference Post Marker .................................................... each
2564.552 Hazard Marker X4-2 ....................................................... each
2564.553 Clearance Marker X4-4 ..................................................... each
2564.554 Snowplow Marker X4-5 .................................................... each
2564.555 End of Roadway Marker X4-11 ........................................ each
Traffic Control Signals

2565.1 DESCRIPTION

A General

This work includes furnishing and installing materials and electrical equipment, or installing Department furnished materials and electrical equipment, or both, to provide a complete, operating signal system.

These Specifications also apply to: revised signal systems, temporary signal systems, automatic traffic recorder (ATR) systems, temporary bridge signal systems, conduit systems, detector systems, materials for a future signal systems, interconnection systems, flasher systems, emergency vehicle pre-emption (EVP) systems or combinations thereof, all as specified in the Contract.

B Definitions

Definitions of words and phrases pertaining to traffic control signal systems and related type work are as defined in the standards of the Institute of Transportation Engineers (ITE), in the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), 1101, and 1103. Definitions of words and phrases in conjunction with traffic signal control equipment and controller units are defined in the National Electrical Manufacturers Association (NEMA) Standards Publication for "Traffic Control Systems". The definitions in the above referenced publications shall govern unless otherwise defined in these Specifications or in the Contract.

2565.2 MATERIALS

A General

A1 Regulations and Code

All electrical equipment to be furnished shall conform to the standards of the requirements of the NEMA; the Underwriters' Laboratories, Inc. (UL); or the Electronic Industries Association (EIA), whichever is applicable.

Materials, electrical equipment, and workmanship shall conform to the standards of the National Electrical Code (NEC), the standards of the American Society of Testing and Materials (ASTM), the standards of the American National Standards Institute (ANSI), the standards of the Institute of Transportation Engineers (ITE), Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), and to local laws and ordinances that apply.

All electrical conductors shall be copper and all wire sizes for electrical conductors shall be based on the American Wire Gauge (AWG).
A2 Materials and Electrical Equipment List

The Contractor shall submit to the Engineer, within 15 calendar days following the date of the Award of Contract, a list of all materials and electrical equipment to be furnished by the Contractor. The list shall include the name of the manufacturer, size, and where the item will be obtained.

A3 Material Samples for Testing

The Contractor shall furnish samples of materials for testing and inspection. Materials may be accepted by the Engineer on the basis of the manufacturer's certification that the material has been sampled, tested, and inspected for compliance with the Contract. The Department reserves the right to accept or reject any material on the basis of its own tests and inspections.

A4 Tests

The Contractor shall make, at no expense to the Department, all tests necessary to demonstrate to the satisfaction of the Engineer that the materials, electrical equipment, and the installation thereof are in accordance with and meet the requirements of the Contract.

The Contractor shall provide, at no expense to the Department, such instruments, apparatus, tools, materials, and labor necessary to make the required tests. Such instruments, apparatus, tools, and materials shall remain the property of the Contractor after the tests are completed.

A5 Warranties, Guarantees, and Instruction Sheets

Warranties and guarantees on new materials and electrical equipment shall apply to the items furnished by the Contractor.

Manufacturers' warranties and guarantees furnished for materials and electrical equipment, and instruction sheets and parts lists supplied with materials and electrical equipment, shall be submitted to the Engineer before final acceptance of the Project or when requested by the Engineer.

The Contractor shall warrant and guarantee all materials and electrical equipment furnished to the Project to be free from defects in materials and workmanship in accordance with the following:

(a) Warranties and guarantees that are offered by the material and electrical equipment manufacturer as a customary trade practice shall be turned over to the Department. The Department shall be named as the obligee on all manufacturers' warranties and guarantees.

(b) The Contractor shall warrant and guarantee satisfactory in-service operation of all materials and electrical equipment for a period of one (1) year. The one (1) year in-service warranty period shall begin with the "turn-on" of the traffic control signal system, except that the one (1) year period for materials and electrical equipment
components placed into operation after the "turn-on" of the traffic control signal system, such as interconnect materials, shall begin on the date the materials and electrical equipment are individually placed in satisfactory service initially. "Turn-on" shall be defined as the time when the complete traffic control signal system meets all installation and operational requirements of the Contract and is placed in automatic operation.

The Contractor shall replace or correct any part or parts of materials and electrical equipment that are found defective within the one (1) year in-service warranty period. No compensation will be made to the Contractor for such replacements or corrections.

The above warranty and guarantee requirements shall not apply to any part or parts of materials and electrical equipment that have been, in the opinion of the Engineer, subject to misuse, negligence, or accident by anyone other than the Contractor.

B  Conduit and Accessories
   B1  Rigid Steel Conduit (RSC) and Conduit Fittings ........ 3801
   B2  Intermediate Metal Conduit (IMC) and Conduit Fittings ................................................................. 3802
   B3  Non-Metallic Conduit (NMC) and Conduit Fittings ................................................................. 3803
   B4  Conduit Expansion fittings ................................................................. 3839

C  Handholes
   Handholes shall be as required by the Contract.

D  Electrical Junction Boxes ................................................................. 3838

E  Concrete ................................................................. 2411
   E1  General
       Concrete for mast arm pole foundations and light standard foundations shall be Mix No. 3Y43.
       Concrete for ground-mount cabinet foundations (for traffic signal cabinets, signal service cabinets, automatic traffic recorder cabinets, etc.), equipment pad foundations, pedestrian push button station foundations, flasher pedestal foundations, and for any new sidewalk construction or sidewalk replacement shall be Mix No. 3A32.
       Concrete meeting the requirements for Type 3, Grade A concrete shall be furnished where the use of a specific mix designation is not indicated in the Contract.
       Concrete pavement or base removed because of trenching or construction operations shall be constructed or replaced with Mix No. 3Y43 high early strength concrete.
       Plastic curing blankets, when used, shall be in accordance with 3756.
Anchor Rods.............................................................................. 3385

Traffic Signal Pedestals and Mast Arm Pole Standards
Anchor rods, nuts, and washers for traffic signal pedestals and mast arm pole standards shall be as indicated in the Contract.

Traffic Signal Cabinets
Anchor rods, nuts, and washers for traffic signal cabinets shall be Type A; shall be galvanized full length in accordance with 3392; shall be four in quantity; and shall be 19 mm (¾ inch) nominal diameter by minimum 460 mm (18 inches) long before bending a 50 mm (2 inch) ell on one end and threaded minimum 100 mm (4 inches) on the other end.

Signal Service Cabinets
Anchor rods, nuts, and washers for signal service cabinets shall be Type A; shall be galvanized full length in accordance with 3392; shall be four in quantity; and shall be 19 mm (¾ inch) nominal diameter by minimum 460 mm (18 inches) long.

Rust Inhibitor
Threaded portions of all anchor rods above concrete foundations shall be coated with a rust inhibitor before installation of mast arm pole standards, traffic signal pedestals, the traffic signal cabinet and other type cabinets on the anchor rods.

Electrical Cables and Conductors................................. 3815
Mast Arm Pole Standards and Luminaires................. 3831
Blank
Traffic Signal Pedestal .................................................. 3832
Vehicle Signal Faces......................................................... 3834
Pedestrian Signal Faces............................................... 3835
Wood Poles................................................................. 3840
Service Equipment....................................................... 3837
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Pedestrian Push Buttons and Signs............................ 3833
Signs.............................................................. 2564

Each pedestal mounted, pole shaft mounted, or mast arm mounted sign shall be the size indicated in the Contract and shall be fabricated in accordance with the Mn/DOT Standard Sign Manual and 3352.

Traffic Signal Cabinet and Control Equipment
The Contractor shall furnish the traffic signal cabinet (or other pad mounted cabinet and control equipment) as specified in the Contract.

Miscellaneous Materials
Materials and electrical equipment that have no requirements included in the Contract shall be in accordance with the best standard practices and workmanship. All materials and electrical equipment shall be approved by the Engineer before installation.
2565.3 CONSTRUCTION REQUIREMENTS

A  General
The location of component parts (including pedestrian curb ramps), as indicated in the Contract, are approximate only. The exact locations will be established by the Engineer.

Highways, streets, and roads shall be kept open to traffic during construction, subject to 1404. Any openings or uncompleted work that may cause a hazard to vehicle or pedestrian traffic shall be suitably protected to the satisfaction of the Engineer.

A1  Compliance with Electrical Codes and Standards
Construction operations shall conform to the National Electrical Code, to the State of Minnesota Board of Electricity Examiners, and to all State of Minnesota laws and local ordinances governing electrical installations.

A2  Permits and Inspections
The Contractor shall secure all necessary permits and inspections with no cost to the Department.

Bidders are advised that compliance with 1702 will be enforced in conjunction with the construction of any kind or type of electrical system or conduit system for the conveyance of electrical cables and conductors, or the required portions thereof, as specified in the Contract. The Minnesota Electrical Act requires that a permit be obtained for the performance of all such work, including the installation of conduits.

A3  Utility Property and Service ......................................... 1507
The electrical utility company will determine the minimum clearance of overhead electrical lines to other overhead structures and equipment operations. The Contractor shall conform to these minimum clearance requirements.

B  Existing Electrical Systems
Existing electrical systems (traffic signal, automatic traffic recorders [ATR], flasher systems, street lighting, etc.), or approved Temporary replacements thereof, shall be kept in effective operation for the benefit of the traveling public during the progress of new work, except when turn-offs are permitted. Turn-offs shall be as specified in the Contract or as directed by the Engineer. The Contractor shall notify the Engineer at least 48 hours in advance of scheduled turn-offs and before performing work on existing electrical systems. The Contractor shall not turn-off an existing traffic signal system without the specific approval of, and only in the presence of the Engineer.

The Department responsible for maintenance will continue maintenance while the Contractor is performing work on existing electrical systems. The Department responsible for maintenance will...
furnish electrical energy for operation and will repair or replace any component parts of an existing electrical system damaged by public traffic or natural causes.

During periods of authorized work suspension, the Department will maintain the existing traffic signal cabinet and control equipment and will maintain the existing traffic control signal system.

Where damage is caused by the Contractor's operations, the Contractor shall, at no expense to the Department, repair or replace any damaged component parts of an existing electrical system promptly to meet all governing specifications for new construction for the component damaged. Should the Contractor fail to perform the required repairs or replacements, the cost of performing such repairs or replacements will be deducted from any moneys due or becoming due the Contractor.

C  **Excavation and Backfill**

Excavation and backfill required for the installation of concrete foundations, cable, conduit, handholes, and other items specified shall be in accordance with the applicable provisions of 2451. Trenches for conduit and holes for concrete foundations and handholes shall not be excavated wider than necessary. Installation of concrete foundations, conduit, and handholes shall follow as soon as practicable after the excavation. Material from excavation shall be placed in locations that will neither cause damage nor obstruction to vehicle or pedestrian traffic nor interfere with surface drainage.

Trenching shall be located at a distance from the edge of the pavement, back of curbing, or edge of surfaced shoulders as indicated in the Contract, or as directed by the Engineer. The distance shall be such that no damage will be done to the pavement, curbing, or surfaced shoulders. The trench shall be of uniform alignment for accurate referencing of the underground installation.

At locations scheduled for guardrail, utilities, cable, or other below ground structures, the Contractor shall modify locations to preclude damage to the cable or conduit by the installation of these other components. Before installation, the Contractor shall coordinate with and obtain approval from the Engineer for the modified locations. Cable damaged by Contractors operation, and for which the location was not coordinated with and approved by the Engineer, shall be replaced at no expense to the Department.

Where trenching and excavation operations require the removal of concrete pavement or concrete sidewalk, the concrete shall be cut with a concrete saw to a depth of not less than 35 percent of the thickness of the concrete along the removal lines before breaking and removing, or the concrete shall be removed to existing joints.
All excavations shall be backfilled around the installed concrete foundations, conduit, and handholes and the backfill material shall be like in kind to the adjacent soils and compacted to approximately the same density. Backfill material shall be placed to avoid the placement of stones immediately adjacent to conduits or direct buried cable. If indicated in the Contract, or if directed by the Engineer, designated layers or portions of the backfill shall be made with granular material furnished in accordance with 2451. Any roadway surfacing (concrete pavement, bituminous surface, or gravel surface, including underlying base courses), sidewalks, curbs and gutters, sod, railways, etc., that are removed by construction operations shall be restored to approximately its original condition by the Contractor at no expense to the Department expense, all to the satisfaction of the Engineer.

Surplus material from excavation and backfill shall be expeditiously removed and disposed of outside the Right of Way in any manner that the Contractor may elect, subject to 2104.3C3.

**D  Conduit and Fittings**

**D1  General**

Conduit and fittings shall be of the type and size as specified in the Contract. It is the Contractor's option to install conduit and fittings of a larger size than specified. Where conduit size is not specified in the Contract, the conduit shall be 21 mm (¾ inch) minimum and shall be sized such that not more than 40 percent of inside cross-sectional area will be occupied by all electrical cables and conductors to be installed within the conduit run.

Conduit installation shall be in accordance with the NEC. All conduit in any one conduit run shall be of the same size and type and shall be continuous from outlet to outlet. Special conduit fittings may be incorporated for pulling electrical cables and conductors or for making short radius bends as necessary within the run.

Damaged conduit, having sharp kinks or reduced cross section will be rejected.

Conduit installation shall be made at the appropriate time to preserve the conduit from damage and to provide for its proper incorporation into the system. Conduit that will be encased in concrete or masonry shall be rigidly supported in position during the casting.

The Contractor shall install all electrical cables and conductors in conduit, except as otherwise specified in the Contract.

**D2  Conduit Placement**

Conduit shall be installed in as straight a run as practicable and shall enter handholes and foundations in line with the general direction of the conduit run as much as practicable.
2565.3

D2a Aboveground

All conduit attached aboveground to wood poles shall be secured with galvanized two-hole pipe straps spaced not more than 1.2 m (4 feet) apart.

All conduit attached aboveground to metal poles shall be secured with minimum 19 mm (\(\frac{3}{4}\) inch) wide stainless steel banding spaced not more than 1.5 m (5 feet) apart.

Conduit shall be supported within 900 mm (3 feet) of each termination or fitting.

Expansion devices shall be installed at each structure expansion joint as indicated in the Contract, or as directed by the Engineer.

All conduit attached aboveground to cabinets, bridges, and other structures shall be secured to the satisfaction of the Engineer.

D2b Underground

Conduit shall be placed by the trenching method, except that the Engineer may direct the Contractor to place conduit under existing pavement by augering, directional boring, or other method approved by the Engineer. If a method other than trenching is used and a distortion in excess of 6 mm (\(\frac{1}{4}\) inch) is created in the existing roadway surface, the Contractor shall remove the distortion and shall restore, at no expense to the Department, the roadway to its original condition.

Conduit shall not be placed under existing concrete or bituminous surfaces or railways by the trenching method or by pushing with pneumatic compaction tools unless authorized by the Engineer. Where conduit is placed below existing roadway pavements by the trenching method, the Contractor shall submit to the Engineer for approval, before starting work, details and description of the planned method of trenching construction including traffic control and restoration of the roadway to its original condition. When augering or boring operations through a roadbed are abandoned for any reason, the resultant voids shall be grouted at no expense to the Department and to the satisfaction of the Engineer.

Where conduit is required to be placed underground below new or reconstructed roadway surface areas or sidewalk, the conduit shall be placed and backfilled by the trenching method to the satisfaction of the Engineer before any new roadway surface or new sidewalk is placed.

Underground conduit shall be placed not less than 450 mm (18 inches) below the surface of any ground area and shall be placed not less than 600 mm (24 inches) below any roadway surface area. All underground conduit placed under railroad tracks shall not be less than 1.10 m (42 inches) below the bottom of the railroad ties or as required by the Railroad Company.
Conduit runs specified in the Contract may be changed, with the approval of the Engineer, to avoid underground obstructions.

Underground conduit placed by the trenching method shall be to a uniform depth below the surface of the adjacent ground line or finished roadway. No conduit shall be placed before inspection of the trench by the Engineer.

Underground conduit runs shall have provisions for drainage of moisture. Horizontal conduit runs shall be sloped to drain at a rate of not less than 0.25 percent (3 inches per 100 feet), and all low points shall be drained. At the low points (not at the open ends of conduit runs) a standard tee conduit fitting shall be installed and a nipple at least 150 mm (6 inches) long shall be extended into a hole approximately 600 by 600 mm (24 by 24 inches) square deep backfilled with crushed rock or approved granular material.

Conduit terminating in handholes or in concrete foundations shall be positioned such that the conduit will be inside the handhole, pole bases, cabinet bases, or structure bases and shall extend from 50 to 75 mm (2 to 3 inches) beyond the top or inside surface of the handhole or concrete foundation and where necessary shall be sloped towards the access opening to facilitate the pulling of cables. The conduit shall be sloped out of the foundation toward the handhole opening for drainage. Conduit couplings shall be located at least 150 mm (6 inches) from the structure surface.

Conduit entering an existing concrete foundation shall be placed by sawing and breaking the concrete in such a manner that the conduit will enter the foundation below the adjacent ground surface and project 25 to 50 mm (1 to 2 inches) above the top of the foundation and inside the pole shaft or cabinet base. The foundation shall be returned to approximately its original form by patching with concrete to the satisfaction of the Engineer.

Conduit to be stubbed out of a concrete foundation for future use shall be threaded and capped on both open ends with standard pipe caps. The conduit shall extend 450 to 600 mm (18 to 24 inches) out from the concrete foundation in the direction specified or as directed by the Engineer.

All open ends of conduits entering a cabinet or pole foundation shall be sealed by use of paraffin or other approved sealing compound following the installation of the cables and conductors.

Conduit Bends

Conduit bends, except factory bends, shall have a radius of not less than 6 times the nominal diameter of the conduit used and shall be made so that the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced.
Bends in runs of conduit shall be held to the minimum required, not to exceed 360 degrees of bend per run between handholes or foundations.

D4 Rigid Steel Conduit and Intermediate Metal Conduit

D4a Joints

The ends of conduit shall be threaded and a standard threaded conduit coupling shall be used to join all standard length conduit. Where standard length conduit is cut, the end shall be threaded and reamed to remove burrs and rough edges. Field cuts shall be made square and true.

All conduit ends joined by coupling shall butt or come together for the full circumference thereof to provide an electrical bonding and grounding connection throughout the entire length of the conduit run.

Coating on the conduit that is damaged by handling or installing, shall be painted with rust preventative paint to the satisfaction of the Engineer.

D4b Open Ends

All open ends of conduit in handholes and conduit extending above any concrete foundation shall be threaded and capped with standard pipe caps, or other method approved by the Engineer, until the wiring is to be installed. When the caps are removed, a grounding type insulated threaded conduit bushing shall be installed on the open ends. The bushing shall be in accordance with the UL Standard 467 for Grounding and Bonding Equipment. The lug shall be compatible with a No. 6 copper bonding conductor. The lug material shall consist of stainless steel, copper, brass, bronze, or be integral to the bushing. The lug and copper bonding conductor at each bushing shall be covered with a corrosion inhibiting compound.

Open ends of conduit terminating on the side of wood poles or other structures shall be capped with weatherhead entrance fittings.

D4c Existing Conduit

Existing underground conduit that is incorporated into a new or revised electrical system shall be cleaned and blown out with compressed air before placing new electrical cables and conductors therein. The Contractor shall replace old grounding bushings and ground wire in existing handholes to maintain a continuously grounded system.

Where a new handhole is to be placed in an existing conduit run, the conduit shall be cut and extended into the new handhole in a manner approved by the Engineer. The open ends of conduits shall be threaded and fitted with grounding type insulated threaded conduit bushings and shall be properly bonded and grounded.
D5  Non-Metallic Conduit

D5a  Joints
The Contractor shall trim the inside and outside of cut ends of non-metallic conduit to remove rough edges. The Contractor shall use standard non-metallic couplings or non-metallic conduit with an attached preformed coupling. The Contractor shall clean non-metallic conduit sections with a joint cleaner and shall cement joints with PVC cement. The PVC cement shall be allowed to set for twenty-four (24) hours before pulling conduit through a directional bored channel. The conduit ends shall butt or come together for the full circumference thereof.

D5b  Open Ends
All open ends of non-metallic conduit shall immediately be capped or plugged to prevent the entrance of moisture until the installation of the electrical cables and conductors. Prior to installation of the electrical cables and conductors, the non-metallic conduit shall be furnished with standard non-metallic conduit bell ends to prevent damage to the electrical cables and conductors.

Open ends of non-metallic conduit not containing electrical conductors shall be capped or plugged utilizing standard non-metallic conduit caps or plugs.

D5c  Conduit Encasement
If specified in the Contract, non-metallic conduit placed by the trenching method shall be granular encased or concrete encased. Granular encased non-metallic conduit shall have the bottom and sides of the trench free of sharp irregularities before the conduit is placed. The trench shall be backfilled the first 150 mm (6 inches) with granular material conforming to 3149.2K. Concrete encased non-metallic conduit shall have the trench width extend approximately 75 mm (3 inches) from each side of the conduit. Concrete shall be Mix No. 3A32 or equal and shall encase the conduit approximately 75 mm (3 inches) on all sides.

D6  Conduit Attached to a Bridge
Conduit shall be mounted and attached to the satisfaction of the Engineer. Conduit supports and spacing of the supports shall be as required by the NEC. Hangers or pipe clamps shall be used for supporting conduit and shall be approved by the Engineer before installation. The hangers or pipe clamps shall be attached using two unit threaded bolt anchorages conforming to the Contract or, if not specified, be approved by the Engineer. The required hardware shall permit removal of the hanger or pipe clamp and shall be installed to permit conduit expansion and contraction.
Expansion fittings shall be furnished in conduit runs attached to a bridge as required by the NEC or as directed by the Engineer. RSC or IMC conduit runs with expansion fittings installed shall be made electrically continuous by a copper bonding jumper having the ampacity as required by the NEC. The bonding jumper shall be internal to the expansion fitting.

E  Handholes

The Contractor shall install handholes as specified in the Contract to the satisfaction of the Engineer. It is the Contractor's option to install additional handholes to facilitate the work at no expense to the Department.

The tops of handholes shall be set so that the cover is 25 mm (1 inch) below grade, except in sidewalk areas, where the cover shall be flush or as directed by the Engineer.

To facilitate drainage, handholes shall be set on a 1 m (3 foot) diameter or square by 300 mm (12 inches) deep aggregate drain bed using 3149.2H coarse filter aggregate.

The Contractor shall remove any excess material inside of existing handholes that are to be used in the new system.

After handhole and conduit installation at each handhole location, all inside handhole sidewalls shall be made as watertight as possible by patching with either concrete for pre-cast concrete handholes, or material compatible caulking compound or other compatible sealing material for PVC Handholes, all to the satisfaction of the Engineer.

Pre-cast concrete handholes with Type HD or other type metal frames and covers required to be placed in areas not surfaced with concrete shall be supported by concrete to the satisfaction of the Engineer. Other type handholes with metal frames and covers are not required to be supported by concrete unless otherwise indicated in the Contract.

F  Concrete Foundations

F1  General

Concrete foundations shall be constructed in accordance with the applicable provisions of 2411 and shall be of the size and shape as specified in the Contract.

Concrete foundations shall be formed (except portions of concrete foundations that extend into solid rock) by using forming tubes or wood forms that shall be true to line and grade. Where soil conditions permit, the Engineer may allow the foundation to be cast with forms or tubes used only on the upper portion of the foundation. Forms shall be rigid and securely braced. Entering conduits, anchor rods, ground rods, etc., shall be placed in proper position and to the proper height, and shall be
Forms shall not be removed until the concrete has cured. The concrete shall be consolidated by means of portable vibrators supplemented by hand spading to ensure a smooth dense surface free of air or water blisters.

Where unstable foundation conditions are encountered, concrete foundation construction may be altered to secure a stable foundation to the satisfaction of the Engineer. Where obstructions (such as solid rock) prevent construction of a concrete foundation as planned, foundation dimensions may be adjusted, as indicated in the Contract, or as the Engineer determines appropriate, to provide a stable foundation.

Concrete foundations shall have an ordinary surface finish conforming to 2401.3F on all sides to approximately 150 mm (6 inches) below the adjacent ground line. The top shall be floated smooth and the edges shall be beveled or chamfered to present a neat appearance.

The exposed concrete above the adjacent ground line, sidewalk, or paved area shall be formed to present a neat appearance and shall be treated with treating oil conforming to 3917.

**F2 Anchor Rods**

In pole foundations, the anchor rods shall be held in a rigid cage in a manner acceptable to the Engineer to maintain good alignment while the concrete is being poured. The anchor rod cage shall be designed without welding or tack welding on the anchor rods. Anchor rods that show evidence of welding or tack welding will be rejected. An accurate template shall be provided for the anchor rod projections. The template shall be left in place until the concrete has cured. Work shall not start on the concrete foundation until the anchor rods have been approved by the Engineer. Foundations in which anchor rods are improperly aligned after the concrete has cured will be rejected. Bolt holes in transformer bases shall not be enlarged to allow for shifted anchorages.

**G Loop Detectors**

Each loop detector shall be an inductive loop detector. One complete loop detector installation shall consist of the following:

(a) An electrical conductor embedded loop or group of loops installed in the roadway as required by the Contract, and

(b) A loop detector lead-in cable to the traffic signal cabinet or other cabinet.

(c) Loop detectors shall be either in non-metallic conduit (N.M.C.) or saw-cut in the roadway as required by the Contract.
G2  Installation
(a) NMC Loop Detector
Loop detectors encased in non-metallic (NMC) conduit shall be in accordance with the NMC Loop Detector Details in the Contract.
(b) Saw Cut Loop Detectors
Saw cut loop detectors shall be installed as specified in the Contract and as follows:
In the event that minor adjustments of the size or shape of the loop detector are made in the field by the Engineer, no additional payment will be made to the Contractor for those adjustments.
An individual saw cut shall be made from each loop detector to the conduit leading to the handhole.
Each loop detector shall have 4 turns of wire.

G3  Loop Detector Test Report
The Contractor shall furnish to the Engineer, in triplicate, a signed and dated "LOOP DETECTOR TEST REPORT" for each loop detector and lead-in cable system furnished and installed as part of the Contract with the following information:
(a) Project numbers, intersection, and location identification.
(b) Loop detector number (as shown in the Plans), dimensions of loop detector (width and length in meters) as installed, and number of turns of wire in loop detector as installed.
(c) Continuity Test--Each loop detector circuit shall be tested for continuity at two locations:
(1) Loop detector at the handhole or junction box before splicing with the loop detector lead-in cable (shall have a value less than 0.5 $\Omega$), and
(2) Loop detector and lead-in cable system at the intersection traffic signal cabinet after splicing in the handhole or junction box shall have a value less than 5.0 $\Omega$. The continuity test ohm reading at the intersection traffic signal cabinet shall be greater than the ohm reading measured at the loop detector adjacent handhole or junction box.
(d) Inductance Test--Each loop detector and lead-in cable system shall have an inductance test measured at the intersection traffic signal cabinet. The inductance shall be in the range of from 50 to 900 $\mu$H.
(e) Insulation Resistance Test--An insulation resistance test at 500 V direct current shall be made at the intersection traffic signal cabinet between one loop detector lead-in cable conductor and the "Equipment Ground Bus" in the cabinet. The insulation resistance shall have a value of not less than 100 $M\Omega$.
NOTE: The continuity test, inductance test, and insulation resistance test shall be made at the intersection traffic signal cabinet
before the loop detector lead-in cable conductors are terminated on the terminal facilities.

The three final loop detector test reports for the intersection will be distributed by the Engineer as follows:
(a) Original report to the official Project file.
(b) Copy in the traffic signal cabinet.
(c) Copy to the Department's Electrical Services Unit or maintaining agency.

All loop detector tests shall be made by the Contractor, in the presence of the Engineer, at no expense to the Department. Loop detector tests shall demonstrate to the satisfaction of the Engineer that the materials and installation of each loop detector and lead-in cable system are in accordance with the Contract. The Contractor shall provide the electrical instruments, apparatus, tools, and labor as may be necessary to make the required loop detector tests on each loop detector and lead-in cable system. Such electrical instruments, apparatus, and tools shall remain the property of the Contractor after the tests are completed.

In the event that a loop detector or lead-in cable system fails any one of the above-mentioned loop detector tests, the Engineer may direct the Contractor to replace any part of or the entire loop detector and lead-in cable system, all at no expense to the Department. All of the above-mentioned loop detector tests shall be repeated and recorded for the "revised" loop detector and lead-in cable system.

Each loop detector and lead-in cable system furnished and installed as part of the Contract shall pass the above-mentioned loop detector tests and be operational to the satisfaction of the Engineer. These tests shall not preclude the Department from testing each loop detector and lead-in cable system with their own test equipment to ensure proper operation.

H Bonding and Grounding

All bonding, grounding, ground rod electrodes, grounding electrode conductors, and grounding connections shall be in accordance with the NEC.

All ground rod electrodes required by the Contract shall be at least 16 mm (5/8 inch) in diameter by 4.6 m (15 feet) in length and fabricated of a material as specified in the NEC.

Metal conduit, metal traffic signal pedestals, mast arm pole standards, light standards, service equipment, metal junction boxes, down guys, span wire, microwave and sonic detector units, traffic signal cabinet or other type cabinet, etc., shall be made mechanically and electrically secure to form a continuous bonded grounded system. The bonding and grounding jumper shall be a copper conductor no less than
No. 6. Grounding of the system and neutral at the service point shall be as required by the NEC, except that the grounding electrode conductor shall be not less than a No. 6.

Attachment of the grounding and bonding jumper to metal traffic signal pedestals, mast arm pole standards, and light standards shall be by means of a 5 mm (\(3/16\) inch) (or larger) brass, bronze, or stainless steel bolt installed in the lower part of the shaft or base. A solder or sheet metal strap connection shall not be used.

In addition to the bonding and grounding provisions described above, if the Plans utilize traffic signal cables with a green conductor, then the green conductor shall be used as an equipment ground. The green conductor of each traffic signal cable shall be attached in a similar manner as the grounding and bonding jumper to the lower part of all metal traffic signal pedestal and pole shafts or bases in which the run of cable terminates. An "Equipment Ground Bus", separate from the neutral terminal strip, will be provided in the traffic signal cabinet or other type cabinet and the green conductor of each traffic signal cable shall be terminated on the "Equipment Ground Bus". The "Equipment Ground Bus" shall be grounded to the cabinet ground rod electrode (if ground rod electrode installed) with not less than a No. 6 grounding electrode conductor.

A No. 6 equipment grounding conductor shall be furnished and properly connected from the "Equipment Ground Bus" in the traffic signal cabinet or other type cabinet to the neutral bonding bar of the service equipment and to each incoming conduit grounding bushing lug.

Ground rod electrodes shall be driven at all service points, at all cabinet locations housing control equipment and electrical equipment, and at locations specified in the Contract. Ground rod electrodes and grounding connections shall be installed in accordance with the NEC. The top of the ground rod electrode installed in the ground shall be level with the surface of the adjacent ground. Where installed in a concrete foundation, the top of the ground rod electrode shall extend not more than 75 mm (3 inches) nor less than 50 mm (2 inches) above the foundation. The service equipment shall be bonded to the ground rod electrode by use of a ground clamp and a No. 6 grounding electrode conductor. If the grounding electrode conductor is in a location subject to physical damage, it shall be enclosed in a 13 mm (½ inch) diameter rigid steel conduit.

Where a bonded grounded continuous rigid steel conduit system is not installed, metal poles, pedestals, cabinets, and other structures requiring a ground rod electrode shall be bonded to the ground rod electrode by a No. 6 grounding electrode conductor enclosed in a 25 mm (1 inch) diameter rigid steel conduit stubbed out of the concrete.
foundation. One end of the bonding jumper shall be attached to the lower part of the pole, pedestal, cabinet, or structure shaft or base and the other end attached to the ground rod electrode by a grounding connection.

For bonding and grounding in all non-metallic conduit systems, an equipment grounding conductor shall be run with all electrical circuits. The equipment grounding conductor may be one conductor of a multi-conductor cable, or, where no cables within the conduit run contain an equipment grounding conductor, a No. 6 green, equipment grounding conductor shall be installed in the conduit run. Where non-metallic conduit is to be installed for future use, the equipment grounding conductor may be omitted.

In addition to the required bonding and grounding jumper and required threaded grounding conduit bushings on open ends of new conduit, the Contractor shall, at the in-place locations directed by the Engineer, furnish and install new bonding and grounding jumpers and new threaded grounding conduit bushings on open ends of in-place conduit.

Installation of electrical cables and conductors and all electrical wiring shall be in accordance with the NEC.

Insulated spade lugs shall be used for terminal connections of conductors.

The ends of all spare electrical conductors not terminated shall be taped to exclude moisture.

Approximately 1 m (3 feet) of slack cable shall be left in each handhole through which a run of cable passes.

Approximately 600 mm (24 inches) of slack cable shall be left in each mast arm pole base, light standard base, and traffic signal pedestal base.

The Contractor shall install unmetered service conductors in a separate conduit system from all other conductors. All conductors of a branch circuit shall be run in a single conduit.

All electrical cables and conductors shall be run continuous without splices from the terminal appliances in the traffic signal cabinet to the terminal blocks or terminal appliances in mast arm pole bases, pedestal bases, junction boxes, etc.

Loop detector lead-in cable shall be installed continuous without splices or terminals from the loop detector conductor and lead-in cable splice to the traffic signal cabinet or other type cabinet.
Interconnect cable between cabinets shall be continuous without splices and shall be run in as straight a line as possible with a minimum number of bends in the cable run.

The size and number of conductors in each cable and the number of cables in a given conduit run shall be furnished exactly as shown in the Plans. For example, the notation on the Plans "2-3/c No. 12" requires two 3-conductor No. 12 cables to be installed in the particular conduit run, plus any other cables and conductors indicated in the conduit run. No additional spares are required.

The Contractor shall wire the electrical system in accordance with the field wiring diagram shown in the Plans. Cables shall be identified as shown on the field wiring diagram in all handholes, junction boxes, traffic signal pedestal bases, mast arm pole bases, light standard bases, and the traffic signal cabinet or other type cabinet. Labels to identify cables shall be plastic or cloth adhesive tape that is embossed or printed with numerals and letters and wrapped around the cable. In addition to labeling each cable within the cabinet, the Contractor shall label in a similar manner each conductor of each cable terminated on the fuse panel or a terminal block (i.e. RED 2-1, YEL 2-1, GRN 2-1, RLTA 5-1, YLTA 5-1, GLTA 5-1, RRTA 4-1, YRTA 4-1, GRTA 4-1, DWK P6-1, WLK P6-1, etc., or the like, indicating the signal indication and the signal face number). The label shall be applied within 75 mm (3 inches) of the terminal point. Terminal blocks in traffic signal pedestal bases and pole bases shall have an identification strip as part of the terminal block and each conductor shall be identified in a similar manner as above as to the signal indication it serves.

J2 Underground Wiring

Electrical cables and conductors shall be pulled through rigid steel conduit (R.S.C.) by hand such that no damage is done to the cable and conductor insulation. The conduit shall be clean at the time of installation and the ends of all electrical cables and conductors shall be taped to exclude moisture until spliced or terminated.

The Contractor shall pull cables and conductors through non-metallic conduit (N.M.C.) by hand, in such a manner, as to not split or otherwise damage the N.M.C. conduit due to "pull rope abrasion". If the Contractor damages the N.M.C. conduit, the Contractor shall replace the damaged portion of the N.M.C. conduit to the satisfaction of the Engineer.

Interconnect cable not placed in conduit shall be placed direct buried by the trenching method or plowing method to a minimum depth of 915 mm (36 inches), except where required to enter a handhole. Interconnect cable entering a handhole shall be installed in the side of the handhole 150-200 mm (6-8 inches) above the bottom of the
handhole [the interconnect cable minimum depth requirement of 915 mm (36 inches) shall be maintained to within 600-915 mm (2-3 feet) of the handhole].

A 75-mm (3-inch) wide, permanent orange, stretchable, non-biodegradable, plastic warning tape shall be placed a minimum of 460 mm (18 inches) above the interconnect cable (or conduit containing the interconnect cable) and at least 300 mm (12 inches) below the surface. The tape shall be imprinted with the inscription: CAUTION - Mn/DOT COMMUNICATION CABLE BELOW.

The Contractor shall sleeve direct buried cable that enters or exits handholes.

J3 Cabinet Field Lead Wiring

No field lead entering a traffic signal cabinet or other type cabinet shall be cut shorter than the farthermost terminal in the cabinet. After all field connections are made to the cabinet terminal facilities, field leads shall be neatly dressed and banded together to provide an orderly arrangement within the cabinet.

J4 Splices

No splices will be permitted that are not called for in the Contract or authorized in writing by the Engineer. When splices are authorized, they shall be permitted only in handholes, control cabinets, junction boxes, or in bases of poles, unless the Contract requires underground cable splices. When underground cable splices are specified, they shall be made with an approved epoxy splice kit.

All splices of conductors and cables shall be good quality electrical splices and shall be waterproof. Splices, except loop detector splices, shall be electrically and mechanically secure without solder, and shall utilize split bolt connectors, or other type connectors as specified in the Contract. Pressure spring type connectors shall not be used. Loop detector splices shall be as specified in 2565.3G (Loop Detectors).

All spliced conductors, except grounding wires, shall be taped with rubber tape (except as otherwise specified in the Contract) to a thickness of at least 1.5 times that of the original insulation. Two layers of protective plastic electrical tape shall be applied over the rubber tape and extend at least 25 mm (1 inch) over the regular conductor insulation. The entire splice shall be made waterproof with waterproofing electrical coating.

Where the Contract requires splices between aluminum and copper conductors in a temporary system, the connectors shall be UL listed for use with the cable materials and for the conditions of use, and shall be designed so that there is no direct contact between the aluminum and copper conductors. Terminals for terminating the aluminum conductors
shall be UL listed for use with aluminum wire. The connections shall be tightened to the manufacturer recommended torque.

J5 Terminal Blocks

Each mast arm pole base, traffic signal pedestal base, light standard base, etc., with vehicle and pedestrian signal indications or pedestrian signal indications, shall have a terminal block for terminating field conductors and traffic signal conductors.

Each terminal block shall be a one-piece phenolic molding with 12 double-point terminals with strap screw contacts for size 10-32 binder head screws. Barriers between terminals shall be minimum 13 mm (\( \frac{1}{2} \) inch) in height. The holes for the binder head screws shall not extend through the plastic. The slots shall be of sufficient size to fit the spade lugs used for terminating conductors.

Each terminal block shall meet 600 V requirements of NEMA and UL for general industrial control devices.

The terminal blocks, screws, and spade lugs in each base shall be covered with an approved electrical insulating coating as specified in the Contract. The Contractor shall remove the white plastic marking strip from the terminal block before application of the electrical insulating coating and reinstall the white plastic marking strip after the coating of the terminal block is complete.

Terminal blocks in bases shall be installed in such a manner that the terminal block screws face the door opening and are accessible.

J6 Aboveground Wiring

All electrical cables and conductors installed aboveground, except where run on overhead span wire, shall be installed in conduit attached to wood poles, metal poles, cabinets, or other structures, or shall be run inside metal poles, pedestals, cabinets, or other structures.

The Contractor shall provide slack (generally 5 percent of the span length) where electrical cables and conductors are installed overhead unsupported and spanned between wood poles or other type supports. Electrical cables and conductors installed overhead in conjunction with a messenger wire shall be attached to the messenger wire using metal or sunlight resistant nonmetallic straps (maximum spacing 450 mm (18 inches) or lacing. All nonmetallic straps shall be approved by the Engineer.

K Service Equipment Installation

Service equipment installation shall be in accordance with the NEC and local laws and ordinances governing such installations.

The service point shown in the Plans is approximate. The exact location will be determined in the field by the power company or the Engineer.
For installation on a wood pole, the Contractor shall install the meter socket at an appropriate height directly above the disconnecting means. Service conduit risers shall terminate near the top of the wood pole or structure and shall be capped with a weatherhead to prevent the entrance of water. Sufficient length of power conductors shall extend beyond the weatherhead (including a sufficient drip loop) for connection to the power conductors from the source of power, which connection will be made by the power company at no cost to the Contractor, unless otherwise specified in the Contract.

For installation on a mounting bracket assembly, the meter socket and disconnecting means shall be located as detailed in the Contract. The Contractor shall install signal service cabinets as specified in the Contract.

Lugs for terminating conductors shall be sized appropriately for the associated conductors. Trimming strands of conductors to fit into undersized lugs is not acceptable.

The Contractor shall make all arrangements with the power company for power connection.

L  Vehicle and Pedestrian Signal Face Installation

L1  Pedestal Mounted (With Signal Bracketing)

Vehicle signal faces and pedestrian signal faces required to be mounted atop a traffic signal pedestal shall be mounted as specified in the Contract. The pedestal mounted assemblies shall be plumb or level, symmetrically arranged, securely assembled and provide for internal wiring within the pedestal shaft signal brackets and pipe fittings.

A one-way pedestal mounted vehicle signal face shall be mounted directly above the pedestal slipfitter collar and shall have a bracket attached to the top of the vehicle signal face and to the pedestal shaft.

L2  Vertical Pole Shaft Mounted (With Signal Bracketing)

Vehicle signal faces and pedestrian signal faces required to be mounted on a vertical pole shaft shall be mounted as specified in the Contract. Threaded 38 mm (1 ½ inches) half-couplings shall be welded into the vertical pole shaft approximately 3 m (10 feet) above the pole foundation. The threaded couplings shall be capable of receiving threaded 38 mm (1 ½ inch) signal brackets and shall provide for internal wiring within the vertical pole shaft. Threaded couplings shall be positioned on the vertical pole shaft as specified in the Contract.

Vehicle signal faces and pedestrian signal faces shall be mounted as specified and all pole mounted assemblies shall be plumb, securely assembled, and provide for internal wiring within the vertical pole shaft, signal brackets, and pipe fittings.
Vertical Pole Mounted (With One Way Mounts)

Vehicle and pedestrian signal faces mounted on vertical pole shafts shall be mounted plumb utilizing signal head mounts.

Two vehicle signal sections shall be mounted below the mount and the remaining vehicle signal sections mounted above. The two signal sections below the mount and the signal sections above the mount shall be fastened together and shall be fastened to the mount by means of a noncorrosive 3-bolt mounting assembly. The 3-bolt mounting assembly shall utilize locknuts to prevent the assembly from loosening due to vibration.

The pedestrian indication shall be mounted below the one way mount by means of a noncorrosive 3-bolt mounting assembly. The indication shall be attached to the one way mount by utilizing a 3-bolt sealed cap assembly. The 3-bolt mounting assembly shall utilize locknuts to prevent the assembly from loosening due to vibration.

Pedestal Mounted (With One Way Mounts)

Vehicle and pedestrian signal faces mounted on vertical pole shafts shall be mounted plumb utilizing signal head mounts. Two vehicle signal sections shall be mounted below the mount and the remaining vehicle signal sections mounted above. The two signal sections below the mount and the signal sections above the mount shall be fastened together and shall be fastened to the mount by means of a noncorrosive 3-bolt mounting assembly. The 3-bolt mounting assembly shall utilize locknuts to prevent the assembly from loosening due to vibration.

The pedestrian indication shall be mounted below the one way mount by means of a noncorrosive 3-bolt mounting assembly. The indication shall be attached to the one way mount by utilizing a 3-bolt sealed cap assembly. The 3-bolt mounting assembly shall utilize locknuts to prevent the assembly from loosening due to vibration.

Mast Arm Mounted

Vehicle signal faces mounted on traffic signal mast arms, either at the extended end of the mast arm or at mid-arm, shall be mounted plumb utilizing signal head mounts. Two signal sections shall be mounted below the mount and the remaining signal sections mounted above.

The two signal sections below the mount and the signal sections above the mount shall be fastened together and shall be fastened to the
mount by means of a noncorrosive 3-bolt mounting assembly. The 3-bolt mounting assembly shall utilize locknuts to prevent the assembly from loosening due to vibration.

The vertical clearance from the bottom of the signal heads (including the background shields) to the pavement shall not be less than seventeen (17) feet nor greater than nineteen (19) feet.

L6 Bagging
The Contractor shall bag all vehicle signal faces and pedestrian signal faces immediately after installation (until such time that the traffic control signal is to be placed in operation) to clearly indicate that the traffic control signal is not in operation. All bagging material shall be “gunnysacks”, or other material as approved by the Engineer. The Contractor shall maintain all bagging to the satisfaction of the Engineer.

M Wood Pole Installation
Wood poles shall be placed in the ground to a depth of approximately 20 percent of the pole length. Excavations should be approximately 200 mm (8 inches) larger than the diameter of the base of the pole and free from loose material. The pole shall be hoisted into place without damage and plumbed or raked as directed by the Engineer. Backfill material shall be selected earth or sand and free from rocks and excessive organic material and placed in several lifts. Each lift shall be moistened and thoroughly compacted. The placed wood pole shall not display a void area between the wood pole and backfill at the ground plane when placed under load.

N Traffic Signal Pedestal Installation
The Contractor shall plumb with "U" shaped galvanized metal shims or metal shims as approved by the Engineer and securely bolt Traffic signal pedestals to the cast-in-place anchor rods of the concrete foundations.

O Blank

P Mast Arm Pole Standard Installation
Mast arm pole standards shall be hoisted into position without damage and plumbed by means of the two nuts and washers on each anchor rod to ensure that the pole face opposite the arm is vertical. Enlargement or alteration of holes in the base plate to accommodate misaligned anchorages will not be permitted.

The transformer base access door shall be placed 180 degrees from the mast arm.

Mast arms, brackets, and other appurtenances to be attached to the vertical pole shaft shall be placed without damage.

Any damage (such as nicks, scratches, and paint removal) shall be repaired and restored to original condition as specified in the Contract. Other damage shall be repaired to the satisfaction of the Engineer.
Q  Sign Installation

Q1  Pedestal or Pole Shaft Mounted
   Each pedestal or pole shaft mounted sign shall be furnished with two standard sign mounting bracket assemblies utilizing a minimum 19 mm (¾ inch) wide stainless steel banding and shall be mounted on the pedestal or pole shaft at the height as directed by the Engineer. At the option of the Engineer, the Contractor shall drill and tap shaft and mount signs to the satisfaction of the Engineer.

Q2  Mast Arm Mounted
   Each mast arm mounted sign shall be furnished with mast arm mounting bracket assemblies in accordance with the mast arm sign mounting details in the Mn/DOT Standard Signs Manual and mounted at the specified location on the mast arm to the satisfaction of the Engineer.

Q3  Sign Post Mounted
   Each sign post mounted sign panel shall be mounted utilizing U-channel sign posts in accordance with the Contract.

R  Cabinet Installation
   Pad mounted cabinets shall be securely bolted to the concrete foundations to the satisfaction of the engineer.
   The Department will furnish to the Contractor rubber gasket sections that the Contractor shall install between the bottom of the aluminum cabinet base and the concrete foundation. The Contractor shall leave one 13 mm (½ inch) gap in the gasket to ensure proper water drainage.

S  Emergency Vehicle Pre-emption (EVP) Installation
   The Contractor shall install EVP detectors and EVP indicator lamps atop traffic signal mast arms, and if required by the Contract, atop traffic signal pedestal shafts, in accordance with the following provisions:

   (1) The detector, indicator light, wiring, and connections shall be installed in accordance with manufacturer's instructions.

   (2) In the event an obstruction is in line with the detector, the Contractor shall advise the Engineer before installation.

   (3) The detector and indicator light shall be attached to the traffic signal mast arm or traffic signal pedestal shaft to the satisfaction of the Engineer.

   (4) Any extension hardware shall be the same outside diameter as the traffic signal bracketing framework, a reducer conduit fitting shall be used to attach the detector and indicator light assembly to the traffic signal mast arm.

   (5) All extension hardware shall be painted the same color as the traffic signal mast arm. The detector and indicator light assembly
shall not be painted.
(6) All hardware shall be tightened securely.
(7) The detector and indicator light shall be installed and mounted in such a way so as to ensure the watertight integrity of the assembly.
(8) The detector and indicator light combination shall have a vertical separation of approximately 150 mm (6 inches).
(9) The detector shield tube shall be installed with the drain hole at the bottom.
(10) There shall be no detector cable splices from the EVP detector on the mast arm to the traffic signal cabinet.
(11) The detector cable shall be appropriately marked in the traffic signal cabinet as to which street and direction it is associated.
(12) All one-way or two-way EVP detectors and one-way or two-way EVP indicator lights shall be operational when the signal system is initially turned on.

**Painting**

Painting metal structures and metal component parts of a traffic control signal system shall conform to all applicable provisions of 2478. Finish coat paint shall be as follows:

1. Dark Green Acrolon 218 or approved equivalent polyurethane finish coat matching Color Number 14062 of the Federal Standard 595B shall be applied on the traffic signal pedestal bases and mast arm pole standard transformer bases.
2. Yellow Acrolon 210 or equivalent polyurethane finish coat matching color Number 13538 of the Federal Standard Color 595B shall be applied on vehicle and pedestrian signal indication housings, mast arm pole standard vertical pole shafts, traffic signal pedestal shafts, pedestal slipfitter collars, pedestal reinforcing collars (wind collars), all signal brackets and pipe fittings, and pedestrian push button stations.
3. Corothane I Mio Aluminum Paint or equivalent moisture-cured polyurethane finish coat shall be applied on mast arm pole vertical shafts, traffic signal mast arms, luminaire vertical pole shaft extensions, and luminaire mast arms.
4. Dull Non-Reflective Black on visors, directional louvers, background shields, and vehicle and pedestrian signal indication housing doors (inside and outside).

In lieu of field painting, equivalent manufacturer's shop coat paint may be accepted by approval of the Engineer, with field touch-up of damaged portions of the finish. If a manufacturer's shop coat paint is accepted or specified in the Contract, the Contractor shall make every effort during installation to protect the factory applied finish. Any nicks, scratches, paint chips or other damage to the finish shall be
2565.3

Mast arm pole standards (includes vertical pole, mast arm, transformer base, and luminaire extension) shall be painted at the manufacturer. Any protective wrap provided by the manufacturer during shipping shall be removed immediately after receipt of the shipment on the project. The Contractor shall make every effort during erection of a painted mast arm pole standard to protect the factory applied finish. The collar used for handling the pole shall be of a material that will ensure protection of the painted finish of the pole. Field painting of mast arm pole standards, other than touch up painting, shall not be permitted. Any nicks, scratches, paint chips or other damage to the finish shall be repaired and restored using the touch up paint provided by the Manufacturer. All touch up painting shall be to the satisfaction of the Engineer.

Existing Materials and Electrical Equipment

U Removing and Salvaging
Where required by the Contract, or directed by the Engineer, materials and electrical equipment of an existing electrical system shall be removed and salvaged in accordance with 2104 and as specified in the Contract. Care shall be exercised in removing salvageable materials and electrical equipment so that they will remain in their existing condition.

Materials and electrical equipment of an existing electrical system required to be removed, but not salvaged, shall become the property of the Contractor and shall be disposed of outside the Right of Way in any manner that the Contractor may elect, subject to 2104.3C3, and as specified in the Contract.

U Reinstalling
Where salvaged materials and electrical equipment are to be reinstalled at new locations, the Contractor shall furnish and install all necessary new materials, such as anchor rods, nuts, and washers, concrete foundations, etc., required to complete the new installation.

Existing materials and electrical equipment required to be removed, salvaged and reused, but found to be unsatisfactory for reuse by the Engineer, shall be replaced by new materials and electrical equipment, the cost of which will be paid for as Extra Work in accordance with 1403.

U Stockpiling
Materials and electrical equipment of an existing electrical system required to be removed and not reused may be stockpiled at the job site until removed outside the Right of Way. Stockpiling shall be in an acceptable manner approved by the Engineer.
V Field Testing
Before completion of the work, the Contractor shall make a functional test in which it is demonstrated to the Engineer that each and every component part of the traffic control signal functions as specified or intended. The Contractor shall not place the traffic control signal in operation until all required field tests have been completed and accepted.

Before final acceptance of the work, the Contractor shall furnish to the Engineer and all manufacturers' warranties, instructions, wiring diagrams, etc., of the materials and electrical equipment furnished by the Contractor.

W Activating Signals
When the traffic control signal system is to be placed in operation, all vehicle signal faces and pedestrian signal faces shall be aimed as directed by the Engineer. The Contractor shall notify the Engineer at least 48 hours in advance of the scheduled traffic signal turn-on.

If directed by the Engineer, the Contractor shall initially place the traffic control signal in the flashing mode of operation for a period of time determined by the Engineer. Upon completion of the period of flashing mode operation, and when directed by the Engineer, the Contractor shall place the traffic control signal in its normal mode of operation. The Contractor shall not turn the signal system ON or OFF without the specific approval of, and in the presence of the Engineer.

X Restoration and Cleanup
Sidewalks, curbs and gutters, pavements, base materials, sod, plants, and other items removed, broken, or damaged by the Contractor's construction operations shall be replaced or reconstructed with the same kind or type of original material or material of equal quality. The reconstruction work shall be done in an acceptable manner for the class or type of work involved and shall be undertaken and completed as soon as practicable. All reconstruction work shall be maintained by the Contractor in a satisfactory condition until final acceptance.

2565.4 Method of Measurement
The new traffic control signal system will be measured as an integral unit complete in place and operating with the complete installation at one intersection being considered as one unit.

2565.5 Basis of Payment
A new traffic control signal system will be paid for on the basis of the following:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
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<tbody>
<tr>
<td>2565.511</td>
<td>Traffic Control Signal System</td>
<td>................................</td>
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661
Plant Installation

2571.1 DESCRIPTION
This work consists of furnishing and planting trees, shrubs, vines, and perennials of the species, variety, grade, size, or age, and root category specified, complete in place at the locations designated in the Plan or as directed by the Engineer. It may also consist of planting or transplanting plants furnished by the Department.

The Contractor shall become familiar with the Project site and the Contract documents before submitting a Proposal, as specified in 1205 (Examination of Plans, Specifications, Special Provisions, and Site Work).

The Contractor shall comply with the current edition of "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects," published by the Mn/DOT Landscape Unit, as the minimum and maximum criteria and standard for all operations.

2571.2 MATERIALS
A Nursery Plant Stock ................................................... 3861

Plants of the species specified shall be furnished in the variety, grade, and size, or age indicated.

A1 Supply of Planting Stock

By submitting a Proposal and accepting award of the Contract, the Contractor acknowledges investigating the supply of planting stock, obtaining firm commitments from suppliers, and assuring delivery of the specified plant stock as required to complete the Contract.

A2 Plant Stock Documentation
As a condition for delivery and approval of the plant stock, the Contractor shall furnish the Engineer with:

(a) A copy of a valid nursery stock (dealer or grower) certificate registered with the Minnesota Department of Agriculture and/or a current nursery certificate/license from a state or provincial department of agriculture for each plant stock supplier.

(b) A Mn/DOT Certificate of Compliance for Plant Stock, Landscape Materials, and Equipment (preliminary and final, with all revisions). The Certificate of Compliance shall state the species, sizes, quantities furnished, and name and location of the original source (nursery growing operation), in accordance with 1603 (Materials: Specifications, Samples, Tests, and Acceptance).

(c) A copy of the most recent Certificate of Nursery Inspection for each plant stock supplier.

(d) All plant material shipped from out-of-state nursery vendors subject to quarantines (Gypsy moth and Japanese beetle) must be accompanied by current documentation certifying that all plants...
shipped are free from regulated pests. To determine if Minnesota vendors are subject to quarantines, call the MDA Supervisor of Plant Regulatory Services at 651-296-8388.

(e) Bills of lading (shipping documents) for all plant stock and landscape materials delivered to the Project.

(f) Invoices (billing statements) for all plant stock and landscape materials used on the Project.

  The required documentation shall verify that the plants are in conformance with the Project requirements.

  All required plant stock documentation shall be supplied to the Engineer no later than one week prior to the proposed beginning of planting (exception—bills of lading are required when plants are delivered and invoices are required prior to payment to the Contractor. If the documentation is not supplied as specified, Mn/DOT will assess a daily charge of $200.00, on a calendar day basis, until the Engineer notes compliance or until the eligible 50% of the Contract price for initial plant operations and/or a maximum of 10% of plant establishment operations (for replacement plants) is forfeited. The Contractor shall not start planting operations until the Engineer has reviewed and accepted all required plant stock documentation. Work performed with plant stock, materials, and equipment that are misrepresented on the documentation will be considered unauthorized work.

A3 Substitutions

Substitutions may be allowed in accordance with 1605 (Substitute Materials). However, the Contractor shall provide written documentation that a specified plant is not available (wholly or partially in sufficient quantities to meet contract requirements) from the individual suppliers on the Mn/DOT Partial List of Nursery Stock Growers and Suppliers. The list of nursery stock suppliers can be found in the most current "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects." All substitute plants shall meet the Contract and site requirements. The Engineer may either approve the substitute plant or extend the Contract time to ensure availability of the specified plant.

B Department Furnished Stock and Transplant Stock

Department furnished stock and transplant stock shall be obtained from sources designated in the Plan or Special Provisions.

C Incidental Materials

C1 Soil Additives

  The Contractor may use soil additives to modify the physical, biological, or chemical properties of the soil to enhance plant growth whether specified or not. The Department will not pay for these soil
additives unless the Contractor can demonstrate that unspecified additives are absolutely necessary to ensure plant growth and survival. The Contractor shall submit soil tests, analysis, and recommendations that support the need for the additives and for compensation as Extra Work. If the Engineer approves such soil additives and if the Contractor incorporates the additives into the work, the Contractor will receive compensation based upon the submitted information.

C1a Select Topsoil Borrow ................................................. 3877
C1b Agricultural Lime ......................................................... 3879
C1c Blank
C1d Peat Moss .............................................................. 3880
C1e Fertilizer ................................................................. 3881
C1f Compost ................................................................. 3890
C1g Iron Sulfate

Iron sulfate, used to lower pH, shall be ferric sulfate or ferrous sulfate in pellet or granular form containing not less than 18.5 percent iron expressed as metallic iron. Acceptance will be on the basis of information contained on the product label.

C1h Activated Charcoal

When activated charcoal is used to neutralize or deactivate residual organic pesticide or chemical contaminants in the soil, the Contractor shall use ordinary charcoal, finely ground to increase absorptive surfaces, and electrically charged to attract the molecules of organic chemicals. The Engineer will accept the charcoal on the basis of information provided by the product label and the manufacturer’s recommendations.

C1i Biological Soil and Root Hormones and Inoculants

Soil and root hormones and inoculants, used to modify the biological characteristics of poor soils by balancing or managing the rhizosphere, will be accepted based on the information provided by the product label and the manufacturer’s recommendations.

C1j Porous Ceramics and Hydrophilic Polymers

Porous ceramics and hydrophilic absorbing polymers, used to modify the physical characteristics of poor soils by balancing water and oxygen in the soil, will be accepted based on the information provided by the product label and the manufacturer’s recommendations.

C1k Fertilizer

Refer to the Plan and special provisions for fertilizer requirements.

C2 Water

Water shall be free of oil, acids, alkalis, salts, and other substances harmful to plants. Water suitable for human consumption will be acceptable without testing. Water from streams, ponds, and lakes shall
not be used without the Engineer’s approval. When the Engineer requires testing, an approved testing laboratory shall perform the tests at no expense to the Department.

C3  Mulch, Type 6 ............................................................. 3882

C4  Rodent Protection

Rodent protection consists of 6 mm (¼ inch) grid welded and galvanized wire mesh (hardware cloth) formed in a double-layered 375 mm (15 inch) diameter cylinder. The Contractor shall place and secure the rodent protection with a 25 by 25 mm (1 inch by 1 inch) heartwood white oak stake to the height shown in the Plan.

C5  Wound Dressing

Wound dressing material shall be latex paint, shellac, or other acceptable material suitable to brush or spray on bruised, abraded, wounded, or cut plant surfaces, as approved by the Engineer. The paint color shall blend with the bark color.

C6  Tree Paint

Tree paint consists of undiluted exterior grade white latex paint, as approved by the Engineer.

C7  Staking and Guying

Staking and guying shall be as shown in the Plan. Posts and straps shall be uniform in style and color. The guying straps shall be non-abrasive to the tree and provide equal tension through the length and width of the straps.

C8  Seedling Tree Shelters

Shelters for seedling trees shall be from the approved list that is on file with the Mn/DOT Landscape Unit. The shelter shall be a seamless, extruded, twin-wall, rigid copolymer polypropylene tube with a laser-line perforation. The shelter material shall be beige-colored, 30 to 40 percent translucent, and resistant to sunlight decomposition for a minimum of 5 years. The shelter shall have a flared top rim, formed stake recess, photo-degradable mesh sleeve covering, and shall conform to the height and diameter as shown in the Plan. The Contractor shall install the shelters with 25 by 25 mm (1 inch by 1 inch) heartwood white oak stakes as shown in the Plan.

C9  Replacements

Replacements consist of plants or incidental materials required to replace dead, defective, or missing plants and incidental materials. The quality of replacements shall be equal to or better than the initially specified material.

C10  Miscellaneous Materials and Equipment

Miscellaneous materials and equipment consists of preparatory work, staking items, herbicides, insecticides, fungicides, and equipment
necessary to install plants as specified and to maintain plants in a healthy and vigorous condition, free from weed encroachment.

2571.3 CONSTRUCTION REQUIREMENTS

A General

An Mn/DOT Certified Landscape Specialist shall be on the Project site at all times to perform or directly supervise the plant installation and establishment, together with all other incidental work. The certification is obtained by completing a 1-day Mn/DOT Landscape Project Installation, Inspection, and Administration training class and passing a take-home test provided by the Mn/DOT Landscape Unit. The certification is valid for 3 years. At least one owner or operations manager of the general contracting firm and the landscape subcontracting firm shall hold valid Mn/DOT certification. The Contractor shall provide experienced crews working under the direct supervision of the certified specialist.

The Contractor shall conduct temporary vegetation protection measures in accordance with 2572 (Protection and Restoration of Vegetation) as incidental work. However, the Department will make payment for protection of specimen, high value, threatened, or endangered vegetation when a bid item is indicated in the Plan.

The Contractor shall conduct temporary erosion control measures in accordance with 2573 (Storm Water Management) as incidental work. The Contractor will not receive compensation for restoring areas damaged by erosion, sedimentation, and other causes when the damage results from the Contractor's operations, neglect, or failure to implement adequate temporary erosion control measures. However, the Department will make payment to prevent serious erosion and sedimentation when a bid item is indicated in the Plan or when the damage is not the result of the Contractor's neglect or operations.

A1 Definitions

A1a Preparatory Work

Preparatory work involves:

1) Attending a Preconstruction Conference.

2) Submitting completed Preconstruction documentation to the Engineer at, or prior to, the Preconstruction conference. If the documentation is not supplied as specified, Mn/DOT will assess a daily charge of $200.00, on a calendar day basis, until the Engineer notes compliance, or until the eligible percentage of the contract amount for Preparatory Work has been forfeited.

Preconstruction documentation includes:

a. A preliminary Mn/DOT Certificate of Compliance for all Plant Stock, Landscape Materials, and Equipment (2571.A2(b)). The
Contractor's authorized representative shall sign the Certificate of Compliance.

b. A copy of a valid nursery stock dealer or grower certificate registered with the Minnesota Department of Agriculture.
c. A preliminary progress schedule.

3) Mobilizing for work on the site, including moving equipment and supplies to the Project site.

4) Protecting or staying away from existing plants in accordance with 1712 (Protection and Restoration of Property), 2031 (Field Office and Laboratory), 2557 (Fencing), and 2572 (Protection and Restoration of Vegetation) during all operations.

The Contractor shall obtain the Engineer's approval before moving equipment and supplies (including mulch and other incidental items) to the Project site prior to performing any work on the site.

A1b Preparation of Planting Holes and Beds

The preparation of planting holes and beds involves:
1) Layout staking of planting beds and isolated plant locations.
2) Applying herbicide and/or conducting other weed control operations.
3) Cultivating the soil and incorporating additives to improve soil properties and drainage.
4) Providing temporary erosion control measures.

A1c Initial Planting Operations

The initial planting operations involves:
1) Providing required plant stock, materials, and equipment that meet all the Contract requirements. Provide plant stock documentation as specified in 2571.2A2.
2) Digging planting holes.
3) Installing plants and required soil and/or root additives.
4) Conducting initial watering.
5) Placing mulch.
6) Protecting plants: including placing rodent guards, staking and guying plants, painting trees, installing seedling tree shelters, and conducting continuous weed control.
7) Cleaning up and Restoring the Project site.
8) Repairing the Project site.

A1d Blank

A1e Plant Establishment Period

The plant establishment period is 2 calendar years from the date all of the initial planting operations on the Project are completed, unless specified otherwise. The work during this period involves watering, weed control, turf maintenance, replacing unacceptable material and plants, and other incidental plant care necessary to protect and establish
plants. Establishment operations shall prevent rutting or include repairing rutting and other damage that may lead to soil erosion and weed infestation.

A2  Plant Layout

The planting locations and layouts shown in the Plan are approximate. The Contractor shall stake the exact locations and layout for the Engineer's approval. In order to remedy localized problems and seasonal conditions that may hinder plant establishment, according to the species and locations specified, the Contractor may request approval to relocate plantings, to make plant substitutions, or to modify soil or drainage characteristics.

The Contractor shall locate plantings:

a. So that a minimum sight distance of 360 m (1200 feet) exists in front of all traffic signs and extends 15 m (50 feet) beyond the sign.

b. So that trees remain outside of the safety clear zones, safety sight corners, and sight lines, all in accordance with the Plan as directed by the Engineer.

A3  Blank

A4  Start of Operations

The Contractor shall not start planting hole or bed preparations, planting operations, or delivery of planting stock to the Project site until the Engineer determines that weather and soil conditions are suitable for such work and are in accordance with the dates shown in the Contract.

The Contractor shall not start planting operations until the documentation requirements of 2571.2 (Materials) and 2571.3B3 (Competence Test) operations have been demonstrated and accepted by the Engineer.

A5  Notices by Contractor

The Contractor shall notify the Engineer at least 3 days prior to the planned delivery date of planting stock and replacement planting stock to the Project site to allow for inspection scheduling.

The Contractor shall notify the Engineer at least 24 hours in advance of beginning and of changing planting hole and bed preparations, plant installation, and establishment operations, including layout staking, clearing, weed spraying, material deliveries, soil cultivation, planting, watering, mulching, plant protection, dead plant removal, weeding, cleanup, and restoration work. The Contractor's notice must include the Project number, Engineer's name, notification date, intended operation(s), intended operation date and duration, estimated start time, and the approximate location where work will begin and occur.
The Contractor shall give the notice in writing unless otherwise designated by the Engineer. A confirmed facsimile notification is acceptable.

A6 Unauthorized Work

The Engineer will consider work performed with uncertified plant stock, without plant stock documentation, without landscape specialist certification, without notification, or in conflict with the working hours of 1803 (Prosecution of Work) as unauthorized work.

A7 Equipment Required

The Contractor shall provide equipment conforming to 1805 (Methods and Equipment) and have the following on the Project at all times:

a. One portable compaction tester capable of measuring compaction in the soil to a minimum depth of 300 mm (12 inches).

b. One soil recovery probe.

c. Calipers with measurement readings in millimeters (inches).

d. One rain gauge per kilometer (mile) of project.

B Preparing Planting Holes and Planting Beds

The Contractor shall conform to 1507 (Utility Property and Service) before cultivating soil or excavating holes on the Project.

B1 Weed Control and Cultivation

The Contractor shall use one or both of the following methods. Method 1, Herbicide Application may begin in spring or fall and shall be applied to actively growing vegetation. Method 2, Cultivate-Fallow-Disk requires fall and spring activity.

B1a Method 1 - Herbicide Application

Before cultivating isolated plant locations and plant beds, the Contractor shall kill turf and weed growth within the areas that will receive mulch in accordance with the following steps.

Step 1. Mow existing vegetation to no less than 75 mm (3 inches) at least one week prior to any herbicide spraying. Remove the cuttings. The vegetation shall be allowed to re-grow to a height of at least 100 mm (4 inches) and no more than 200 mm (8 inches) prior to applying the herbicide.

Step 2. At least 3 days prior to the proposed application date, submit labels of all intended herbicides and a copy of a valid pesticide applicator license to the Engineer for review and approval.

Step 3. Spray any regrowth and kill all vegetation (top growth and roots) using a non-selective, non-residual post emergence herbicide containing 41% glyphosate as the active ingredient. Crews licensed by the Minnesota Department of Agriculture and experienced in the use of chemical pesticides shall
perform the work in accordance with the manufacturer's recommendations. The herbicide shall be applied to dry foliage on actively growing vegetation. The application shall be made in August or September preceding fall or spring planting, or in May if August or September application is not possible. If precipitation occurs within 6 hours after spraying, the Contractor shall respray. Additional herbicides may be applied on a prescriptive basis if approved by the Engineer.

Step 4. Prior to placing any specified soil additives, deep cultivate the planting holes and beds by thoroughly loosening the soil to a minimum depth of 200 mm (8 inches), as measured from the existing grade elevation of the soil. Operations (in this step and the following step) shall not result in soil compaction due to excessively wet soil conditions (field capacity or wetter) or improper methods. The Contractor shall demonstrate proper methods and equipment in a competence test for this operation as specified in 2571.3B3.

Step 5. Unless otherwise specified, add soil additives and thoroughly incorporate them into the previously deep-cultivated soil to a minimum depth of 200 mm (8 inches), as measured from the finished grade elevation of the soil. The equipment and methods shall be in conformance with 2571.3B3 (Competence Test).

Step 6. Use a compaction tester to verify that planting areas have been loosened to less than 1400 kPa (200 psi) at the initial minimum cultivation depth of 200 mm (8 inches) plus the depth of added soil additives as measured from the finished grade elevation of the soil.

B1b Method 2 - Cultivate-Fallow-Disk

The Contractor shall cultivate, fallow, and disk isolated plant locations and plant beds to kill turf and weed growth within the areas that will receive mulch in accordance with the following steps:

Step 1. Mow the planting area to a maximum height of 75 mm (3 inches).

Step 2. In late summer or early fall, and prior to placing any specified soil additives, thoroughly deep cultivate the planting areas to a minimum depth of 200 mm (8 inches), as measured from the existing grade elevation of the soil. Operations (in this step and the following step) shall not result in soil compaction due to excessively wet soil conditions (field capacity or wetter) or improper methods. The Contractor
shall demonstrate proper methods and equipment in a competence test for this operation as specified in 2571.3B3.

Step 3. Unless otherwise specified, add soil additives and thoroughly incorporate them into the previously deep-cultivated soil to a minimum depth of 200 mm (8 inches), as measured from the finished grade elevation of the soil. The equipment and methods shall be as specified in 2571.3B3 (Competence Test).

Step 4. Use a compaction tester to verify that planting areas have been loosened to less than 1400 kPa (200 psi) at the initial minimum cultivation depth of 200 mm (8 inches) plus the depth of added soil additives as measured from the finished grade elevation of the soil.

Step 5. Allow the planting areas to lie fallow until spring with tilling ridges or other temporary erosion control methods, as approved by the Engineer.

Step 6. In the spring, shallow disk or till the planting areas to a depth of no more than 75 mm (3 inches) to break the soil crust without exposing the underlying weed seed bank in the soil.

B2 Planting Soil

Planting soil for planting holes and beds shall consist of 100 mm (4 inches) of Grade 2 compost thoroughly mixed with the inplace cultivated soils. Planting soil also consists of the underlying deep-cultivated soil without compost (see 2571.3B1 and as shown in the Plan). This mixture shall be excavated when planting holes are dug and then replaced as backfill for all planting holes and beds.

B3 Competence Test

Prior to conducting ongoing operations throughout the Project site, the Contractor must obtain approval from the Engineer by demonstrating competence. For preparation of planting hole and bed operations, cultivate the soil and incorporate soil additives for one shrub bed and one individual tree. For initial planting operations, conduct one individual test planting for each root category or method of planting. The test planting shall include a coniferous tree, coniferous shrub, deciduous tree, deciduous shrub, seedling, vine and perennial, as it applies. The test shall include initial watering, guying, painting, protective devices, and mulching. The Contractor may continue only when the Engineer has approved the methods, equipment, and procedures.

B4 Wet Soils, Rock, and Debris

If excessively wet soils, bedrock, or excessive quantities of boulders and construction debris are encountered, the Contractor shall
reconfigure, relocate, or delete the affected planting area as approved by the Engineer.

B5  Temporary Erosion Control

The Contractor shall employ temporary erosion prevention methods in cultivated planting hole and bed areas when necessary and to the satisfaction of the Engineer.

B6  Hardpan Layers or Compacted Soil

If hardpan layers or compacted soil layers are exposed below the normal planting depth, the Engineer may require additional deep ripping or other measures to ensure proper root development and drainage. Work shall conform to 2105.3G (Finishing Operations, Compaction Correction) and will be paid for as Extra Work when approved by the Engineer.

If it becomes evident that the Contractor's operation are compacting the planting soil, the Engineer will require additional preparation to re-aerate and loosen the affected planting soil. This work shall be provided at no cost to the Department.

B7  General

Planting hole cultivation will not be required for machine-moved (hydraulic spade) transplanted stock other than loosening the soil outside the soil ball perimeter as specified in the Plan. This loosening shall be 500 mm (18 inches) wide adjacent to the spade-moved soil and 300 mm (12 inches) deep. Loosen the soil prior to placing mulch. Soil additives are not required, unless specified in the Contract.

The Contractor shall not stockpile soil, compost, or other materials on the Project without approval and direction by the Engineer.

If the Contractor wishes to place woodchip mulch in prepared planting areas as temporary erosion control prior to planting, the Engineer must provide approval prior to placement. The Contractor shall rake woodchip off all prepared planting areas prior to digging planting holes. Woodchip mulch that is contaminated with soil must be removed from the Project site. Planting holes contaminated with woodchip mulch will not be accepted.

C  Delivery and Storage of Plants

Plant stock shall be installed on the day of delivery to the Project site, unless temporary storage methods are approved by the Engineer. From the time of delivery until planting, storage methods shall prevent plant damage from exposure to drying winds, direct sunlight, excessive heat, freezing, low humidity, inadequate ventilation, and animal or human harm. If roots become frozen, the plant will be rejected. Prior to being installed, the roots of all plants shall be kept completely covered with a suitable moisture-holding material such as woodchips, straw, sawdust, moss, or soil and there shall be no discernable voids or
air pockets. This material shall be kept continuously moist. Immerse the roots of bare root stock in water for at least one hour, and no more than 24 hours, immediately prior to planting. Plants shall be properly cared for at all times and shall not remain stored from one planting season to the next.

D  BLANK

E  Pruning - Top Growth and Roots

Immediately prior to planting, the Contractor shall prune, as necessary, the roots of all bare root plants and the top growth of all deciduous plants to the Engineer’s satisfaction. Broken or badly bruised roots and dry root tips shall be cut back to sound, healthy tissue. Pruning shall include removing dead, rubbing, damaged, or diseased branches, and unwanted suckers and may be necessary to improve plant symmetry, structure, and vigor. Coniferous trees and shrubs shall be pruned only to the extent of removing damaged growth or a competing leader.

When pruning any woody vegetation, the Contractor shall use good horticultural practices, as shown in the “Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects”. Pruning cuts shall leave a branch collar (Shigo method) and shall produce a clean cut in live wood without bruising or tearing the bark. No pruning stubs shall be left. When trees that typically exhibit a dominant central leader have multiple stem leaders, the stem that will best develop as a central leader shall be preserved. The remaining stems shall be removed or cut back so they will not compete with the selected leader.

All pruning shall be done at the Project site, using a bypass scissors-type pruner or a pruning saw. A bypass pole pruner may be used only during the plant establishment period and only if approved by the Engineer. The use of hedge shears or anvil action pruners will not be permitted at any time.

The Contractor shall avoid pruning oak trees during April, May, June, and July in order to prevent the spread of oak wilt. Any accidental cuts or wounds to oaks shall be immediately treated (within 5 minutes) with an approved wound dressing. The dressing shall conform to 2571.2C. The Contractor shall have wound dressing on the Project at all times during the oak wilt season.

F  Installation of Plants

F1  General

The Contractor:

(a) Shall conform to 2571.3B3 (Competence Test) prior to beginning any initial planting operations.

(b) Shall dig all planting holes to the configuration and minimum dimensions shown in the Plan. The Contractor shall not work in
planting holes and beds unless soil moisture is at field capacity or drier.

(c) Shall provide adequate drainage where planting holes and beds are dug in heavy clay or impervious soils and a percolation rate of at least 1.2 mm (1/2 inch) per hour is not observed after partially filling presaturated test holes with water. Do not install plants in standing water. The Contractor may:

1. Raise the planting area,
2. Install a granular filter,
3. Install a tile drainage system, or
4. Construct a combination of the features as shown in the Plan and as approved by the Engineer.

Due to nursery practices, the root flare of balled and burlapped and container plants may be found below the soil grade. In no case will plants be accepted if more than 100 mm (4 inches) of soil is found above the bottom of the root flare or if plants are installed with the bottom of the root flare below the finished soil elevation. Plants with less than 100 mm (4 inches) of excess soil over the root flare may be accepted if the excess soil can be removed without damaging the plant. Plants shall be installed plumb and set so that after installation and backfill consolidation, the bottom of the root flare is at the finished soil elevation, as shown in the Plan and the current edition of "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects." Care shall be taken to ensure that roots are not damaged while placing and compacting the backfill.

The backfilling operations shall be accomplished in more than one stage in accordance with the Plan. Sufficient planting soil shall be placed prior to the initial watering in order to cover the root system completely and provide firm support for the plant in the hole. The remaining backfill shall be placed within 5 days after the initial watering following water permeation and soil settlement.

F2 Balled and Burlapped Stock

Balled and burlapped plants may be installed without removing the entire burlap covering or wire baskets. Before completing the planting hole backfilling, remove the top third or the top two horizontal rings of the wire basket, whichever is greater. Remove all burlap and nails to expose the entire top third of the soil ball. Remove all twine or rope entirely. Dispose of all waste off the Project site. Treated burlap will be allowed on the root balls but vertical slits must be cut through the burlap at the time of installation. The slits shall be at 150 mm (6 inch) intervals around the circumference of the root ball in a manner that does not damage the root system.
If desired or necessary, staking and guy ing may be used to provide additional support between the stem and root ball. In the case of trees, especially conifers, with light textured soil balls and/or exposure to high winds, steep slopes, and wet soils, it is recommended that the Contractor install staking and guy ing prior to removing the twine, wire baskets, burlap, and nails. Staking and guy ing plants with broken soil balls will not be acceptable. Plants with broken soil balls shall be rejected. Staking and guy ing shall be installed in accordance with 2571.3J1.

F3 Container Stock

Plants supplied in containers shall be installed immediately upon being removed from the containers. Remove plants from all plastic, metal, and wood containers so as not to disturb the root system or the soil in which they were planted. Under no conditions shall plants be removed from the container by pulling on the main stems or plant growth. The outside of the root ball shall be scored or pruned in order to redirect circling roots. Paper fiber pots need not be removed, however, the container must be slit vertically at 150 mm (6 inch) intervals around the circumference of the pot. The top of the paper fiber pot must be removed to at least 25 mm (1 inch) below the soil grade.

F4 Bare Root Stock

Before installing bare root trees and shrubs, place and firm the planting soil in the bottom of the hole so plants are installed with the roots evenly distributed and spread in their natural position and at the proper depth. Carefully place and compact the growing medium around the roots.

F5 Machine Moved Stock

The Contractor shall install trees as designated in the Contract by hydraulic spade-type mechanized digging equipment.

The Contractor shall not install trees until the Department of Agriculture has inspected and found the trees to be free from plant pests.

Trees supplied by Mn/DOT are an exception.

The Contractor is responsible for all appropriate permits and certifications required for plants moved off of the Department's Right of Way.

The Contractor shall:

(a) Apply at least 40 L (10 gallons) of water to the root ball during the digging operations.

(b) Cover the spade portion of the digger with a tight hood during transport to ensure soil does not shift out of the digger.
(c) Cover trees with a tarp when trees are transported during the growing season and if the transport speed exceeds 48 kph (30 mph).

(d) Support the tree in a manner that will prevent shifting and root ball damage.

(e) Fill holes created by tree removal from public property within 24 hours. Fill holes so that after settling, the fill will be the same as the surrounding ground surface.

(f) Reset trees that are not plumb with a spade of the same size or larger. To avoid mixing soil and mulch, pull mulch away from the planting hole. Straightening trees by tightening guy wires will not be permitted.

(g) Prune trees to remove double leaders and broken, dead, diseased, or crossed branches. Pruning methods shall be in conformance with 2571.3E. To avoid spreading oak wilt, prune all oak trees as specified in 2571.3E.

(b) Blank

F6  Seedling Stock
The Contractor shall:

(a) Prevent damage to the fine root hairs on seedlings during storage, handling, or planting. The Contractor shall not prune roots of seedlings unless approved by the Engineer.

(b) Prevent tangled or turned up root ends (J-root).

(c) Set the root collar to the depth shown in the Plan and current edition of "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects."

(d) Place seedlings in the ground so that the seedling assumes a position within 20 degrees of vertical.

(e) Plant and tamp the ground around seedling roots firmly, without excessive compaction. Air pockets or voids around the roots will not be permitted. The Engineer will determine acceptable planting by a tug test and by inspecting for air pockets and excessive compaction in the root zone. The tug test is satisfied if gently pulling the seedling, at its base, does not pull the roots out of the ground or loosen the soil in the root area.

(f) Protect deciduous seedlings with seedling tree shelters according to the Plan, when specified in the Contract.

(g) Apply mulch to the depth specified in the Mulch Placement Detail in the Plans.

F7  Preparing Planting Holes and Planting Beds by Plant Type

1) Vine Planting Locations
The Contractor shall use the Herbicide Application Method (2571.3B1a) to control undesirable turf and weed growth. Spray to kill
a continuous area 600mm (2 feet) wide that extends 1.5 m (5 feet) beyond the terminal vines. For each vine, loosen the soil to the Planting Hole Dimensions specified in the Plan. A dead turf strip shall remain between prepared planting holes. Mulch to continuously cover all sprayed and loosened areas along the planted side of walls or fences. Apply mulch to the depth and width specified in the Plan.

G Blank

H Following Plant Installation

H1 Watering and Backfill

Within 2 hours of installation, water each plant to thoroughly saturate the backfill soil, provide for soil settling, and fill voids in the backfill. Additional planting soil and multiple waterings may be necessary for thorough backfilling to eliminate soil air pockets.

Within 5 days after installation, the Contractor shall add sufficient planting soil around each plant, if necessary, to bring the soil to the specified level shown in the Plan. Plants shall be thoroughly watered unless soil moisture is at optimum or excessive levels. Plants that are improperly positioned with respect to depth and plumbness shall be reset or replaced. Reset and replaced plants shall be watered within 2 hours to thoroughly saturate the backfill soil.

At all times, the Contractor shall have sufficient watering equipment and forces available to completely water all plants once each week. Watering intervals shall be varied and based on prevailing soil moisture and weather conditions.

H2 Mulch Placement

Planting bed soil shall be fine-graded and leveled with hand tools prior to placing mulch to avoid impeding or puddling surface drainage and to prevent mulch depth irregularities. Mulch material shall be placed no later than seven days after installation. In cases where soil moisture is excessive, to allow for evaporation, delayed mulch placement may be requested by the Contractor and approved by the Engineer. Place mulch as shown in the Plan.

I Blank

J Protection of Plants

The Contractor shall take precautionary and protective measures to ensure healthy growth and survival of all plants.

J1 Staking and Guying

The Contractor shall:

(a) Stake and guy trees in accordance with the details shown in the Plan.

(b) Stake and guy trees only when necessary to maintain the plant in a plumb condition. Circumstances that may warrant staking and guying include excessive soil moisture, light-textured soil, steep
slopes, high wind, or vandalism. Staking and guying shall be installed at no cost to the Department unless specified otherwise in the Contract.

c) Remove the staking and guying after 1 year.

J2 Rodent Protection

The Contractor shall place rodent protection around all trees in accordance with the details in the Plan unless specified otherwise.

J3 Tree Painting

To prevent bark from splitting in the winter, the Contractor shall paint trees in accordance with the species, notes, and details shown in the Plan. The Engineer may require additional applications to achieve opaque coverage.

K Disposal of Excavated Materials

Excess and unwanted excavated materials shall be removed from the planting areas and disposed of to the Engineer's satisfaction within 3 days after the excavation.

L Cleanup and Restoration Work

Cleanup and restoration work shall be accomplished as the final step of the initial planting operations and throughout the plant establishment period, to the Engineer's satisfaction. Turf disturbed during plant installation or establishment operations shall be repaired with the seed mix(es) specified in the Plan. The Contractor shall:

1) Repair turf in all disturbed areas including, but not limited to, roadway access points, equipment circulation areas and pathways, and all stockpile or staging locations.

2) Remove all woodchip or material stockpiles to the Engineer's satisfaction.

3) Immediately prior to sowing seed or laying sod, roughen the soil surface. Soil shall be prepared as specified in 2575.3B (Soil Preparations).

4) Uniformly broadcast a slow release fertilizer. The fertilizer analysis and application rates will be as specified in the Plan or as directed by the Engineer.

5) Lay sod or uniformly hand broadcast seed at 1.5 times the rate specified in Table 2575-1, Seed Mixture Application Rates. For large areas, the Engineer may require or approve other establishment methods. Seed shall be in accordance with the requirements of 3876 and seeding shall occur in accordance with Table 2575-2, Season of Planting.

6) Rake and firm the seeded areas to ensure seed/soil contact.

7) Broadcast or disc anchor mulch, Type 1 in all seeded areas.

7) Install erosion control measures as necessary or as directed by the Engineer.
M  Plant Establishment Period
M1  Establishment Period

The Contractor shall maintain the work and care for the installed plants from completion of the initial planting operations until final acceptance at the end of the Plant Establishment Period.

M2  Establishment Work

The Contractor shall keep all plants in a healthy growing condition, using good horticultural practices generally and continuously throughout the establishment period. A prerequisite for work being continuously acceptable during the plant establishment period is that non-compliance conditions which require work by the Contractor cannot remain out of compliance for more than a continuous three week period, on a calendar day basis. Work shall be performed on a day to day basis during the growing season and as necessary during the remainder of the year, with necessary replacements being made as required.

If at any time, inspection shows that the plant establishment operations have not been generally and continuously in compliance, the Engineer will notify the Contractor in writing of such default and the Contractor shall comply with the instructions. If the Contractor does not proceed satisfactorily within 3 working days after receiving written notice from the Engineer to remedy plant establishment deficiencies, Mn/DOT will assess a daily charge of $200.00, on a calendar day basis, until the Engineer notes compliance with the notice or until the eligible percentage of the annual contract amount for plant establishment work has been forfeited. The charge will continue until defaults are corrected to the Engineer’s satisfaction and without further notice from the Engineer. The Contractor shall replace plant stock as required in the Contract but only within the optimum planting dates specified, extended, or shown in the Plan or as required by the Engineer.

M2a  All Plants

In plant establishment work, the Contractor shall generally and continuously:

1. Maintain adequate (but not excessive) soil moisture in conformance with 2571.3H and watering guidelines provided in the Plan. It is advised that the Contractor use a soil moisture meter to determine soil moisture levels.
2. Repair, adjust, or replace, the staking and guying, mulch material, planting soil, rodent protection, seedling tree shelters, tree painting, and other incidental items in conformance with the Plan.
3. Apply insecticides, fungicides, and other cultural procedures, as necessary, to maintain healthy, vigorous plants free from harmful insects, fungus, and disease. All chemical applications shall be
performed by an operator licensed by the Minnesota Department of Agriculture.

(4) Remove dead plants. Furnish and install replacement plants with new mulch, planting soil, and other incidental items in conformance with 2571.3M3 (Replacement Requirements) and at no cost to the Project. The Contractor shall remove dead, dying, and unsightly plants on a continuous basis as these conditions occur, or as directed by the Engineer. Plant stock documentation for replacements shall conform to 2571.2A2.

(5) Maintain the plants in a plumb condition at the appropriate planting depth.

(6) Maintain all planting areas in a weed-free condition by continuously removing all weed growth in the mulched planting areas as necessary.

(a) Remove all weeds (top growth and roots) within the mulch limits by hand pulling (pre-watering is advised) or other methods as approved by the Engineer. Remove all County-regulated noxious weeds to at least 900 mm (3 feet) beyond the mulch limits with a method approved by the Engineer. Remove all weed parts from the Project site in such a manner as to avoid spreading weeds.

(b) Spray application of chemicals for weed control in the mulched planting areas will not be permitted during the plant establishment period unless the Engineer authorizes otherwise. A non-selective, non-residual post emergence herbicide containing 41 percent glyphosate as the active ingredient may be applied, with a surfactant, on a spot treatment basis only, with a brush or wick applicator, if authorized by the Engineer. Additional herbicides may be applied on a prescriptive basis if approved by the Engineer. A broad-spectrum dichlobenil based granular herbicide (pre-emergent) may be applied in conformance with product labeling and manufacturer's recommendations for residual weed control, if authorized by the Engineer.

(c) Weed whips and weed clippers will not be accepted as weed control.

(d) Mow the turf areas to at least 900 mm (3 feet) beyond the mulch limits and to a height no shorter than 100 mm (4 inches) when that turf grows taller than 230 mm (9 inches) adjacent to the mulched planting areas.

(e) Mow areas of Contractor-installed turf establishment or turf repair if the vegetation grows to a height of 500 mm (18 inches). Using a rotary mower, mow to a height of 150-300 mm (6-12 inches). It is anticipated mowing may be necessary as early as June 30 and as late as August 15 (when the cover crop is setting seed). The
Engineer may also require mowing in September. The Contractor shall control County-listed noxious weeds at all times. Unless specified, mowing shall be incidental to the Project.

(9) Prune to remove dead, rubbing, damaged or diseased branches, unwanted suckers, and to improve plant form and structure.

(10) Scout to assess the condition of the plants and the planting site. The Contractor shall look for abiotic and biotic factors that may influence a plant's health, vigor, and performance. Twice-monthly scouting is advised. The Contractor shall submit a written report to the Engineer whenever scouting or plant establishment work has been performed on the Project. The report frequency and content will be used by the Engineer to assess plant establishment compliance. The report must include the Project number, Engineer's name, employee's name, date the work was performed, work location, and the work completed. The report may be a copy of the Plan with the Contractor's notes, if approved by the Engineer. Items noted on the report may include, but are not limited to weather conditions, soil moisture, watering, repairing or adjusting rodent protection and tree shelters, staking and guying, painting, insect or disease problems and treatment recommendations, assessment of overall plant conditions, weeding, mowing, dead plant removals, and replacing plant stock.

(11) Perform other plant establishment operations consistent with proper plant care.

M3 Replacement Requirements
The Contractor shall:

(a) Replace all dead, defective, or missing plants and incidental materials as required in the Contract or when ordered by the Engineer. Replacements ordered by the Engineer shall be made within 2 weeks of the Engineer's notice, unless approved otherwise. Replacements of initially installed plants and materials will be made at no cost to the Project because the Contractor will receive payment for the initially installed plant. The Contractor will not be responsible for replacement trees when the transplant trees are furnished by Department. However, the Contractor shall remove the dead or defective trees at no expense to the Department or as directed by the Engineer.

(b) Replace all installed plants that are lost due to accidents, vandalism, theft, rodent damage, and other causes.

(c) Repair or replace all damage caused by the Contractor's operations.

The requirements for all replacement plantings shall be the same as for initial planting including preparatory work.
Within the first year of the 2-year plant establishment period, the Contractor is responsible for determining which plants need to be replaced. The Contractor shall assess the plant's condition and base the replacements on present or probable compliance with the Project requirements. At least one week prior to the anticipated plant replacements, the Contractor will submit a summary report of proposed plant replacements. The report shall include, by attachment, copies of plan sheets with the proposed replacement quantities and locations clearly identified. The Contractor shall also clearly mark the plants to be replaced with brightly colored paint in the field.

When less than a full year remains in the plant establishment period, the Contractor will not be required to replace plants unless the period is extended by a Supplemental Agreement or Change Order to provide one full year of establishment care.

After initial replacements, if additional replacements are required, the Engineer will decide if replacements will be at the Contractor's expense, deleted from the Plan, or replaced with compensation. Replacements with compensation will only be considered when plant failure is not a consequence of the Contractor's operations. Replacements with compensation require at least one year of plant establishment care and must be installed during the optimum planting dates, as shown in the Plan, unless approved by the Engineer.

N Acceptance of Work
For acceptance at full payment, plants shall meet all requirements including the criteria listed in the current edition of "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects," published by the Mn/DOT Landscape Unit. The plants shall be healthy, vigorous, and structurally sound.

N1 Acceptance of Preparatory Work
The Engineer will accept the preparatory work after the Contractor has satisfactorily secured commitments for required materials (Mn/DOT Certificate of Compliance for Plant Stock, Landscape Materials, and Equipment), obtained the Engineer's approval for the progress schedule, moved equipment and supplies to the Project site, and provided for protection of existing plants.

N2 Acceptance of Preparation of Planting Holes and Beds
The Engineer will accept the preparation of planting holes and beds after the Contractor has satisfactorily completed staking, initial weed control, soil cultivation with incorporation of additives, and temporary erosion prevention measures.
N3  Acceptance of Initial Planting Operation
   Initial acceptance will be made upon satisfactory completion of the
   initial planting operation for the individual plant.
N4  Final Acceptance
   Final acceptance will be made after final inspection of the
   completed Project at the end of the plant establishment period.
N4a Final Inspection
   On or about the date on which the plant establishment period
   expires, the Engineer will make an inspection of the Project and notify
   the Contractor of any dead, defective, or missing plants and work that
   must be performed prior to acceptance. Dead or defective plants shall
   be removed where so ordered and turf shall be restored as specified in
   the Plan or as directed by the Engineer. Restoration shall be consistent
   with the surrounding turf.

   As a condition for acceptance of the work, plant establishment
   operations shall not be past due at the time of the final inspection.
   Every plant shall have received a thorough watering within the
   preceding 10 days before inspection, unless soil moisture is at sufficient
   levels. The mulched planting areas shall be weed-free (top growth and
   roots). All work shall be in good order and in compliance with all plant
   establishment requirements. Work shall include, but is not limited to
   replenishing mulch, tree painting, straightening and imbedding rodent
   protection, pruning, and removing replacement plant staking and guying
   as necessary or as directed by the Engineer.

   The Engineer will make a determination as to which plants will be
   accepted for payment at the Contract unit prices, at a reduced payment,
   or at no payment. The Engineer may consider as unacceptable any
   machine transplanted trees that are mechanically damaged and trees
   with reduced vigor and growth resulting from improper transplanting
   operations. The Engineer may accept these trees at an adjusted
   payment according to 1503 (Conformity with Plans and Specifications)
   or at no payment.

   Upon final acceptance, the Contractor will not be required to
   provide any further care for the plantings. However, final acceptance of
   the work will not be made until cleanup and restoration work are
   completed to the Engineer's satisfaction.
N5  Blank

2571.4 METHOD OF MEASUREMENT
A  Plants Furnished and Planted
   Trees, shrubs, vines and perennials of each species, variety, size, or
   age, and root category furnished, planted, and maintained by the
   Contractor will be measured separately by the number of acceptable
   plants.
B  Plants Planted
   Trees, shrubs, vines and perennials of each species, variety, size, or age, and root category furnished by the Department and planted and maintained by the Contractor will be measured separately by the number of acceptable plants.

C  Plants Transplanted
   Trees, shrubs, vines, and perennials of each size and type furnished by the Department and transplanted will be measured separately by the number of plants moved and maintained in an acceptable manner.

2571.5 BASIS OF PAYMENT
   Payment for plant installation at a percentage of the Contract price per unit of measure will be compensation for all costs relating to furnishing, installing, and maintaining, or installing and maintaining, the required plants and materials specified.
   If the Engineer requires additional materials and work beyond that specified or shown in the Contract, the Contractor will receive compensation for the additional materials and work as Extra Work.

A  Initial Payment
   Initial payment of up to but not exceeding 80 percent of the Contract unit price will be paid in partial payment amounts for satisfactory completion of the following work:
   A1  Preparatory Work
      Up to but not exceeding 10 percent of the Contract amount for the plants to be planted.
   A2  Preparation of Planting Holes and Beds
      Up to but not exceeding 20 percent of the Contract amount for the plants to be planted.
   A3  Initial Planting Operation
      Up to but not exceeding 50 percent of the Contract amount for the plants planted.
   A4  Maximum
      Up to but not exceeding 80 percent of the Contract amount for the plants planted.

B  Interim Payment
   The Engineer may authorize an interim partial payment of up to but not exceeding 10 percent of the Contract amount for the plants planted, at the end of the first calendar year of the plant establishment period when required plant establishment operations on the entire Project have been acceptable generally and continuously throughout this period. The Engineer will not authorize interim partial payment if these conditions are not met.
C Final Payment

Final payment will be made after final inspection and upon final acceptance of the completed Project at the end of the plant establishment period. Final payment may involve full payment, reduced payment, or no payment for the individual plants.

Payment will be made on a per unit basis.

No payment will be made for replacement plants unless authorized by the Engineer.

The amount of the initial and interim payments will be deducted from the final payment to the Contractor.

Any percentage of initial and interim payment that is withheld may continue to be withheld from the final payment.

Any assessments charged during the Contract period will not be reimbursed at final payment.

If the final voucher shows that the total of all initial and interim payments made exceeds the total amount due the Contractor, the Contractor shall promptly refund the overpayment. Final payment shall conform to 1908 (Final Payment).

C1 Full Payment

Full payment up to 100 percent of the Contract unit price will be made for the individual plant that is acceptable at final inspection if the Contractor has met the following requirements:

(a) Acceptance of the preparatory work.
(b) Acceptance of the preparation of the planting hole or bed.
(c) Acceptance of the initial planting operations.
(d) Compliance with all plant establishment work requirements generally and continuously and at the time of inspection and the plant has had the minimum 2-year plant establishment period or, in the case of a replacement plant, the plant has had a minimum of 1 year of plant establishment.

C2 Reduced Payment and No Payment

C2a Reduced Payment

Reduced payment at up to a percentage of the Contract unit price will be made for the individual plant that is not acceptable at the final inspection, for one or more of the following reasons:

(1) The plant is acceptable at final inspection and the Contractor has brought the plant establishment operations into compliance, with the exception that all plant establishment work requirements were not generally or continuously acceptable during the plant establishment period. General and continuous acceptance shall conform to 2571.3M2 (Establishment Work).

(2) The plant is acceptable at final inspection with the exception that the protection of existing vegetation, the preparation of the
planting holes or beds, or the initial planting operations were unacceptable.

(3) The plant is acceptable at final inspection with the exception that all plant establishment work requirements are not acceptable at the time of inspection, or the plant has not had the minimum 2-year plant establishment period or the minimum 1-year plant establishment period in the case of a replacement plant.

(4) The Department-furnished plant or machine transplant is not acceptable at final inspection but the protection of existing vegetation, the preparation of the planting hole or bed, the initial planting operations, and the continuous plant establishment operations have all been acceptable.

(5) The plant is not acceptable at final inspection but all protection of existing vegetation, the preparation of the planting holes or beds, and the initial planting operations were acceptable, and the Contractor has been in general compliance continuously with the plant establishment work requirements for the minimum 2-year plant establishment period and the minimum 1-year plant establishment period in the case of a replacement plant.

C2b No Payment
   No payment will be made for an unacceptable plant with unacceptable establishment care.

C2c Reduced Payment or No Payment
   Reduced payment for the individual plant at up to a percentage of the Contract unit price or no payment will be made in accordance with the following:
<table>
<thead>
<tr>
<th>Condition of Acceptance</th>
<th>Total Payment Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>The plant is acceptable at final inspection but existing vegetation was not protected.</td>
<td>80% - 95%</td>
</tr>
<tr>
<td>The plant is acceptable at final inspection and the Contractor has brought the plant</td>
<td>50%</td>
</tr>
<tr>
<td>establishment operations into compliance, but the Contractor was not generally or</td>
<td></td>
</tr>
<tr>
<td>continuously in compliance with all plant establishment requirements.</td>
<td></td>
</tr>
<tr>
<td>The plant is acceptable at final inspection but the preparation of the planting hole or</td>
<td>50%</td>
</tr>
<tr>
<td>bed or the initial planting operation was unacceptable.</td>
<td></td>
</tr>
<tr>
<td>The plant is acceptable at final inspection but, the Contractor is not currently in</td>
<td>50%</td>
</tr>
<tr>
<td>compliance with all plant establishment requirements.</td>
<td></td>
</tr>
<tr>
<td>The Department-furnished plant or machine transplant is not acceptable at final</td>
<td>50%</td>
</tr>
<tr>
<td>inspection but the protection of existing vegetation, the preparation of the planting</td>
<td></td>
</tr>
<tr>
<td>hole or bed, and the initial planting operation were acceptable and the Contractor has</td>
<td></td>
</tr>
<tr>
<td>been generally and continuously in compliance with the plant establishment requirements.</td>
<td></td>
</tr>
<tr>
<td>The plant is not acceptable at final inspection but the protection of existing</td>
<td>35%</td>
</tr>
<tr>
<td>vegetation, the preparation of the planting hole or bed, and the initial planting</td>
<td></td>
</tr>
<tr>
<td>operation were acceptable and the Contractor has been generally and continuously in</td>
<td></td>
</tr>
<tr>
<td>compliance with the plant establishment requirements.</td>
<td></td>
</tr>
<tr>
<td>The plant is not acceptable at final inspection and the Contractor has not been</td>
<td>0%</td>
</tr>
<tr>
<td>generally and continuously in compliance with the plant establishment requirements.</td>
<td></td>
</tr>
</tbody>
</table>
D  **Bonus Payment**

A bonus payment of 10 percent of the total final Contract price for plant installation will be paid when 90 percent or more of all initially installed plants, and related contract operations have been accepted generally and continuously throughout the Contract period.

The qualifying percentage will be based upon the number of initially installed individual plants receiving full payment divided by the total Plan quantity of individual plants in the Contract. Any replacements made within the first Plant Installation Period (PIP) are considered initially installed plants.

To be eligible for the bonus payment, plants must be installed within the Plant Installation Period (PIP) identified in 1806 (Determination and Extension of Contract Time). This shall apply unless the PIP has been modified and approved otherwise in writing by the Engineer.

E  **Payment Schedule**

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2571.501</td>
<td>Coniferous tree (size &amp; root category)</td>
<td>tree</td>
</tr>
<tr>
<td>2571.502</td>
<td>Deciduous tree (size &amp; root category)</td>
<td>tree</td>
</tr>
<tr>
<td>2571.503</td>
<td>Ornamental tree (size &amp; root category)</td>
<td>tree</td>
</tr>
<tr>
<td>2571.504</td>
<td>Coniferous shrub (size &amp; root category)</td>
<td>shrub</td>
</tr>
<tr>
<td>2571.505</td>
<td>Deciduous shrub (size &amp; root category)</td>
<td>shrub</td>
</tr>
<tr>
<td>2571.506</td>
<td>Vine (age or size &amp; root category)</td>
<td>vine</td>
</tr>
<tr>
<td>2571.507</td>
<td>Perennial (age or size &amp; root category)</td>
<td>plant</td>
</tr>
<tr>
<td>2571.541</td>
<td>Transplant tree (spade size (1))</td>
<td>tree</td>
</tr>
<tr>
<td>2571.544</td>
<td>Transplant shrub</td>
<td>shrub</td>
</tr>
<tr>
<td>2571.546</td>
<td>Transplant vine</td>
<td>vine</td>
</tr>
<tr>
<td>2571.547</td>
<td>Transplant perennial</td>
<td>plant</td>
</tr>
</tbody>
</table>

**NOTE:** State Root Category: -Seedling, -Bare Root, -Machine Moved - Container Grown - Balled & Burlapped

(1) Spade size 1.1 m (42 inch), 1.5 m (60 inch), 1.9 m (78 inch), 2.1 m (85 inch), 2.3 m (90 inch).
Protection and Restoration of Vegetation

2572.1 DESCRIPTION
This work consists of protecting and preserving vegetation from damage and taking corrective action when damage occurs. Vegetation includes but is not limited to trees, brush, roots, woody vines, and perennial forbs and grasses.

2572.2 MATERIALS
A Plant Materials ............................................... 2571 and 2575
B Temporary Fence
   The Contractor shall provide temporary fence that is:
   (1) At least 1.2 m (4 feet) high.
   (2) Conspicuous in color.
   (3) Commercially available snow fence or other fencing material acceptable to the Engineer.
C Water .............................................................. 2571.2
D Sandy Loam Topsoil
   The Contractor shall provide well-drained sandy loam topsoil, with a coarse sand component, meeting the requirements of Table 2572-1 and the Mn/DOT Grading and Base Manual. The Engineer may determine acceptability of topsoil without the test data specified in Table 2572-1.

TABLE 2572-1

<table>
<thead>
<tr>
<th>SANDY LOAM TOPSOIL GRADATION</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay (by mass)</td>
<td>5 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Silt (by mass)</td>
<td>10 %</td>
<td>30 %</td>
</tr>
<tr>
<td>Coarse Sand and Gravel (by mass)</td>
<td>50 %</td>
<td>70 %</td>
</tr>
<tr>
<td>Organic Matter (by mass)</td>
<td>3 %</td>
<td>20 %</td>
</tr>
<tr>
<td>pH</td>
<td>6.1</td>
<td>7.5</td>
</tr>
<tr>
<td>Soluble Salts</td>
<td>--</td>
<td>0.15 siemens/m (1.5 mmho)</td>
</tr>
</tbody>
</table>

(A) Gravel not to exceed 10 percent by mass.

2572.3 CONSTRUCTION REQUIREMENTS
A Protecting and Preserving
   The Contractor shall protect and preserve:
   (1) Specimen trees.
   (2) Threatened and endangered plants, as listed on the Federal and state threatened and endangered species list.
2572.3

(3) Vegetation designated in the Contract to be preserved.
(4) Trees, brush, and natural scenic elements within the Right of Way and outside the actual limits of clearing and grubbing consistent with 2101.3.
(5) Other vegetation the Engineer identifies to be protected and preserved.

The Contractor shall not place temporary structures, store material, or conduct unnecessary construction activities within a distance of 8 m (25 ¾ feet) outside of the dripline of trees designated to be preserved without approval from the Engineer.

The Contractor shall not place temporary structures or store material (including common borrow and topsoil) outside of the construction limits in areas designated in the Contract or by the Engineer to be preserved.

The Contractor shall not place or leave any waste material on the project site, including bituminous and concrete waste, so as to interfere with 2105.3 (Finishing Operations) or 2575 (Turf Establishment). Concrete waste is defined to include all excess material not used on the project, including excess material ground to form rumble strips. The Contractor may dispose of excess material in accordance with 2104.3C (Disposal of Materials and Debris).

A1 Temporary Fence

The Contractor shall place temporary fences to protect vegetation before starting construction. The Contractor shall place temporary fence at the construction limits and at other locations adjacent to vegetation designated to be preserved when specified in the Contract, directed by the Engineer, or allowed by the Engineer. The Contractor shall place tree protection signs supplied by Mn/DOT) along the temporary fence at 15.25 m (50 foot) intervals or no fewer than two per fence or as specified by the Engineer. The Contractor shall not remove the fence until all work is completed or until removal is allowed by the Engineer.

The fence shall prevent traffic movement and the placement of temporary facilities, equipment, stockpiles, and supplies from harming the vegetation.

A2 Clean Root Cutting

The Contractor shall cleanly cut all tree roots at the construction limits when specified in the Contract or directed by the Engineer.

The Contractor shall immediately and cleanly cut damaged and exposed roots. Trees designated for protection shall have damaged roots cut back to sound healthy tissue and shall have topsoil immediately placed over the exposed roots. The Contractor shall immediately cover root ends that are exposed by excavation activities
with 150 mm (6 inches) of topsoil as measured outward from the cut root ends. The Contractor shall limit cutting to a minimum depth necessary for construction and shall use a vibratory plow or other approved root cutter prior to excavation.

A3 Watering
The Contractor shall water root-damaged trees during the growing season when root damage occurs in order to maintain adequate but not excessive soil moisture. The Contractor shall saturate the soil within the undisturbed portion of the dripline of impacted trees to a depth of 500 mm (20 inches). The Contractor shall adjust the intervals and frequency of watering according to prevailing moisture and weather conditions.

A4 Sandy Loam Topsoil
The Contractor shall place sandy loam topsoil, instead of common borrow fill, within the dripline of specimen trees when specified in the Contract or directed by the Engineer. The Contractor shall place the topsoil in a manner that will avoid over-compaction, as approved by the Engineer. The Contractor shall establish turf consistent with the adjacent areas as approved by the Engineer.

A5 Utility Construction
The Contractor shall bore (tunnel) under roots of trees that are to be preserved when utility installations take place within the tree protection zone as defined in Table 2572-2. Open trenching will not be permitted within this zone.

<table>
<thead>
<tr>
<th>Tree Diameter at 1.4 m (4.5 feet) Above Ground mm (inches)</th>
<th>Minimum Distance from Face of Tree Trunk M (feet)</th>
<th>Minimum Depth of Tunnel m (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 50 (2)</td>
<td>0.6 (2)</td>
<td>0.6 (2)</td>
</tr>
<tr>
<td>51-100 (2 to 4)</td>
<td>1.2 (4)</td>
<td>0.75 (2.5)</td>
</tr>
<tr>
<td>101-225 (4 to 9)</td>
<td>1.8 (6)</td>
<td>0.75 (2.5)</td>
</tr>
<tr>
<td>226-350 (9 to 14)</td>
<td>3.0 (10)</td>
<td>0.9 (3)</td>
</tr>
<tr>
<td>351-480 (14 to 19)</td>
<td>3.6 (12)</td>
<td>1.0 (3.25)</td>
</tr>
<tr>
<td>Over 480 (19)</td>
<td>4.8 (15)</td>
<td>1.2 (4)</td>
</tr>
</tbody>
</table>

A6 Blank
A7  Pruning
The Contractor shall prune trees specified in the Contract or as directed by the Engineer in accordance with 2571.3. Pruning shall include the removal of dead, broken, rubbing branches, and those limbs that may interfere with the existing and proposed structures.

A8  Destroyed or Disfigured Vegetation
If the Contractor destroys or disfigures vegetation designated to be preserved, the Contractor shall, at no expense to the Department, restore the damaged vegetation to a condition equal to what existed before the damage was done. The Engineer may assess damages against the Contractor on vegetation where an equal level of restoration is not accomplished. The Engineer will assess damages of trees and landscaping at not less than the appraisal damages as determined by the International Society of Arboriculture appraisal guide. The Engineer will determine and assess damages of other vegetation.

A9  Oak Trees
The Contractor shall avoid wounding of oak trees during April, May, June, and July in order to prevent the spread of oak wilt. If the Engineer determines that work must take place near oak trees during those months, resulting wounds shall immediately be treated with a wound dressing material consisting of latex paint or shellac. Paint colors shall blend with the bark color. The Contractor shall have an approved wound dressing on the project at all times during this period.

A10 Other Vegetation Protection Measures
The Contractor shall provide other vegetation protection measures; including root system bridging, compaction reduction, aeration, and retaining walls; as specified in the Contract or as directed by the Engineer.

B  Plant Installation ........................................................ 2571
C  Disposal of Material and Debris ............................. 2104.3

2572.4  METHOD OF MEASUREMENT

A  Temporary Fence
The Engineer will measure temporary fence by length along the bottom of the fence between end posts. Measurement will only be made for fence placed, maintained, and removed.

B  Clean Root Cutting
The Engineer will measure clean root cutting by length along the plow line. The beginning and ending points will be where the construction limit intersects the dripline of the tree or brush or in accordance with lines shown on the Plan.

C  Water
The Engineer will measure water by volume used to protect and
restore vegetation. No measurement will be made of other water used in conjunction with the work, whether for maintenance of sod, or otherwise.

D  **Sandy Loam Topsoil**

The Engineer will measure sandy loam topsoil used by authority of the Engineer by compacted volume furnished and placed. The material may come from the Project.

E  **Pruning**

The Engineer will measure pruning by the hours of actual pruning work.

**2572.5  BASIS OF PAYMENT**

The Department will pay for the acceptable quantities at the appropriate Contract price per unit of measure. In the absence of a Contract bid price, the Contractor will receive compensation for the work specified in the Contract or directed in writing by the Engineer according to the following unit prices; or in the absence of both, as Extra Work. This payment is full compensation for all costs relating to the specific pay item.

A  **No Payment**

The Contractor will not receive compensation for:

1. Boring under roots in the tree protection zone, dressing of wounds, and disposal of material and debris.
2. Pruning that is necessary to allow for the Contractor's operations or to remedy damage caused by the Contractor's operations.

B  **Payment at Unit Prices**

The Department will pay at the following unit prices for protection and restoration of vegetation items in the absence of a Contract bid price:

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Temporary Fence ..........</td>
<td>$8.00 per meter ($2.50 per linear foot)</td>
</tr>
<tr>
<td>(2) Clean Root Cutting ......</td>
<td>$11.50 per meter ($3.50 per linear foot)</td>
</tr>
<tr>
<td>(3) Water .....................</td>
<td>$8.00 per cubic meter ($3.00 per 100 gallons)</td>
</tr>
<tr>
<td>(4) Sandy Loam Fill ...</td>
<td>$10.00 ($7.65) per cubic meter (cubic yard)</td>
</tr>
<tr>
<td>(5) Prune Trees ...............</td>
<td>$75.00 per hour</td>
</tr>
</tbody>
</table>

C  **Payment at Contract Bid Prices**

The Department will pay at the Contract bid price as follows:

<table>
<thead>
<tr>
<th>Item No. Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2572.501</td>
<td>Temporary Fence meter (linear foot)</td>
</tr>
<tr>
<td>2572.502</td>
<td>Clean root cutting meter (linear foot)</td>
</tr>
<tr>
<td>2572.503</td>
<td>Water liter (gallon)</td>
</tr>
<tr>
<td>2572.504</td>
<td>Sandy loam fill cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2572.505</td>
<td>Prune trees hour</td>
</tr>
</tbody>
</table>
2573

Storm Water Management

2573.1 DESCRIPTION
This work consists of: 1) managing storm water runoff and project related water discharges in order to minimize sediment pollution during construction and over the life of the contract and 2) managing the discharges associated with dewatering and basin draining activities as set forth in the NPDES permit. The work includes furnishing, installing, maintaining and utilizing storm water best management practices and any work specified in conjunction therewith as well as removing temporary sediment control devices when no longer necessary.

2573.2 MATERIALS
A  Bale Barriers, as specified for Type 1 Mulch ........... 3882
B  Silt Fence .......................................................... 3886
C  Flotation Silt Curtain .......................................... 3887
D  Temporary Ditch Checks ..................................... 3889
E  Storm Drain Inlet Protection ............................... 3891
F  Temporary Downdrain ......................................... 3892
G  Sandbags ............................................................ 3893
H  Sediment Mat ...................................................... 3894
I  BLANK
J  Filter Logs ......................................................... 3897
K  Flocculants ......................................................... 3898

2573.3 CONSTRUCTION REQUIREMENTS
A  General ...... Also refer to: 1701, 1716, 1717, 2105.5, 2575
   In accordance with 1716 the Contractor has responsibility for charge and care of the Project and shall take necessary precautions against injury or damage to the Project by action of the elements. In addition, the Contractor shall take necessary precautions to prevent off site damage resulting from work conducted on the Project or Project related storm water runoff.

   The Contractor is responsible for preventing or minimizing sediment loss from the Project by directing storm water runoff to constructed ponds and sediment traps as well as installing temporary sediment control devices in drainage locations where runoff can leave the Project limits and/or enter into environmentally sensitive areas.

   The Contractor shall schedule, construct and/or install temporary sediment control and storm water management measures as required by the Contract and as stated in the permits required for the Project without having to obtain prior approval or having to be so directed by the Engineer. In the case of errors or omissions, the Contractor shall inform the Engineer upon immediate discovery.
The Contractor shall install temporary storm water management and sediment control devices in conformity with the details, typical sections, and elevation controls shown in the Contract. The actual installation location of temporary storm water management and sediment control devices may be slightly adjusted from that indicated in the Plan to better accommodate the actual field conditions and increase the effectiveness of a device. The Department will not conduct location staking unless requested by the Contractor. Errors, omissions, and changed site conditions affecting the location or placement of the temporary storm water management or sediment control devices shall be brought to the attention of the Engineer by the Contractor.

A1 Erosion Control Supervisor

The Contractor shall provide an Erosion Control Supervisor with a valid certification to direct the Contractor and subcontractor(s) operations and insure compliance with Federal, State and Local ordinances and regulations. The certification is obtained by completing a two (2) day Erosion/Sediment Control Site Management training class and passing the required test, from a Mn/DOT approved provider as listed in the Mn/DOT certification schedule.

The Erosion Control Supervisor shall implement the SWPPP and conduct the Contractor’s erosion and sediment quality control program. In addition, the Erosion Control Supervisor shall be available to be on the Project within 24 hours at all times from initial disturbance to final stabilization as well as perform the following duties:

1. Coordinate and schedule the work of subcontractors such that erosion and sediment control measures are fully executed for each operation and in a timely manner over the duration of the Contract.
2. Oversee the work of subcontractors so that appropriate erosion and sediment preventive measures are undertaken at each stage of the work.
3. Prepare the required weekly erosion control schedules and present it to the Engineer.
4. Attend all weekly construction meetings to discuss the findings of the NPDES inspection log and other related issues.
5. Prepare the erosion/sediment control site plans requested by the Engineer.
6. Provide for erosion/sediment control methods for Contractor's temporary work not shown on the plans, such as work platforms, temporary construction, pumping operations, plant and storage yards, and cofferdams.
7. Ensure that applicable permits are acquired and complied with for borrow pits, dewatering and any temporary work conducted by the Contractor in rivers, lakes and stream
8. Ensure that all erosion/sediment control work is conducted in a timely manner.
9. Ensure that erosion/sediment control work is installed to the fullest extent prior to suspension of the work.
10. Coordinate with Federal, State and Local Regulatory agencies on resolution of erosion/sediment control issues due to the Contractor's operations.
11. Ensure that proper cleanup occurs from vehicle tracking on paved surfaces and/or any location where sediment leaves the Right-of-Way.
   If the Contractor fails to provide a certified Erosion Control Supervisor for the Project, the Engineer shall issue a written order to the Contractor. The Contractor shall respond within 24 hours and provide the required Erosion Control Supervisor or be subject to a $1000 per calendar day deduct for noncompliance.

A2 Construction of Temporary Storm Water Basins
   Temporary storm water basins shall be constructed concurrently with the start of soil disturbing activities whenever possible. The basins must be made fully functional and have storm water runoff from the localized watershed directed to the basins. The exposed sideslopes of the basins must be mulched and/or seeded within the time periods as set forth in 1717, or as directed by the Engineer.

A3 Temporary Sediment Control Measures
   Sediment control measures must be installed down gradient prior to or in conjunction with soil disturbing activities. The Contractor shall schedule, install and maintain temporary sediment control measures as an ongoing effort on a site-by-site basis over the life of the Contract. The Contractor is responsible for minimizing the potential for sedimentation after temporary sediment control devices have been installed by implementing a good quality erosion control program and staging construction as needed. If the Engineer determines that the Contractor has not followed good erosion control practices that result in sedimentation outside of the Right of Way, the Contractor shall retrieve all sediment that has left the Right of Way and restore the property to the pre-existing condition, to the fullest extent possible at the Contractor's expense.

A4 Dewatering and Pumping
   If dewatering or pumping of water is necessary, the Contractor is responsible for obtaining any necessary permits in accordance with 1701 and 1702. If the discharge from the dewatering or pumping process is turbid or contains sediment-laden water, it must be treated through use of sediment traps, vegetative filter strips, flocculants, or other sediment reducing measures such that the discharge is not visibly
different from the receiving water. The discharge location of the
dewatering process must also be protected from excess erosion. Unless
otherwise provided in the Contract, the best management practices used
to control erosion and suspended sediment during the dewatering or
pumping operation shall be furnished by the Contractor. The
Contractor shall submit a dewatering plan to the Engineer prior to
initiating dewatering activities.
A5  Vehicle Tracking onto Paved Surfaces
The Contractor shall use wood chip pads, temporary paving, or
other appropriate Best Management Practices (BMPs) at major vehicle
exit locations to minimize vehicle tracking of sediment from the Project
onto paved surfaces. BMPs to protect vehicle exit sites shall be
furnished by the Contractor and shall be incidental to the Project for
which no direct compensation will be made.

The Contractor is responsible for insuring paved streets are clean at
the end of each working day. Tracked sediment on paved surfaces must
be removed by the Contractor within 24 hours of discovery, in
accordance with 1717.2. Payment for street sweeping to provide safe
conditions for the traveling public, environmental reasons or regulatory
requirements shall be as provided in accordance with 1514.
A6  Infiltration Areas
Infiltration areas and constructed infiltration systems should not be
constructed until the contributing drainage area and/or adjacent
construction site have been completely stabilized. When this timing of
construction is not possible, the Contractor shall insure sediment from
exposed soil areas of the Project does not enter into the infiltration area
or system. Payment for constructing infiltration areas shall be as
provided for in the Contract.
A7  Critical Resources
The Contractor shall schedule and phase construction in critical
resource areas to the best of his ability in order to minimize the
potential of sediment entering into a critical resource. Critical resources
include but are not limited to, protected wetlands, surface waters, trout
streams, Special Waters, impaired waters, rivers, and endangered
species habitat. Measures to minimize sediment potential include
practices such as hand clearing and grubbing, limited bare soil exposure
time, and immediate final establishment of vegetation.
B  Installation of Bale Barriers
Bales shall be trenched into the ground 100 mm (4 inches) and
staked with two 50 mm x 50 mm (2 inch x 2 inch) wood stakes. The
stakes shall be of sufficient length such that at a minimum the top of the
stakes are flush with the top of the bale and are also embedded into the
ground a minimum of 250 mm (10 inches).
C Silt Fence Installation

C1 Machine Sliced
The geotextile shall be inserted by a machine in a slit in the soil 200-300 mm (8-12 inches) deep with the salvaged edge on top. The slit shall be created such that a soil-slicing blade slightly disrupts soil upward as the blade slices through the soil. Directly behind the soil-slicing blade, the geotextile shall be mechanically inserted down into the soil slit such that 200-300 mm (8-12 inches) of the geotextile is below the ground surface. Soil slicing and installation is a simultaneous operation, achieving consistent placement and depth. No turning over (plowing) of soil is allowed for the slicing method. Compact the soil immediately next to the geotextile by operating the wheels of a tractor or skid steer on each side of the geotextile a minimum of 2 times. Posts shall be installed adjacent to the back face of the geotextile with the nipples facing away from the geotextile fabric. Posts shall be embedded a minimum of 0.6 m (2 feet) into the ground and installed a maximum of 1.8 m (6 feet) apart for general use and 1.2 m (4 feet) apart in ditch check applications. Secured at each post, three plastic zip ties shall be inserted through the geotextile within the top 200 mm (8 inches) of the fabric, puncturing holes vertically a minimum of 25 mm (1 inch) apart. 

C2 Heavy Duty
The heavy duty silt fence system shall be hand installed with the salvaged edge on top. The bottom edge of the geotextile shall be placed into a 150 mm (6 inch) deep by 100 mm (4 inch) wide trench with the bottom edge of the geotextile wrapping back up to the soil surface. The trench shall be backfilled and tamped for compaction. Posts shall be installed adjacent to the back face of the geotextile with the nipples facing away from the geotextile fabric. Post shall be embedded a minimum of 0.6 m (2 feet) into the ground and installed a maximum of 1.8 m (6 feet) apart. Secured at each post, three plastic zip ties shall be inserted through the geotextile within the top 200 mm (8 inches) of the fabric, puncturing holes vertically a minimum of 25 mm (1 inch) apart.

C3 Super Duty
The bottom edge of the geotextile shall be placed 100-150 mm (4 to 6 inches) underneath the face of the median barrier exposed to direct storm water runoff. The median barriers shall be placed end to end in such a way to minimize the gap between each barrier. The geotextile shall be attached to the face of the barrier with wire or plastic zip tie inserted into the top 200 mm (8 inches) of the geotextile and tied to each eyelet on the barrier.

C4 Preassembled
The geotextile shall be installed with the salvaged edge on top. The bottom edge of the geotextile shall be placed into a 150 mm (6 inch)
deep by 150 mm (6 inch) wide trench. The trench shall be backfilled and tamped for compaction. Post shall be embedded a minimum of 450 mm (18 inches) into the ground and installed a maximum of 1.8 m (6 feet) apart.

D  Flotation Silt Curtain Installation

The curtain shall be constructed with connecting devices at each end so that sections can be joined together. Connecting devices shall be designed to prevent silt from permeating through the connection and at the specified strength to prevent ripping out. The depth of the curtain shall be a minimum of 0.6 m (2 feet) to a maximum of 3.0 m (10 feet). Unless otherwise specified in the Contract, the depth of curtain shall be 1.2 m (4 feet). Installation shall typically be on the bottom of the water body.

D1  Still Water

The curtain shall be anchored along its length with enough weight to hold it in place. Both ends of the curtain shall be secured to land.

D2  Moving Water

The curtain shall be anchored out in the waterway in a herring bone configuration. The curtain shall be placed at an approximate 30 degree angle from shore, pointing up stream. Curtains shall not be placed across flowing water courses. Anchors shall be 136 kg (300 pounds) and located a maximum of 14.2 m (50 feet) spacing along the curtain. Each anchor shall be marked by a buoy. One end of the curtain shall be secured to land.

D3  Work Area

The curtain shall extend at a 45 degree angle from both ends secured to shore to enclose the work area. The work area shall extend a maximum of ¼ of the stream width. The curtain shall extend a maximum of ⅓ of the stream width. The curtain shall be anchored out in the waterway with a minimum of 18 kg (40 pounds) at a maximum of 30 m (100 feet) intervals along the length of the curtain.

E  Temporary Ditch Check Installation

All ditch checks shall be sufficiently long perpendicular to the ditch gradient such that the top of the device in the middle of the ditch is lower in elevation than the bottom of the terminating points on the ditch sideslopes.

E1  Type 1- Sliced in Silt Fence

Installation procedures are in accordance with 2573.3 C1. Maximum post spacing shall be 1.2 m (4 feet).

E2  Type 2- Bioroll

The bioroll shall be installed and anchored with wood stakes. The stakes shall be at a minimum nominally 13 mm x 50 mm (½ inch x 2 inch) and a minimum of 400 mm (16 inches) long with a pointed end.
The stakes shall be driven through the back half of the bioroll at an angle of approximately 45 degrees with the top of the stake pointing upstream. The maximum spacing between stakes shall be 0.3 m (1 foot). When more than one bioroll is needed for length, the ends shall be overlapped 150 mm (6 inches) with both ends staked.

E3  Type 3- Bioroll Blanket System

The blanket shall be rolled out on bare soils and across the ditch with the leading edge that is subject to flow buried in a 100 mm (4 inch) deep by 100 mm (4 inch) wide trench. The trench shall be backfilled and compacted. The blanket shall form a minimum width of 3.7 m (12 feet) perpendicular to the ditch gradient. The blanket shall be stapled with either U shaped, 11 gage or heavier steel wire having a span width of 25 mm (1 inch) and a length of 150 mm to 200 mm (6 to 8 inches) at a maximum spacing of 3 m (1 foot) on center.

The bioroll shall be installed on top of the blanket and anchored with wood stakes. The stakes shall be at a minimum nominally 13 mm x 50 mm (½ inch x 2 inch) and a minimum of 400 mm (16 inches) long with a pointed end. The stakes shall be driven through the back half of the bioroll at an approximate angle of 45 degrees with the top of the stake pointing upstream. The maximum spacing between stakes shall be 0.3 m (1 foot). When more than one bioroll is needed for length, the ends shall be overlapped 150 mm (6 inches) with both ends staked.

E4  BLANK

E5  Type 5- Rock Weeper

A Type IV geotextile (3733) shall line the bottom of the rock weeper. The rock weeper shall be created such that the side profile forms a triangle with 1:6 (V:H) slopes on both the front and back slopes. Coarse concrete aggregate shall be installed on the front half of the triangle with a 1:6 slope to a height of ½ m (1 ½ feet). The riprap shall be installed on the back half of the triangular section. The center cross-section of the weeper shall be constructed such that center point of the rock weeper is approximately 100 mm (4 inches) lower than the end points of the weeper at the ditch side slopes.

E6  Type 6- Geotextile triangular dike

The leading edge subject to flow of the geotextile apron shall be buried in a 100 mm (4 inch) deep by 100 mm (4 inch) wide trench. The trench shall be backfilled and compacted. The flat geotextile portion shall be stapled with U shaped, 11 gage or heavier steel wire having a span width of 25 mm (1 inch) and a length of 150 mm to 200 mm (6 to 8 inches) at a maximum spacing of 300 mm (1 foot) on center.
E7  Type 7- Rock check
Riprap shall be installed on top of a Type IV geotextile liner (3733). Class II crushed riprap shall be used in the absence of a specified class. Rock shall be configured in a trapezoidal shaped berm with respect to the side profile such that the bottom of the berm is approximately 1.5 m (5 feet) wide, the top of the berm is approximately ½ m (1 ½ feet) wide, and the depth of the berm is approximately ½ m (1 ½ feet) deep. The center cross-section shall be constructed such that the center point of the rock check is approximately 100 mm (4 inches) lower than the end points of the rock check at the ditch side slopes.

F  Storm Drain Inlet Protection
Storm drain inlet protection shall consist of the best management practices and devices for preventing sedimentation into and through underground drainage systems. Storm drain inlet protection applies to manholes, catch basins, curb inlets and other drop type inlets constructed for the ingress of surface water runoff into underground drainage systems. Storm drain inlet protection as described herein, will not include practices to protect culverts. See Section G for culvert protection.

The Contractor must protect storm drain inlets with sediment capture devices prior to soil disturbing activities that would result in sediment laden storm water runoff entering the inlet. The Contractor shall provide effective storm drain inlet protection over the life of the Contract until all sources with potential for discharging to an inlet have been paved or stabilized. As the Contractor's operations change, the storm drain inlet Best Management Practice for sediment control must be modified by the Contractor to ensure proper effectiveness for sediment capture.

The Contractor is responsible for preventing or minimizing the potential for unsafe, flooding, or siltations problems. For example, devices must be regularly cleaned out and emergency overflow must be an integral part of the device to reduce the flooding potential; and devices must be placed such that driving hazards or obstructions are not created. Sediment deposited in and/or plugging drainage systems will be the responsibility of the Contractor and shall be removed at no expense to the Department.

G  Culvert Protection
Methods to protect the various types of culverts both at the inlet and/or outlet shall be as indicated in the Plan. Unless otherwise provided for in the Contract, materials and/or devices used shall be paid for separately.
H  Sediment Mat Installation
Mats shall be laid flat on the bottom of the streambed and anchored with wood stakes. The stakes shall be nominally 50 mm x 50 mm (2 inch x 2 inch) with a pointed end. Stakes shall be of sufficient length to be embedded a minimum of 0.45 m (18 inches) into the streambed and also appear above the water surface. The maximum spacing between stakes shall be 0.6 m (2 feet) along all edges of the mat. When more than one mat is necessary, the upstream mat edge shall overlap the downstream mat a minimum of 0.15 m (6 inches). The sides of adjoining mats shall overlap a minimum of 0.15 m (6 inches).

I  BLANK

J  Filter Log Installation
Filter logs shall be placed in accordance with the Plan. Straw and wood fiber filter logs shall be staked in place with wood stakes. Wood stakes shall be at a minimum 13 x 51 mm (½ x 2 inch) nominal size by 400 mm (16 inches) long. The stakes shall be driven through the back half of the log at an angle of approximately 45 degrees with the top of the stake pointing upstream. When more than one log is needed for length, the ends shall be overlapped 150 mm (6 inches) with both ends staked. Staking shall be every 0.3 m (1 foot) along the log unless precluded by paved surface or rock.

K  Flocculants
Flocculants shall not be applied directly to surface waters unless regulatory approval has been obtained. Flocculants shall be applied within containment areas such as temporary storm water ponds, temporary sediment traps, and containment systems. Before applying a flocculant, the pH and temperature of the storm water must be tested and be within the manufacturer's specified ranges. Adequate retention time for chemical reaction (approximately 15-20 minutes) for clay-sized particles to settle must be achieved such that the discharge of the treated water is visually the same as the receiving water.

K1  Liquid Floc
Liquid Flocculant shall be hydraulically applied over the surface of the water to be treated. The liquid flocculant concentrate shall be diluted to form a stock solution. The stock solution shall be applied at the appropriate rate to yield 1ppm in the final treated water volume.

K2  Flocculant Log
The flocculant log shall be securely anchored in an area where the water to be treated will flow over the flocculant log. Flocculant logs are not to be left in standing, stagnant water.
K3  Granular Flocc

Granular based flocculant shall be mixed with water in a tank to form a stock solution. The stock solution shall be hydraulically applied at the appropriate rate to yield 1ppm in the final treated water volume.

L  BLANK

M  Maintenance

M1  General

The Contractor shall maintain all temporary sediment control devices until they are no longer necessary and are removed. Maintenance consists of keeping the devices functioning properly. The Contractor shall repair or replace plugged, torn, displaced, damaged, or non-functioning devices to the satisfaction of the Engineer.

M2  Temporary Sediment Control Devices

The Contractor shall remove sediment from devices such as bale barriers, silt fences, ditch checks and storm water filter logs when the sediment reaches one-third of the height of the device and reshape the area to the Plan specifications. If sediment removal causes damage to a device or the device is non-functional, the Contractor shall replace the device. Sediment removal shall occur within 24 hours of discovery or as soon as field conditions allow access. Removal of sediment shall be incidental to the Project for which no direct compensation will be made.

M3  Sediment Basins and Traps

When the depth of sediment collected in the basin reaches 50 percent of the height of the riser, or 50 percent of the storage volume, the basin shall be drained and the sediment removed. Drainage and removal shall be completed within 72 hours of discovery, or as soon as field conditions allow access. Removal of sediment shall be paid for separately.

After the entire Project has undergone final stabilization, all temporary sedimentation basins to be used as permanent water quality management basins must be cleaned out and shaped by the Contractor to the Plan's specifications.

M4  Storm Drain Inlet Protection Devices

The Contractor shall clean, remove sediment or replace storm drain inlet protection devices on a routine basis such that the devices are fully functional for the next rainstorm event. Removal and disposal of trapped sediment in inlet protection devices shall be incidental to the Project. Sediment deposited in and/or plugging drainage systems is the responsibility of the Contractor and shall be removed at no expense to the Department.

N  Sediment Removal

The Contract shall remove sediment deposited in sediment basins and traps once the sediment reaches 50 percent of the basin or trap's
sediment storage capacity within 72 hours of discovery. Sediment removal shall consist of excavating and other associated operations to remove sediment and restore the capacity of the temporary sediment control device. Sediment shall be removed to the original grade or as necessary to restore the function of the device. Sediment removed shall be spread or disposed of to the satisfaction of the Engineer. The Contractor will be compensated for sediment removal on an equipment rental hourly basis in accordance with 2123. Spreading, hauling, and disposing of material shall be at no expense to the Department.

Sediment removal shall be accomplished with a backhoe or other suitable equipment capable of reaching out and excavating semi-solid material. The backhoe shall be of the full-revolving crawler type and shall have a minimum bucket size 0.4 m³ (½ cubic yard). Size of the boom and the power unit shall be as recommended by the manufacturer for use with the bucket size. Depending on site conditions, the Engineer may allow a rubber tired tractor type backhoe to be used. Payment for the rubber tired tractor backhoe will be prorated based on rated capacity of the machine.

O Removal of Temporary Devices

The Contractor shall remove all temporary sediment control devices upon completion of the Contract work unless otherwise specified in the Contract or directed by the Engineer. All removed materials become the property of the Contractor.

The Contractor shall spread accumulated sediment to form a suitable surface for turf establishment or dispose of the sediment elsewhere. The Contractor shall shape the area to permit natural drainage. All work shall be done to the satisfaction of the Engineer.

P Workmanship and Quality Control

The Contractor is responsible for maintaining quality control on the project by ensuring that all work performed and all materials furnished are in conformance with the dimensions, installation requirements and material specifications shown in the Plans or indicated in the Specifications. Quality workmanship shall be used in all aspects of the work and shall be uniform in character throughout the project.

P1 Certified Installers

When erosion or sediment control practices are installed, a certified installer shall be on the Project to install the practices or direct the installation. Certified installer requirements shall apply to the following operations:

Seeding
Sodding
Mulching
Silt fence or other perimeter sediment control device installations
Erosion control blanket installation
Hydraulic Soil Stabilizer installation
Silt curtain installation
Ditch check installation
Compost installation
Erosion Stabilization Mat installation

Each Contractor or subcontractor installing erosion or sediment control practices shall provide at least one certified installer at the time of installation. The certification is obtained by completing and passing an Erosion/Sediment Control Inspector/Installer training course that is taught by a Mn/DOT approved provider as listed in the Mn/DOT certification schedule.

If the Contractor or subcontractor(s) fails to provide the required certified installer(s), the Erosion Control Supervisor shall notify the Engineer. If either the Erosion Control Supervisor or the Engineer determines that one or more required certified installers have not been provided, the Contractor shall respond to the Engineer’s notification within 2 days with the appropriately certified or provisionally certified person(s), or be subject to a $500.00 per required installer per calendar day deduction for noncompliance.

Q Workmanship Rework Schedule

Performance of the work shall be controlled by the Contractor so that the materials installed and the workmanship practices are of good quality. When the quality falls below the threshold level defined in Table 2573-1, the Contractor shall take immediate action to correct the situation and prevent it from reoccurring. As indicated in the table, the Contractor shall correct unacceptable workmanship to qualify for payment.
### TABLE 2573-1
Temporary Erosion Control: Corrective Action

<table>
<thead>
<tr>
<th>Item</th>
<th>Corrective action required when</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt Fence</td>
<td>Improper geotextile used&lt;br&gt;Insufficient geotextile embedment&lt;br&gt;Insufficient compaction of soil&lt;br&gt;Soil turned over and/or loosened due to inadequate equipment for sliced type&lt;br&gt;Inadequate fastening of geotextile, posts, etc.&lt;br&gt;Incorrect post spacing</td>
</tr>
<tr>
<td>Bale Barriers</td>
<td>Not notched in&lt;br&gt;Not properly staked into the ground</td>
</tr>
<tr>
<td>Floatation Silt Curtain</td>
<td>Curtain not anchored on land&lt;br&gt;Curtain not weighted sufficiently in water</td>
</tr>
<tr>
<td>Ditch Checks</td>
<td>Not trenched in for silt fence, blanket or triangular dike&lt;br&gt;Not stapled properly for blanket or triangular dike&lt;br&gt;Water flows around the end rather than over the middle&lt;br&gt;Incorrect post spacing for silt fence or biroll/blanket system&lt;br&gt;Biorolls not staked properly&lt;br&gt;No geotextile used for Type 5 or 7</td>
</tr>
<tr>
<td>Storm Drain Inlet Protection</td>
<td>Inlet opening is not protected.&lt;br&gt;Emergency overflow is not provided where required&lt;br&gt;Device not cleaned out</td>
</tr>
<tr>
<td>Filter Logs</td>
<td>Not staked properly resulting in under mining or movement of logs&lt;br&gt;Log ends not overlapped when more than one is needed in a line</td>
</tr>
</tbody>
</table>

The above table pertains to a threshold level of workmanship only and does not pertain to the use of nonconforming materials. The disposition of nonconforming materials shall be in accordance with 1503. The Contractor at no cost to the Department shall perform any corrective actions required for acceptance of the work.
2573.4  METHOD OF MEASUREMENT
A  Bale Barriers
   Bale barriers will be measured by the length furnished and acceptably installed.
B  Silt Fence
   Silt fence will be measured by length furnished and acceptably installed. Measurement will be along the base of the fence from outside to outside of the end posts for each section of fence.
C  Sandbag Barriers
   Sandbag barriers will be measured by surface area acceptably installed based on actual measurement taken along the length of the barrier times its height. When more than one thickness of bags is installed, the surface area of each layer of thickness will be measured and added to the quantity.
D  Flotation Silt Curtain
   Flotation silt curtain will be measured by length furnished and acceptably installed.
E  Sediment Traps
   Sediment trap quantities will be measured by volume for basin excavation and construction. Excavation will be measured by volume of the material in its original position. Quantities will be based on actual field measurement and increases or decreases to the estimated Plan quantity will not be considered as a basis of claim for adjusted unit prices. Materials used to provide an overflow will be measured and paid for separately.
F  Temporary Pipe Downdrains
   Temporary pipe downdrains will be measured by length finished and acceptably installed. Materials, such as riprap, used to provide an outlet will be measured and paid for separately.
G  Bituminous Lined Flumes
   Bituminous lined flumes will be measured by area on the basis of actual surface dimensions as placed without regard to the type of bituminous mixture used or number of courses placed. The type of bituminous used shall be as provided for in the Contract or as directed by the Engineer. Damaged areas restored, by order of the Engineer, will be added to the original quantity. Materials, such as riprap, used to provide an outlet will be measured and paid for separately.
H  Diversion Mounds
   Diversion mounds will be measured by volume after compaction and in its final configuration. Quantities will be based on actual field measurement.
I  BLANK
J  BLANK
K Sediment Removal
Sediment removal will be measured by the number of hours of actual equipment working time in accordance with 2123.4. Sediment removed may be fluid or semi-solid and its consistency shall not be considered a basis of claim for adjusted unit prices.

L Sediment Mats
Sediment mats will be measured by the area furnished and acceptably installed.

M Temporary Ditch Checks
Types 1, 2, 3, 6 temporary ditch checks will be measured by length furnished and acceptably installed. Types 5 and 7 will be measured by volume based on field measurement.

N Culvert Protection
Culvert protection devices will be measured by the quantity of each device furnished and installed. Quantities for new devices to replace the original device installed will be measured and added to the total quantity.

O Storm Drain Inlet Protection
O1 Each Storm Drain Inlet
Storm drain inlet protection will be measured by the number of individual inlets properly protected over the life of the Contract without regard to the various types or number of devices used at each storm drain inlet.

O2 Lump Sum
Storm drain inlet protection will be measured by lump sum. Lump sum shall be considered to include all materials and labor as necessary to provide proper inlet protection over the life of the contract regardless of quantities required. Under this provision, no measurement will be made of any individual device or inlet location.

P Filter Logs
Filter logs will be measured by the length furnished and acceptably installed.

Q BLANK

R Flocculants
R1 Type A will be measured by the volume of liquid flocculant concentrate used and acceptably placed. No measurement will be made for the amount of water used to dilute the concentrate.
R2 Type B will be measured by each flocculant log furnished and acceptably placed.
R3 Type C will be measured by the mass of granular flocculant used and acceptably placed. No measurement will be made for the amount of water used to dissolve and dilute the granular flocculant.
Erosion Control Supervisor

No direct measurement will be made of the various duties that the Erosion Control Supervisor performs or of the number of hours required, but all such work will be construed to be included in the single Lump Sum Payment. Upon satisfactory completion of either one-half the allowable Working Days for the Project, or one-half of the anticipated Project duration time, the Engineer may authorize partial payment not exceeding 50 percent of the Contract bid price. The remaining percentage will be paid upon satisfactory performance of duties at the Engineer’s discretion and completion of the Project.

2573.5 BASIS OF PAYMENT

Payment for storm water management and sediment control items will be compensation in full for all labor, materials, equipment, and other incidentals necessary to complete the work as specified, including the costs of maintenance and removal as required by the Contract. The Contractor will receive compensation at the appropriate Contract prices, or in the absence of a Contract bid price, according to the following unit prices, or in the absence of a Contract price and unit price, as Extra Work.

A General

Upon satisfactory installation of temporary sediment control devices, the Engineer may authorize partial payment not exceeding 80 percent of the Contract bid price for that item, unless otherwise indicated in the Contract. The remaining percentage will be paid after the devices are removed.

B Storm Drain Inlet Protection

B1 Partial Payments

Storm drain inlet protection will be paid in partial payment amounts for satisfactory completion of the following work.

- Initial Installation ........................................................... 25% payment
- Maintenance during first half of Contract period ........... 25% payment
- Maintenance during last half of Contract period and removal of the devices .................................... 50% payment

B2 Deductions

If the Contractor fails to properly install, remove sediment, or maintain storm drain inlet protection, the Contractor shall be subject to a $500.00 per calendar day deduction for noncompliance. The deduction shall apply to each inlet that is out of compliance and shall be deducted from monies owed to the Contractor.

C BLANK

D BLANK
E  Unit Prices

The Department will pay the following unit prices for temporary sediment control items in the absence of a Contract bid price:

1. Bale Barrier ................................................. $6.00/m ($1.85 per linear foot)
2. Silt Fence, Heavy Duty ....................... $10/m ($3.00 per linear foot)
3. Flotation Silt Curtain, Type: Still Water, 1.2 m (4 feet) depth
   ....................................................... $52/m ($16.00 per linear foot)
4. Sediment Trap Excavation
   ....................................................... $4/m$^3$ ($3.00 per cubic yard)
5. Bituminous Lined Flume
   ....................................................... $6/m^2$ ($5.00 per square yard)
6. Silt Fence, type Machine Sliced
   ....................................................... $6.50/m ($2.00 per linear foot)
7. Sediment Removal, Backhoe .......................$120 per hour
8. Filter Log, Type Straw Biolog ......................$1.00/m ($3.00/foot)
9. Filter Log, Type Rock Log .......................$0.55/m ($1.80/foot)
10. Flocculant Sock ............................................... $200 each

F  Pay Items

Payment for temporary erosion control items will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2573.501</td>
<td>Bale Barrier</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2573.502</td>
<td>Silt Fence, Type (1)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2573.504</td>
<td>Sandbag Barrier</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2573.505</td>
<td>Flotation Silt Curtain, Type (1)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2573.506</td>
<td>Sediment Trap Excavation</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2573.507</td>
<td>Temporary Pipe Downdrain</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2573.508</td>
<td>Bituminous Lined Flume</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2573.509</td>
<td>Diversion Mound</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2573.511</td>
<td>Sediment Mat</td>
<td>square meter (square foot)</td>
</tr>
<tr>
<td>2573.512</td>
<td>Temporary Ditch Check, Type (1)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2573.513</td>
<td>Temporary Ditch Check, Type (1)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2573.520</td>
<td>Sediment Removal, Backhoe</td>
<td>hours</td>
</tr>
<tr>
<td>2573.530</td>
<td>Storm Drain Inlet Protection</td>
<td>each</td>
</tr>
<tr>
<td>2573.531</td>
<td>Storm Drain Inlet Protection, Lump Sum</td>
<td></td>
</tr>
<tr>
<td>2573.540</td>
<td>Filter Log, Type (1)</td>
<td>meter (linear foot)</td>
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<tr>
<td>2573.541</td>
<td>Liquid Floc</td>
<td>cubic meter (gallon)</td>
</tr>
<tr>
<td>2573.542</td>
<td>Flocculant Sock</td>
<td>each</td>
</tr>
<tr>
<td>2573.543</td>
<td>Granular Floc</td>
<td>kg (lb)</td>
</tr>
<tr>
<td>2573.550</td>
<td>Erosion Control Supervisor</td>
<td>Lump Sum</td>
</tr>
</tbody>
</table>

Note: (1) Specify Type
Controlling Erosion and Establishing Vegetation

2575.1 DESCRIPTION
This work shall consist of reducing the risk of soil erosion by: 1) providing temporary shaping and grading; 2) applying temporary soil covers; and 3) establishing a perennial ground cover. Temporary shaping and grading includes measures such as shaping to temporarily direct water flow, smooth-rough grading to allow for adequate installation of temporary erosion control materials, cat-tracking and other measures effective at reducing the soil erosion potential. The use of temporary soil covers includes but is not limited to, mulch, establishment of an annual vegetative cover, erosion control blanket and hydraulic soil stabilizers. Establishment of a perennial vegetative cover shall include soil tilling, liming, fertilizing, seeding, sodding, mulching, and any other work specified in conjunction therewith.

2575.2 MATERIALS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Seed, mix as specified</td>
<td>3876</td>
</tr>
<tr>
<td>B</td>
<td>Blank</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Sod</td>
<td>3878</td>
</tr>
<tr>
<td>D</td>
<td>Lime</td>
<td>3879</td>
</tr>
<tr>
<td>E</td>
<td>Fertilizer</td>
<td>3881</td>
</tr>
<tr>
<td>F</td>
<td>Mulch</td>
<td>3882</td>
</tr>
<tr>
<td>G</td>
<td>Erosion Control Netting</td>
<td>3883</td>
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<tr>
<td>H</td>
<td>Erosion Control Blanket</td>
<td>3885</td>
</tr>
<tr>
<td>I</td>
<td>Hydraulic Soil Stabilizer</td>
<td>3884</td>
</tr>
<tr>
<td>J</td>
<td>Compost</td>
<td>3890</td>
</tr>
<tr>
<td>K</td>
<td>Blank</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Erosion Stabilization Mat</td>
<td>3888</td>
</tr>
</tbody>
</table>

2575.3 CONSTRUCTION REQUIREMENTS

2575.3.1 General
The Contractor is responsible for minimizing soil erosion and preventing damage from sedimentation over the various stages of construction at all seasonal times during the year for the duration of the Contract by utilizing the best management practices established in 2573 in conjunction with the erosion control practices contained herein. The Contractor shall use other erosion control best management practices such as limiting the amount of exposed erodible soils, and providing horizontal cat track indentation to enhance the effectiveness of the sediment and erosion control devices. The Contractor shall protect slopes, ditch outlets, drainage outlets, and storm water discharge points from erosion in accordance with the time schedules established in the permit requirements.
A1 Concurrent Critical Area Stabilization

The Contractor shall use the various methods provided in Section N- Rapid Stabilization, to temporarily stabilize disturbed areas within 61 m (200 feet) of surface waters as necessary for the duration of the Contract. The Contractor shall schedule, construct and/or install rapid stabilization measures in critical areas designated in the Contract or in accordance with permit requirements without having to obtain prior approval or having to be so directed by the Engineer.

A2 Spring and Fall Growing Seasons

The Contractor shall schedule and install temporary and permanent erosion control measures, finish earthwork operations, place topsoil, and establish turf in a continuous operation on an area by area basis to the fullest extent practical. The Contractor shall establish turf on the completed sections as required, without unnecessary delay and before weed growth or soil erosion occurs.

The dates for the season of planting for the various seed mixtures are listed in 2575-1. The Engineer may adjust a specified date by up to 10 days depending on prevailing weather conditions.

<table>
<thead>
<tr>
<th>Seed Mixture Number</th>
<th>Spring</th>
<th>Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>---</td>
<td>Aug. 1 – Oct. 1</td>
</tr>
<tr>
<td>110</td>
<td>May 1 – Aug. 1</td>
<td>---</td>
</tr>
<tr>
<td>150, 190</td>
<td>April 1 – July 20</td>
<td>July 20 – Oct. 20</td>
</tr>
<tr>
<td>240, 250, 260, 270</td>
<td>April 1 - June 1</td>
<td>July 20 - Sept. 20</td>
</tr>
<tr>
<td>280</td>
<td>April 1 – Sept. 1</td>
<td>---</td>
</tr>
<tr>
<td>310, 325, 328, 330, 340, 350</td>
<td>April 15 – July 20</td>
<td>Sept. 20 – Oct. 20</td>
</tr>
</tbody>
</table>

For the portion of Minnesota north of, and including TH 2, the Season of Planting for Mixtures 150 through 280 shall be April 15 through September 20.

A3 Summer Season

When the dates in the season of planting prohibit seeding of the specified seed mixture, the Engineer may specify an alternative seed mixture or temporary mulch may be placed and seeding be conducted at a later date.

A4 Early Winter Season

Early winter season work shall consist of the erosion control operations necessary to protect the site through the following spring snowmelt conditions. Early winter season is defined as the period where soil temperatures are such that seed will not germinate and normal plant rooting does not occur. The soil may be cold and friable, frozen or lightly snow covered.
A4a Dormant Seeding

Dormant seeding shall be defined as seeding done on exposed cold soils so that normal seed germination does not occur until the following spring. Dormant seeding shall occur after October 20 and when soil temperatures at a depth of 25 mm (1 inch) are at or below 4 °C (40 °F).

In wind swept areas, exposed sites, and areas where dormant seeding does not typically establish well, temporary mulch may be ordered by the Engineer in lieu of dormant seeding.

Snow seeding shall be defined as seeding over the top of snow so that the seed melts through the snow and germinates upon warm up in the spring. Snow seeding can be done during the thawing days in February and March.

A4b Winter Mulching

Snow mulching shall be defined as mulch material spread over the top of snow so that the mulch melts through the snow and sticks to the site. All mulch materials listed under specification 3882 may be placed as snow mulching.

Frozen ground mulching shall be defined as mulch material spread over frozen ground. Mulch materials Type 4, 5, 6 and 9 that do not require disc anchoring into the soil may be placed without modification. Mulch Types 1, 7 and 8 may be anchored with Type 1 or Type 6 hydraulic soil stabilizers or may be "frozen" to the soil by applying water over the mulch. Applying water at the rate of 19 m³/ha (2000 gallons per acre) can be used as a direct substitution for disc anchoring.

A4c Dormant Sodding

The Contractor may place sod at locations at least 3 m (10 feet) from the shoulder, on slopes, and in ditches as dormant sodding after November 1 when all of the following conditions are met:
(a) The Engineer authorizes dormant sodding.
(b) The soil is prepared for sodding, either frozen or unfrozen.
(c) The sod on slopes and in ditches is pegged or stapled.
(d) The sod is watered to saturation immediately after placement.
(e) The sod is watered a second time, or receives 25 mm (1 inch) of rain, 7 to 10 days after placement. The Engineer may also accept a heavy snowfall instead of the second watering.

A4d Winter Erosion Control Blanket Installation

Erosion control blankets may be installed over frozen ground. However, 150 mm (6 inch) long nails with washers can be used to anchor the blanket in lieu of staples.
A4e  Application of Commercial Fertilizer

Commercial fertilizer shall not be placed over frozen ground or snow. The application of fertilizer shall occur after the runoff from spring snowmelt has ceased.

B  Grading Preparations Prior to Seeding

All washouts on the areas to be permanently seeded, sodded or have temporary erosion control materials installed shall be filled prior to the soil loosening operations. Topsoil shall be placed to the depths indicated in the Plans. Fill material shall be compacted sufficiently to provide reasonably uniform density in the upper soil layer to resist erosion. Drainageways shall be shaped and the soil loosened prior to placing sod or erosion control blankets.

B1  Grading Prior to Temporary Seeding or Erosion Control Installation

When installing erosion control materials in locations where the final topsoil grade has not been established, the Contractor shall provide smooth-rough grading to allow for adequate installation of erosion control materials and/or temporary seeding. The smooth-rough grading shall remove large clods of soil greater than 75 mm (3 inches) in diameter and ruts deeper than 75 mm (3 inches) and shall be incidental to the Project for which no direction compensation will be made.

B2  Tillage

Immediately prior to sowing the seed or placing sod, the Contractor shall loosen the soil to a minimum depth of 75 mm (3 inches) on all areas except slopes steeper than 1 vertical to 2 horizontal, using disks, harrows, field diggers or other suitable cultivating equipment. All track imprints from wheeled or tracked equipment shall be tilled out of the soil surface. In compacted areas, the Contractor shall rip, use additional equipment, or other necessary measures to ensure proper soil loosening. On slopes the cultivating equipment shall be operated in a general direction at right angles to the direction of surface drainage wherever practical. The soil surface shall be left in a roughened condition with clods, lumps, and tillage ridges approximately 75 mm (3 inches) high left in place for maximum resistance to erosion. No additional loosening of the soil will be required on slopes steeper than 1 vertical to 2 horizontal, other than that obtained with the equipment used in removing vegetation or performing the finishing operations. Vegetation other than undesirable weeds shall be disked into the soil, cleared, or chopped up with a rotary or flail mower.

On all areas to be sodded, the Contractor shall prepare the soil surface as necessary to provide a reasonably smooth, moist, and evenly textured foundation. The soil shall be loosened to a minimum depth of 75 mm (3 inches) prior to sodding.
C Applying Fertilizer and Conditioners

The Contractor shall apply fertilizers, compost, and liming materials, where specified, at the rates indicated in the Contract, using mechanical spreading devices to the fullest extent practical, and providing uniform distribution of the material over the designated areas. Lime application rates specified in the Contract are based on 500 kg ENP per metric ton (1000 pounds ENP per ton) of Agricultural Liming Material. The actual lime application rate shall be adjusted to supply 500 kg ENP per metric ton (1000 pounds ENP per ton) of liming material.

The Contractor shall apply fertilizer, lime or compost prior to the seeding or sodding. The soil shall be tilled at least once, within 24 hours, following the application of fertilizer, lime or compost and prior to the seeding or sodding. Where fertilizer is required on sodding areas, it shall be applied prior to placing the sod. Where fertilizer is required on seeded areas, the time between fertilizing and seeding shall not exceed 48 hours.

When approved by the Engineer, the Contractor may use Grade 1 compost at an equivalent nutrient application rate in lieu of commercial fertilizer.

D Sowing Seed

The Contractor shall ensure that the seed is stored properly between the time of purchase and installation. Industry standards for seed storage are 50 degrees Fahrenheit and 50% humidity. The Contractor shall protect the seed from moisture until it is sown. Wet or moldy seed shall not be used.

The Contractor shall sow the seed uniformly at the rate of application specified in Table 2575-2.
The Contractor shall sow seed on a prepared seedbed prior to applying mulch and as otherwise directed by the Plan or approved by the Engineer. The Contractor shall firm the seeded areas after seeding and prior to mulching. The soil firming shall be done with a drag, cultipacker, or other approved soil firming equipment. On slopes too steep to operate mechanical equipment, the seed shall be covered by hand raking or other approved means prior to mulching. Soil firming or seed covering shall be accomplished immediately after seeding.

On all seeding areas within 3 m (10 feet) of the shoulder, the Contractor shall seed and immediately firm the seedbed, mulch, and anchor the mulch as a continuous operation. Should the mulch application or mulch anchoring be delayed so that the seed or mulch becomes dislodged by traffic or wind, the affected areas shall be reseeded and remulched at no expense to the Department.

On areas outside 3 m (10 feet) of the shoulder, no more seed shall be sown on any day than can be mulched within 24 hours. Should the mulch application be delayed more than 24 hours, the Engineer may order the area reseeded and remulched at no expense to the Department.

The Contractor shall not broadcast seed or hydoseed when the wind velocity exceeds 25 km/h (15 mph) or during gusts that would affect seed placement.
D1 Temporary Seeding

Temporary seeding may be required on graded areas where the permanent seeding cannot be performed. For this purpose winter wheat, oats or other seed mixtures as determined by the Engineer will be used.

Topsoil covering may not be required for temporary seeding if the subsoil is reasonably suitable for plant growth, as determined by the Engineer. Soil preparation for temporary seeding shall be the same for permanent seeding except for areas such as stockpiles.

Temporary seeding shall be accomplished in accordance with Seeding of Traditional Mixes.

D2 Seeding Traditional Seed Mixes

Mixtures 100 through 280 inclusive shall be sown by means of mechanical or hydro spreading of the seeds at the specified rate of application. The use of hand operated mechanical spreaders will be permitted only on areas that are inaccessible to, or too small for, the specified equipment.

If a seed drill of the agricultural type is used, the drill shall be operated in a general direction at right angles to the direction of surface drainage, wherever practical, and the seed shall not be sown to a depth greater than 10 mm (3/8 inch). Small seed species such as timothy, alfalfa, white clover, red clover, etc., shall be sown through the grass seed attachment or by other approved means.

D3 Seeding Native Mixes

Native mixes (305-350) can be seeded with a native seed drill, a drop type seeder or a hydroseeder. The drill shall accurately meter the types of seed to be planted and keep all seeds uniformly mixed during drilling. The drill shall be equipped with disk furrow openers and packer assembly to compact the soil directly over the drill row. Maximum row spacing shall be 200 mm (8 inches). Depth of seed placement shall be such to obtain a final planting depth of 3 to 10 mm (1/8 to 3/8 inch). In lieu of a drill with disc openers, a drop type seeder that is equipped with a fluffy seed box and a "Brillion type" soil packer assembly may be used. All drill seeding shall be done at a right angle to surface drainage. The Engineer may allow the use of a cyclone or spinner type seeder on small areas (0.4 ha (1 acre) or less) or on areas that are inaccessible to other equipment. The rate of application must be adjusted according to the percent Pure Live Seed (PLS) in the mixture combined with the bulk portion of seed mixture. The bulk seeding rate for PLS species is determined by the following formula:

\[
\text{Bulk Application (kg or lbs)} = \frac{(\text{kg or lbs. PLS})(\% \text{ PLS})}{(100 - \% \text{ Germination} \times \% \text{ Purity})}
\]
D4  Hydroseeding
When a hydroseeder is used, every effort shall be taken to obtain a uniform distribution over the seeded area. A tracer, 22.5 kg (50 pounds) of 3884 Type 5 or 6, shall be added to each 1.9 m³ (500 gallons) of water in the hydroseeder tank to visually inspect the uniformity of the seed application. The hydroseeder shall have continuous agitation action that keeps the seed mixed in the water slurry until pumped from the tank and the pump pressure shall be such that a continuous nonfluctuating stream is maintained. Flood type nozzles shall be used to the fullest extent possible along with sufficient water volume to obtain total ground coverage. During application the spray shall be directed to obtain a uniform material distribution as evidenced by a uniform wetting of the soil surface. If a non-uniform distribution results (such as skipped areas and saw tooth patterns), the affected areas shall be reseeded at no expense to the Department. The seed or seed/fertilizer mixture shall be emptied within 1 hour after the seed is added to the tank. Seed that is allowed to remain mixed with the fertilizer for a period longer than 1 hour will not be accepted for use and no compensation will be made for seed so rejected.

D5  Interseeding
Interseeding may be used for seeding into temporary mulched areas or for drilling additional seed into previously seeded areas. The interseeding drill shall contain trash rippers and at least two seed boxes, a fine seed box and a box for larger or fluffy seeds. The drill shall slice through the vegetative mat and make a 25 mm (1 inch) wide by 10 to 25 mm (3/8 to 1 inch) deep furrow into the underlying soil. The drill seed disk openings shall place seeds in the furrows. The drill shall drop the seed onto the ground surface from the fine seed box and place the large or fluffy seed to a final planting depth of 6 to 10 mm (1/4 to 3/8 inch).

D6  Permanent Seeding into Temporarily Mulched/Blanketed Areas
The Contractor shall permanently seed areas that have previously been temporarily mulched. Without additional tillage or site prep work, the Contractor may use an approved interseeding drill and drill seed directly into temporarily mulched or temporarily seeded areas. In lieu of using an interseeding drill, the Contractor may lightly disc the mulched areas and then conduct the seeding. Fertilizer shall be applied within 24 hours of interseeding or light disking. The Contractor shall leave existing cover in place as practical for its mulching value.
Seeding into previously placed erosion control blankets can be accomplished by attaching a hose to a hydroseeder and "blasting" a
seed/water solution into the blanket. Blasting the seed/water solution shall be done from a distance of approximately 2 m (6 feet) away.

**E  Temporary Mulching**

Temporary mulching shall be defined as placing mulch over broad large areas, generally 0.8 ha (2 acres) or more, to protect the overall site during the period of time when seeding cannot be performed. Temporary mulching shall be used to supplement other erosion control best management practices of establishing permanent vegetation or the rapid stabilization of critical areas within 61 m (200 feet) of surface waters. The provisions for temporary mulching may be used where the provisions for rapid stabilization (Section N) do not apply. In areas where temporary mulch is placed, the Contractor shall shape the area, loosen the soil as necessary, mulch and anchor the mulch.

**F  Applying Mulch**

The Contractor shall spread mulch by mechanical means to provide a uniform distribution at the target application rate specified. When poor mulch distribution occurs, the Contractor will be required to remulch areas where coverage is too light and remove the excess where coverage is too heavy as determined by the Engineer.

The Contractor shall not operate mulch-blowing equipment on slopes that are too steep for the equipment or that cause rutting of the soil surface (slopes 1:4 and steeper). Blower attachments shall be used such that the mulch can be applied without having to traverse the slopes. The Contractor shall regrade, reseed and remulch slopes that are rutted up at the Contractor's expense.

**F1  Type 1, 3, 7, and 8 Mulches**

Wherever possible, Type 1, 3, 7, and 8 mulches shall be placed with blower equipment. The target rate of application shall be 4.5 metric tons (t) per hectare (2 tons per acre). The actual rate of application shall be as directed by the Engineer to match varying material or Project conditions so that approximately 10 percent of the soil surface is visible through the mulched areas.

**F2  BLANK**

**F3  BLANK**

**F4  Type 4 Mulch**

Type 4 mulch shall be applied as a dual operation with the Type 1 mulch blown on the soil surface at 3.4 metric tons per hectare (1 ½ tons per acre) and immediately over-sprayed with Type 5 hydraulic soil stabilizer at 840 kg/ha (750 pounds per acre). Seeding and fertilizing shall be done prior to mulching, not in conjunction with Type 5 hydraulic soil stabilizer placement. Disk anchoring will not be required.
F5  Type 5 Mulch
Type 5 mulch shall be applied at a rate of 150 m$^3$/ha \((80 \text{ cubic yards per acre})\) when specified as an erosion control material.

F6  Type 6 Mulch
The rate and application procedure for Type 6 mulch shall be as specified in the Plans or Special Provisions.

F7  BLANK

F8  BLANK

F9  Type 9 Mulch
The Contractor shall apply Type 9 (aggregate) mulch at a rate of application as stated in the Contract. Prior to placing the mulch, the Contractor shall uniformly compact and smooth the foundation, cover the foundation with a 150 µm \((6 \text{ mil})\) plastic sheeting, and then uniformly spread the aggregate mulch to the Plan thickness by a method that does not harm the foundation. The Contractor shall level the finished aggregate surface so that it is flush with adjacent areas. The plastic sheeting is an incidental cost to the completed work.

F10  Shoulder Mulch Overspray
Shoulder mulch overspraying shall consist of Type 1 Hydraulic Soil Stabilizer sprayed onto Type 1 mulch on a 1 meter \((1 \text{ yard})\) wide strip immediately abutting a gravel or paved shoulder. During placement, the Contractor shall seed, firm the seedbed, place Type 1 mulch, immediately disk anchor the mulch (if provided for in the Contract), and then uniformly overspray with, Type 1 Hydraulic Soil Stabilizer as a continuous operation. Wherever possible, the Type 1 Hydraulic Soil Stabilizer shall be sprayed with a distributor spray bar. Application rate for the Type 1 Hydraulic Soil Stabilizer shall be 220 kg/ha \((200 \text{ pounds per acre})\). Shoulder mulch overspray will be for those areas designated in the Plans and will be paid for under the Type 1 Hydraulic Soil Stabilizer pay item.

G  Disk Anchoring
Where provided for in the Contract, the Contractor shall anchor Type 1, Type 3, Type 7, and Type 8 mulches with a disk anchoring tool. This equipment shall anchor the mulch by punching it into the soil to a depth of 50 to 75 mm \((2 \text{ to } 3 \text{ inches})\). Spacing between the blades or disks shall not exceed 200 mm \((8 \text{ inches})\). The mulch shall be anchored immediately after placement unless otherwise authorized by the Engineer.

H  Hydraulic Soil Stabilizers
H1  Type 1 Natural Tackifier
Natural tackifiers are added to water and applied by a hydrosprayer. Natural tackifiers can be used by themselves, as an additive to other soil stabilizers, or as an overspray on mulched areas. When used as an
additive to other soil stabilizers, they shall be added at the rate specified by the manufacturer. When used as an overspray on mulched areas, they shall be applied at the rate specified by the manufacturer. During placement, every effort shall be taken to obtain a uniform distribution over the target area.

Type 5 or 6 shall be applied with hydraulic spray equipment in a water-slurry at the rate of 2353 kg/ha (2100 pounds per acre). For planning purposes, the approximate water to bale ratio is 475 L of water per 22.7 kg bale (100 gallons of water per 50 pound bale); however the actual water to bale ratio shall be in accordance with the manufactures recommendations. Using the color of the material as a metering agent, the slurry shall be uniformly sprayed on the prepared seedbed. The Engineer may verify, by inspection of tank loading and spray application, that materials applied correspond with the application requirements within reasonable limitations.

Type 8 Bonded Fiber Matrix (BFM)

Type 8 hydraulic soil stabilizer shall be applied with hydraulic spray equipment by a manufacturer's certified applicator. Seeding shall be done as a separate operation prior to the BFM application whenever possible. The combination of seed and BFM as a single operation will be allowed in small or inaccessible areas as determined by the Engineer. Installation rate shall be between 3300 and 4620 kg/ha (3000 and 4200 pounds per acre) depending on site characteristics as provided for in the plans. The general application rate shall be 3850 kg/ha (3500 pounds per acre). For planning purposes, the approximate water to bale ratio is 380 L/22.7 kg (100 gallons per 50 pound) bale; however the actual water to bale ratio shall be in accordance with the manufactures recommendations. In all cases 100% continuous ground coverage shall be obtained. Application shall be done on dry soils (field capacity or less) and at least 24 hours in advance of projected rainfall to allow adequate drying time. The BFM shall be applied from at least two alternate directions, preferably 90 degrees apart, to ensure all soil surfaces are covered. For application rates of 3850 kg/ha (3500 pounds per acre) and above, the BFM shall be applied in two stages (one half rate each) with ample time between stages for the first application to dewater. BFM shall not be used in water bearing soils or by itself in ditch bottoms carrying concentrated flow. After the BFM soil stabilizer is applied and dries for 24 to 48 hours, the Engineer may sample and
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quantify a portion of the installation to ensure the minimum specified rate has been applied. If it is found that the specified quantity per acre has not been achieved, the Contractor shall apply an additional amount to equal the specified rate within 48 hours of receiving the test results. The Contractor shall not be paid extra mobilization costs for spraying additional material.

I Placing Sod

Before sod is delivered to the work site, the Contractor shall have all necessary equipment and forces available and shall have prepared the sodding areas sufficiently in advance in accordance with 2575.3B to avoid delays in placing the sod. The Contractor shall place sod according to the Plan and these requirements.

The Contractor shall place sod strips with staggered end joints and without stretching, in such a manner that all edges will firmly abut the edges of adjoining strips. In no case shall the sod be placed so loosely or under such tension that it will cover an area larger than the area from which it was originally lifted.

Joints between the sod and in-place improvements such as curbs, walks, and existing turf, shall abut tightly and shall be such that drainage will be conducted over the surface. Elsewhere, the outside edges of the sodded areas shall be rolled in or banked flush with soil, thoroughly compacted to form a flush surface as directed by the Engineer. The Contractor shall place the sod in such a manner that surface drainage along the boundary of the sodded area will not erode or undermine the sod.

The Contractor shall water and compress the sod into the soil by rolling or tamping while laying the sod or immediately after completing the sod placement on each area. The initial watering and rolling or tamping shall be sufficient to provide a firm contact and bond between the sod and the underlying soil and provide a smooth, even surface free of humps and depressions, but in no case shall the rolling or tamping result in excessive compaction. The Engineer may require the watering of areas to be sodded prior to the sod placement.

The Contractor shall repair damaged areas within 5 working days after completing the sod placement and rolling or tamping operations. This repair work shall include reseeding and remulching of any seeded or mulched areas adjacent to the sod. All waste sod, together with any stones or other debris removed from the sodding areas, shall be disposed of in a manner satisfactory to the Engineer.

The Contractor is responsible for successful establishment of the sod and shall replace or repair displaced or damaged sod during the maintenance period. The Contractor may peg or staple sod to prevent displacement.
I1  Slopes
The Contractor shall carefully place sod strips from the bottom of the slope and progress upward. The sod shall be placed with the longitudinal axis of each strip at right angles to the slope. Staking or stapling may be required to prevent slumping or displacement of the sod. At the top of the slope, the sod must be trenched 75 mm (3 inches) into the topsoil on slopes steeper than 1V:4H.

I2  Ditch Bottoms
In ditch bottoms and other waterways where a concentrated flow of water is expected, the sod shall be placed so that the longitudinal axis of each strip is parallel to the direction of water flow in the main channel. The end of the strips will overlap a minimum of 100 mm (4 inches) with the upstream end on top of the downstream end. The sod will also be shingled and overlap a minimum of 75 mm (3 inches) on the sides of the strips. When shingled properly, the water will flow over, NOT under, from one roll of sod to the next. The uppermost strip of sod will have 75 mm (3 inches) of sod trenched into the topsoil on side-slopes steeper than 1:4.

The sod shall have netting material that is either incorporated into the rooting material of the sod during initial growth, or placed on the bottom of the sod mat at the time of harvest. Alternatively, Type I netting may first be secured in the ditch bottom followed by sod placement.

The sod shall be stapled once it has been put in place. All joints and outer edges of the sod shall be stapled at 0.9 m (3 feet) intervals or less. Staples shall be placed throughout the sod at a minimum spacing of 2 staples/m² (square yard). All staples shall be inserted flush with the ground surface.

J  Placing Erosion Netting, and Blankets
J1  Erosion Control Netting
Netting placed in ditch bottoms, flumes or water courses shall be rolled out flat, parallel to the direction of water flow. Netting placed on cut or fill slopes shall be rolled out flat, parallel or perpendicular to the direction of water flow. The edges of adjacent strips shall overlap a minimum of 50 mm (2 inches) and a maximum of 100 mm (4 inches), with the net on the upstream side of any lateral water flow being on the top.

The netting shall be secured in place by means of wire staples driven reasonably vertical into the soil. The netting shall not be stretched prior to stapling. Staples shall be placed 1 m (3 feet) apart along the ends and edges of each strip. Additional rows of staples shall be placed parallel to the edge row of staples so that the distance
between adjacent rows does not exceed 1 m (3 feet). Staples shall be placed 1 m (3 feet) apart within these rows. Where possible, staples of adjacent rows shall be placed so as to form a sawtooth pattern.

Erosion Control Blankets

The Contractor shall shape and prepare the site so it is free of large rocks, soil clumps or vehicle imprints that would prevent the blanket from lying flush to the surface contours. The Contractor shall place the blankets as specified in the Contract on the specified areas within 24 hours after sowing of the seed on that area.

The Contractor shall roll out or lay the blankets parallel to the direction of water flow, with the netting on top. For blankets with netting on two sides, the bottom side of the blanket shall show the majority of the thread stitching. The blankets shall be spread evenly without stretching, and so the fibers are in direct contact with the soil over the entire area. Adjacent strip edges shall overlap each other at least 102 mm (4 inches). Strip ends shall overlap each other at least 178 mm (7 inches). All overlaps shall be made with the upgrade strip placed over the down grade blanket strip. All overlaps for all Categories, excluding category 0, shall be stapled at ½ m (1 ½ foot) intervals.

At the top of slopes and the beginning of each blanket in ditch bottoms the Contractor shall bury the upgrade end of the blanket strip in a check slot. The check slot, or trench, shall be approximately 150 mm (6 inches) wide by 150 mm (6 inches) deep. The blanket end shall be inserted into the check slot such that the blanket is in contact with all three sides of the check slot. The blanket shall be stapled in the bottom of the trench every 0.3 m (1 foot). The check slot shall be backfilled and compacted. When a slope length is greater than 30 m (100 feet), a second check slot shall be dug perpendicular to the slope gradient one-third up from the bottom of the slope. The blanket shall follow the slope down into the check slot and back up to the slope gradient. This check slot shall also be stapled, backfilled and compacted.

Category 00 blankets shall be stapled on the edge of the blanket every 1 m (3 feet) and watered in to bond the blanket to the soil. All other blankets, excluding category 00, shall be anchored to the soil surface with evenly distributed staples through out the blanket at the rate specified in Table 2575-3. All staples shall be inserted flush with the ground surface.
TABLE 2575-3
STAPLING OF BLANKETS

<table>
<thead>
<tr>
<th>Slope (V:H)</th>
<th>Minimum Number of Staples per square meter (square yard)</th>
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<tbody>
<tr>
<td>Flatter than 1:2</td>
<td>1 (1.2)</td>
</tr>
<tr>
<td>1:2 – 1:1</td>
<td>1.4 (1.7)</td>
</tr>
<tr>
<td>Channel or Ditch applications</td>
<td>2.9 (3.5)</td>
</tr>
</tbody>
</table>

K  Placing Erosion Stabilization Mats

The Contractor shall shape and prepare the site so it is free of large rocks, soil clumps or vehicle imprints that would prevent the Mat from lying flush to the surface contours. The erosion stabilization mat shall conform to the class shown in the Plan. All Erosion stabilization mats shall be soil filled.

The Contractor shall install the mat, seed, fertilize, place topsoil, and blanket all in one continuous operation. The Contractor shall roll out or lay the mat parallel to the direction of water flow. The mat shall be spread evenly without stretching, and so the fibers are in direct contact with the soil over the entire area. The beginning edge of each mat shall be buried and stapled in a check slot as described in K2. Adjacent strip edges shall overlap each other at least 102 mm (4 inches). The mat shall be stapled at a uniform density of 2.9 staples/m² (3.5 staples per square yard).

The mat shall be directly seeded and fertilized at ½ of the amounts specified in the Plan. On top of the seed and fertilizer, topsoil meeting the criteria of 3877 "Select Topsoil Borrow" that has been screened and pulverized shall be backfilled over the mat at a depth of 12-25 mm (½ - 1 inch). A sample of the topsoil shall be provided to the Engineer prior to installation. The remaining ½ of the seed mix and fertilizer shall be spread on top of the topsoil. The soil filled mat shall have a Category 4 blanket, meeting 3885 installed in accordance with K2 on top of the seeded topsoil to prevent erosion of the topsoil. No tracked equipment or sharp turns shall be made on the mat.

L  Maintenance

L1  Sod

After the sod is placed and until it is accepted, the Contractor shall water and maintain sod in a condition satisfactory to the Engineer. The sod shall be cared for on a timely day by day basis. Watering and replacement of sod shall be accomplished as the need arises and without the Engineer having to so order.

The Contractor shall maintain the sod for 30 calendar days. The Engineer will then make the final inspection and consider acceptance of the sod.
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During the maintenance period, the Contractor shall promptly replace all sod that dries out to the point where it is presumed dead, and all sod that has been damaged, displaced, or weakened to the point where its replacement is necessary, or has become heavily infected with weeds. Areas replaced with new sod shall be maintained by the Contractor for at least 20 calendar days after placement.

L2 Erosion Control Blanket and Erosion Stabilization Mats

The Contractor shall maintain the erosion control blanket installation for 30 days when specified in the Contract or when the Engineer allows erosion control blankets and seed to be substituted for sod. All Erosion Stabilization Mats shall be maintained by the Contractor for 30 calendar days. Maintenance consists of thoroughly watering the blankets and mat systems immediately after placement (28 m³/ha (3000 gallons per acre)), with additional watering performed as necessary. Until acceptance, the Contractor shall be responsible for controlling erosion and establishing a permanent vegetative cover to the satisfaction of the Engineer. In the event of seeding failure or erosion during the maintenance period, the Contractor shall restore such areas at no additional cost to the Department.

L3 Sod Alternatives

When other products and methods are used in lieu of sod, the area shall be maintained by the Contractor ensuring the same outcome as a sodded area. Weeds shall be controlled and the maintenance requirements of specification 2575.3L2 shall apply.

L4 Mulch

When so directed by the Engineer, the Contractor shall, at any time before completion of the Project, remulch any areas on which the original mulch has eroded, washed away, or blown off, and reseed any areas on which the original seed has failed to grow, using the project seed mixture or one prescribed by the Engineer.

L5 Mowing and Weed Spraying

When the Contract includes items for mowing or weed spraying, the Contractor shall perform the specified work one or more times, wherever and whenever the Engineer directs, either on the areas seeded or sodded under the Contract. The equipment used shall not be so heavy that it causes soil slips or ruts on the slopes or in the ditches.

The Engineer may order weed spraying wherever heavy weed growth exists within the Right of Way. The weed spray mixture to be furnished and used shall be as provided in the Plans. The Contractor shall be responsible for performing the work at such time and in such a manner that will avoid spray drift outside the areas designated for spraying.
L6 General
Until final inspection and acceptance of the work is made, the Contractor shall use due care to protect the site during the time vegetation is establishing. Additional seed and mulch material used for reseeding and remulching and repairing damaged areas beyond the Contractor's control will be measured and paid for at the Contract prices, provided the original work was performed satisfactorily in accordance with requirements.

M Turf Establishment, Lump Sum
Turf Establishment may be specified in the Plans as a lump sum bid item for establishing vegetation on small areas of 1 ha (2 ½ acres) or less per Contract. The lump sum item shall be considered to provide for restoring disturbed areas. Such work shall include tilling, fertilizing, mulching and establishment of vegetative cover. Under this provision the Contractor shall be responsible for controlling erosion and establishing a permanent vegetative cover to the satisfaction of the Engineer.

Unless otherwise specified in the Plans, the Contractor may establish vegetative cover by sodding or by seeding and mulching. If the Contractor elects to establish vegetative cover by seeding, seed furnished and placed shall consist of a mixture of desirable perennial grasses and legumes equivalent to that contained in 3876 for Mixture 250. Upon seeding, the areas shall be fertilized with 22-5-10 analysis slow release fertilizer (see 3881.2) at 330 kg/ha (300 pounds per acre) and mulch equivalent to 3882, Type 1 shall be furnished and placed to prevent erosion and siltation. Acceptance of the areas by the Engineer will not be made until it is evident that the seed so placed has germinated and will establish an adequate protective cover. In the event of seeding failures, the Contractor will be required to correct and reseed such areas at no expense to the Department until adequate turf is established. When sod is used, the placement, maintenance, and acceptance shall be as specified in 2575.3.

N Rapid Stabilization
This work shall consist of operations necessary to rapidly stabilize small critical areas within 61 m (200 feet) of Surface Waters, to prevent off site sedimentation and/or to comply with permit requirements. The work shall be performed numerous times during the Contract and will be conducted on several small areas that may or may not be accessible with normal equipment. This work shall be done in accordance with the applicable details and locations shown in the Plan. The methods may be conducted independently or in combination. One or several locations may be stabilized by the Contractor per site visit per calendar
day. The number of locations stabilized per site visit or per calendar day will not justify an adjustment in the Contract unit price.

The materials required shall be as follows:

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1</td>
<td>Type 1 Mulch @ 4.5 metric ton/ha (2 tons per acre) Disc anchoring</td>
</tr>
<tr>
<td>Method 2</td>
<td>Type 1 Mulch @ 3.4 metric ton/ha (1.5 tons per acre) Type 5 Hydraulic Soil Stabilizer @ 840 kg/ha (750 pounds per acre)</td>
</tr>
</tbody>
</table>
| Method 3 | Type 6 Hydraulic Soil Stabilizer @ 160 kg/ 3.8 m³ of slurry mix (350 pounds per 1000 gallons of slurry mix)  
Seed mixture 190 @ 4.5 kg/3.8 m³ of slurry mix (10 pounds per 1000 gallons of slurry mix)  
Fertilizer 10-10-20 @ 22.7 kg/ 3.8 m³ of slurry mix (50 pounds per 1000 gallons of slurry mix)  
Water @ 3.3 m³/3.8 m³ of slurry mix (875 gallons per 1000 gallons of slurry mix) |
| Method 4 | Erosion Control Blanket Category 3  
Seed mixture 190 @ 1.1 kg/100 m² (2 pounds per 100 square yards)  
Fertilizer 10-10-20 @ 4.3 kg/100 m²(8 pounds per 100 square yards) |
| Method 5 | Rip Rap Class II  
Geotextile Type III |

Note: 3 m³ (1000 gallons) of slurry mix will cover 0.067 ha (1/6 acre).

N1 Placement

Method 1

Prior to placement the soil surface should be in a loose condition so that the mulch can be anchored. The mulch shall be placed to obtain approximately 90% ground coverage. Wherever possible, the mulch shall be placed by blower equipment. In inaccessible areas the mulch may have to be placed by hand. Immediately after placement, the mulch shall be anchored with a disc anchoring tool. The approximate area of coverage is 0.2-0.8 ha (½-2 acres).

Method 2

Prior to placement the soil surface should be in a loose condition. The mulch shall be placed to obtain approximately 75% ground coverage. Wherever possible, the mulch shall be placed by blower equipment. In inaccessible areas the mulch may have to be placed by hand. Immediately after placement, the mulch shall be over-sprayed
with Type 5 Hydraulic Soil Stabilizer at a rate of 840 kg/ha (750 pounds per acre). The approximate area of coverage is 0.2-0.8 ha (½-2 acres).

Method 3

Rate of slurry application shall be variable depending on surface roughness, slope configuration and degree of undulation but it is expected that 56 m³ of slurry will be needed per hectare (6 M gallons per acre). This rate is equivalent to applying Type 6 Hydraulic Soil Stabilizer at 2353 kg/ha (2100 pounds per acre). Amount of material applied shall be such to obtain 100% soil surface coverage. In inaccessible areas, the mix may be pumped through a hose. The approximate quantity of coverage is 11.4-34 m³ (3000-9000 gallons) of slurry.

Method 4

The fertilizer, seed and erosion control blanket shall be placed as described in 2575.3. The upgrade end of each blanket strip shall be buried at least 150 mm (6 inches) in a vertical check slot. Staples shall be placed at seams and throughout the blanket at a maximum spacing in all directions of 0.6 m (2 feet). The approximate area of coverage is 75 – 650 m² (100 – 800 square yards).

Method 5

Rock and geotextile shall be placed in the areas and to the configurations as directed by the Engineer. The approximate quantities per Project visit are 9-18 metric tons (10-20 tons).

O Acceptance of Work

The Contractor shall notify the Engineer at least 24 hours in advance of beginning and also of changing turf establishment operations. The Contractor shall schedule working hours according to 1803. Work done without notification, without inspection according to 1511, or outside of the scheduled working hours without prior approval will be considered as unauthorized work. Turf establishment that is not verified by inspection in accordance with 1511 will be considered as unauthorized work.

O1 Seeding

The Engineer will generally accept permanent seeding in area increments once the seed has been properly placed in accordance with the specifications. After acceptance of seeding by the Engineer, the Contractor is relieved of responsibility for further maintenance and repair of the seeding and mulching performed on the area accepted, except for the repair of damages due to causes entirely within the Contractor’s control.
O2  Mulching
The Engineer will accept mulching 2 days after initial placement. Areas where the mulch has blown off or washed away during the 2 day period will be remulched at no expense to the Department.

O3  Sod
Upon satisfactory placement of the sod, the Engineer may authorize partial payment not exceeding 80 percent of the Contract bid price. The remaining percentage shall not become due and payable until expiration of the sod maintenance period, and then only as otherwise provided for in the Contract.

Upon expiration of the sod maintenance period on individual areas or sections of the Project, the Engineer will make an inspection of the work and will accept all sod that is in normal, healthy growing condition. No payment will be made for sod that is not in acceptable condition at the time of the final inspection an amount will be deducted from any moneys due or that may become due the Contractor equal to 100 percent of the Contract bid price per unit of measure of unacceptable sod. Sod that is within 3 m (10 feet) of the shoulder or is directly abutting a roadway surface that is acceptably maintained, but dies out due to salt or winter maintenance activities beyond the Contractor's control, may be paid for at 100 percent of Contract price provided that the sod has been maintained for at least 20 calendar days prior to December 1.

O4  Erosion Netting, Blankets and Stabilization Mats
When maintenance is not specified in the Contract, the Engineer will accept blankets and erosion control netting and mats, at the time of acceptance of the sodding or seeding over which the materials are properly placed.

When maintenance is specified as an integral part of a erosion control blanket installation or stabilization mat the Engineer may authorize partial payment for the installation in an amount not exceeding 80 percent of the Contract bid price. The remaining percentage shall not become due and payable until final acceptance by the Engineer.

O5  Products Used in lieu of Sod
When other products or methods are used in lieu of sod, the Engineer may authorize partial payment not exceeding 80% of the substituted product price upon proper placement. The remaining percentage shall not become due and payable until the expiration of the maintenance period, and then only as acceptable to the Engineer.

O6  Hydraulic Soil Stabilizers
Hydraulic soil stabilizers, except for Type 8, will be accepted upon satisfactory placement. Acceptance of acres covered by Type 8 will be
made by the Engineer when it is evident that the seed placed has germinated and will establish an adequate protective cover. In the event of seeding failures or erosion, the Contractor will be required to correct and reseed such areas at no expense to the Department until adequate vegetative cover is established. Upon proper placement of Type 8 the Engineer may authorize partial payment for the installation in an amount not exceeding 80% of the Contract bid price. The remaining percentage shall not become due and payable until final acceptance by the Engineer.

**P  Restoration**

After acceptance of turf establishment in an area, the Engineer may order the Contractor to restore areas damaged by erosion and sedimentation that occurred beyond the Contractor's control. Restoration work consists of scarifying, grading, shaping, excavating, tilling, and any other operation the Engineer considers necessary to restore eroded areas and clean up sedimentation. Depressions and washouts resulting from erosion shall be shaped, filled with suitable material, and compacted to the satisfaction of the Engineer. Sedimentation shall be removed to the original grade or as necessary to properly restore the area as determined by the Engineer. Sediment removed shall be spread or disposed of to the satisfaction of the Engineer.

The Engineer will determine the seed, mulch, erosion blankets, and sod used in the restoration.

The Contractor will be compensated for restoration costs at the Contract unit prices. If no Contract unit prices are provided for in the Contract, the Contractor will be compensated for restoration costs as Extra Work. No compensation, however, will be made when the damage results from the Contractor's neglect or operations.

**Q  BLANK**

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**S  BLANK**

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**V  Workmanship and Quality Control**

The Contractor is responsible for maintaining quality control on the project by ensuring that all work performed and all materials furnished are in conformance with the dimensions, installation requirements and material specifications shown in the Plans or indicated in the Specifications. Quality workmanship shall be used in all aspects of the work and shall be uniform in character throughout the project.
2575.4  

**Workmanship Rework Schedule**  
Performance of the work shall be controlled by the contractor so that the materials installed and the workmanship practices are of good quality. When the quality falls below a threshold level defined in Table 2575-4, the contractor shall take immediate action to correct the situation and prevent it from reoccurring. As indicated in Table 2575-4 the contractor shall correct unacceptable workmanship to qualify for payment.

**TABLE 2575-4**  
**REQUIRED CORRECTIVE ACTION**

<table>
<thead>
<tr>
<th>Item</th>
<th>Corrective action required when:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeding</td>
<td>Not uniform placement</td>
</tr>
<tr>
<td></td>
<td>Not seeded with drill when required</td>
</tr>
<tr>
<td></td>
<td>Depth of seed incorrect</td>
</tr>
<tr>
<td></td>
<td>No seedbed firming</td>
</tr>
<tr>
<td></td>
<td>Incorrect rate of seed application</td>
</tr>
<tr>
<td></td>
<td>Less than 76 mm (3 inches) tillage</td>
</tr>
<tr>
<td></td>
<td>Not mulched within 24 hours</td>
</tr>
<tr>
<td>Fertilizer and lime</td>
<td>Incorrect rate of application</td>
</tr>
<tr>
<td></td>
<td>Not uniform placement</td>
</tr>
<tr>
<td></td>
<td>Not incorporated properly</td>
</tr>
<tr>
<td>Mulch material, hydraulic soil stabilizer</td>
<td>Incorrect rate of application</td>
</tr>
<tr>
<td></td>
<td>Not uniform placement</td>
</tr>
<tr>
<td></td>
<td>Rutting of slopes with equipment</td>
</tr>
<tr>
<td>Erosion control blankets and mats</td>
<td>Inadequate soil loosening or preparation</td>
</tr>
<tr>
<td></td>
<td>Upgrade ends not embedded on slopes</td>
</tr>
<tr>
<td></td>
<td>Improper overlaps and joints</td>
</tr>
<tr>
<td></td>
<td>Insufficient number of staples</td>
</tr>
<tr>
<td></td>
<td>Improper stapling pattern</td>
</tr>
<tr>
<td></td>
<td>No embedment of joints in drainageways</td>
</tr>
<tr>
<td>Turf establishment lump sum</td>
<td>Erosion not controlled</td>
</tr>
<tr>
<td></td>
<td>Insufficient vegetative cover established</td>
</tr>
</tbody>
</table>
The above table pertains to a threshold level of workmanship only and does not pertain to the use of nonconforming materials. The disposition of nonconforming materials shall be in accordance with 1503. The Contractor at no cost to the Department shall perform any corrective actions required for acceptance of the work.

2575.4 METHOD OF MEASUREMENT

A  Fertilizer
Fertilizer will be measured by the weight of each kind furnished and applied. When a different analysis fertilizer than in the Plans, is used it will be converted to equivalent of planned fertilizer.

B  Lime
Agricultural lime will be measured by the weight of material furnished and applied. Industrial Slag will be measured by mass on the same basis as Agricultural Lime.

C  Seeding
Seeding will be measured by the area seeded, regardless of the seed mixture or quantity of seed used, and regardless of whether the seed was furnished by the Contractor or the Department. Areas reseeded by order of the Engineer, after the original seeding of the area was accepted, will be measured and added to the area originally seeded.

D  Seed
The Engineer will measure seed by mass of each mixture or species except when pure live seed (PLS) is indicated. When PLS is indicated, the Engineer will measure the portion of the seed mixture by mass of PLS and add it to the mass of seed mixture specified as bulk mass.

E  Mulch
The Engineer will measure:
(1) Mulch material of Types 1, 3, 4, 7, and 8 by the mass of each type furnished and applied acceptably. Type 4 mulch shall consist of a measurement of Type 1 mulch and Type 5 hydraulic soil stabilizer.
(2) Type 5 and 6 mulch material by volume (vehicular measure) of the material furnished and acceptably used.
(3) Type 9 (aggregate) mulch by volume, based on the area of aggregate furnished and acceptably placed to the Plan thickness.
(4) Additional mulch materials ordered by and then accepted by the Engineer in remulched areas will be added to the mulch quantities originally used and accepted.

F  Water
Water used by order of the Engineer for establishment of areas covered with mulch will be measured by volume.
G  Disk Anchoring
    Disk anchoring of Type 1, Type 3, Type 7 and Type 8 mulches will be measured by the area of mulch disked acceptably.

H  Sodding
    The Engineer will measure sodding that is acceptably installed and maintained by the surface area based on field measurement. Where sod is authorized to be placed shingle-style, the overlapped portion of the sod will also be measured.

I  Hydraulic Soil Stabilizers
    The Engineer will measure Type 1 by the area acceptably covered taking into account the type of material used and the manufacturer's recommended application rate. The Engineer will measure all other hydraulic soil stabilizers by the mass or weight of each type used. The Engineer may convert the mass or weight of material used to a square meter (square yard) basis.

J  Lump Sum Turf Establishment
    The item of turf establishment, lump sum will be considered to include all materials and labor as necessary to accomplish the work regardless of quantities involved. Measurement will be by lump sum unit, and under this provision, no measurement will be made of any individual turf establishment item.

K  Erosion Netting, Blankets and Stabilization Mats
    Erosion netting and blankets of each kind will be measured separately by the area covered. Overlapped portions will not be added additionally to the area measured.
    Erosion Stabilization mats will be measured by the area covered. Overlapped portions will not be added additionally to the area measured. Seed, fertilizer, topsoil and blankets placed in conjunction with the erosion stabilization mat system will be measured separately.

L  Mowing
    Mowing will be measured by the area acceptably mowed.

M  Weed Spraying
    Weed spraying will be measured by the area acceptably sprayed.

N  Weed Spray Mixture
    Weed spray mixture will be measured by the volume of ingredients furnished and used.

O  Blank

P  Compost
    Grade 1 compost will be measured by mass of material furnished and applied. Grade 2 compost will be measured by loose volume determined by vehicular measurement of material delivered.
Q  Rapid Stabilization
  Method 1 and 2 will each be measured by the hectare (acre) acceptably installed. Disc anchoring or hydraulic soil stabilizer shall be considered incidental for which no direct payment will be made.
  Method 3 will be measured by the cubic meter (M Gallons) of slurry furnished and acceptably placed. Seed, fertilizer, and hydraulic soil stabilizer shall be considered incidental for which no direct payment will be made.
  Method 4 will be measured by the square meter (square yard) of blanket acceptably installed. Seed and fertilizer shall be considered incidental for which no direct payment will be made.
  Method 5 will be measured by the metric ton (ton) of rock furnished and acceptably installed. Geotextile shall be considered incidental for which no direct payment will be made.

2575.5 BASIS OF PAYMENT
  Payment for any of the turf establishment items at the Contract prices per unit of measure will be compensation in full for all labor, materials, equipment, and other incidentals necessary to complete the work as specified, including the costs of maintenance, replacement, and repair as required by the Contract.

A  Erosion Control Items
  Payment for erosion control blankets may include maintenance, when so specified. If no maintenance is specified, payment shall be compensation in full for all labor, materials, equipment, and other incidental items necessary for proper installation of the blankets. If maintenance is specified, payment shall also include the cost of watering, replacement, and repair as required by the Contract.
  Payment for hydraulic soil stabilizers will be based upon acceptance of the application by the Engineer. Payment for Type 1, 5, and 6 shall be compensation in full for all labor, materials, and equipment, for proper installation of the materials. Type 8 shall be eligible for partial payment not to exceed 80% of the contract bid price upon satisfactory installation of the material. The remaining 20% shall be made available when final acceptance is made based on adequate vegetative cover and erosion control.

B  Temporary Seeding
  Interim seeding, and the application of fertilizer and mulch as required in conjunction therewith, will be paid for at the Contract prices or, in the absence of a Contract bid price, according to the established unit prices, or in the absence of a Contract price and unit price, as Extra Work.

C  Seed
  Seed will be paid for by the mass of each mixture or species except
when pure live seed (PLS) is indicated. When PLS is indicated on a portion of the seed mixture, payment will be made by mass of the PLS species plus the mass of the bulk portion of the seed mixture. Payment for seed not meeting germination and purity requirements of 3876 shall be subject to 1503. When components are missing from the specified mixture the affected seeded areas shall be reseeded with the correct mixture by the Contractor at no additional cost to the Department and a deduction of the value of the missing ingredients shall also be applied.

D Mulch
D1 Type 4 Mulch
Type 1 mulch and Type 5 hydraulic soil stabilizer will be paid for separately.
D2 Shoulder Mulch Overspray
Type 1 hydraulic soil stabilizer shall be paid for independent of the Type 1 mulch and disk anchoring or shoulder mulch overspray.

E Mowing and Weed Spraying
Payment for mowing and weed spraying at the Contract prices per unit of measure will be compensation in full for all labor and equipment employed in the work, and for all materials used, except that separate payment will be made for the weed spray mixture furnished and applied in conjunction with the item of weed spraying.

F Sod
Netted and stapled sod shall be paid at 150% of unnetted sod.

G Products in Lieu of Sod
Payment for products used in lieu of sod, that are not as labor intensive or do not require the same watering sequence as sod shall be paid for at 75 percent of the sod Contract price.

H Rapid Stabilization
Payment for the various items of work required for Rapid Stabilization will be made in accordance with the appropriate Contract bid price per unit of measure for each method specified. Such payment, in each instance, shall be construed to be compensation in full for all costs incidental thereto including mobilization.

I Unit Prices
The Department will pay the following unit prices for erosion control and vegetation establishment items in the absence of a Contract bid price:
(1) Additional tillage ordered by the Engineer before seeding interim mulched areas will be paid for at the same unit price as disk anchoring.
(2) Disk Anchoring ....................... $75 per hectare ($30 per acre)
(3) Temporary Seed Mixtures
Mixture 100-110 ................... @ $0.44 per kilogram ($0.20 per pound)
Mixture 150 ...................... @ $3.00 per kilogram ($1.35 per pound)
Mixture 190 ...................... @ $2.75 per kilogram ($1.25 per pound)

(4) Erosion Control Blanket Category 4
............................................................... $2.20 m² ($2.00/square yard)

(5) Rapid Stabilization Methods
Method 1 ........................................ $900/ha ($400/acre)
Method 2 ........................................ $1235/ha ($500/acre)
Method 3 ........................................ $86/m² ($325/M gallon)
Method 4 ........................................ $3.00/m² ($2.50/sq yd)
Method 5 ........................................ $27/metric ton ($25/ton)

(6) Water ......................................... $4.65/cubic meter ($17.00/MGal)

J Payment Schedule
Payment for turf establishment and maintenance will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2575.501</td>
<td>Seeding</td>
<td>hectare (acre)</td>
</tr>
<tr>
<td>2575.502</td>
<td>Seed, Mixture ___ or (Species) ___</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2575.505</td>
<td>Sodding Type ___</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2575.511</td>
<td>Mulch Material, Type ___</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2575.513</td>
<td>Mulch Material, Type ___</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2575.519</td>
<td>Disk Anchoring</td>
<td>hectare (acre)</td>
</tr>
<tr>
<td>2575.521</td>
<td>Erosion Control Netting ___</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2575.523</td>
<td>Erosion Control Blankets, Category ___(1)</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2575.525</td>
<td>Erosion Stabilization Mat, Class ___</td>
<td>square meter (square yard)</td>
</tr>
<tr>
<td>2575.531</td>
<td>Fertilizer, Type ___</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2575.532</td>
<td>Fertilizer, Type ___</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2575.533</td>
<td>Agricultural Lime</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2575.535</td>
<td>Water</td>
<td>cubic meter (M Gallons)</td>
</tr>
<tr>
<td>2575.541</td>
<td>Mowing</td>
<td>hectare (acre)</td>
</tr>
<tr>
<td>2575.545</td>
<td>Weed Spraying</td>
<td>hectare (acre)</td>
</tr>
<tr>
<td>2575.547</td>
<td>Weed Spray Mixture</td>
<td>liter (gallon)</td>
</tr>
<tr>
<td>2575.550</td>
<td>Compost, Grade 2</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2575.551</td>
<td>Compost, Grade 1</td>
<td>metric ton (ton)</td>
</tr>
<tr>
<td>2575.555</td>
<td>Turf Establishment</td>
<td>lump sum</td>
</tr>
<tr>
<td>2575.560</td>
<td>Hydraulic Soil Stabilizer, Type ___</td>
<td>kilogram (pound)</td>
</tr>
<tr>
<td>2575.561</td>
<td>Hydraulic Soil Stabilizer, Type 1</td>
<td></td>
</tr>
<tr>
<td>2575.570</td>
<td>Rapid Stabilization Method 1 or 2</td>
<td>hectare (acre)</td>
</tr>
</tbody>
</table>
2575.5

2575.571 Rapid Stabilization Method 3
.................................................... cubic meter (M Gallons)
2575.572 Rapid Stabilization Method 4
.................................................... square meter (square yard)
2575.573 Rapid Stabilization Method 5 ................. metric ton (ton)
Note: (1) If maintenance applies, a subnote will be placed on the pay item shown in the summary of quantities in the Plan: "Includes Maintenance."

2577

Soil Bioengineered Systems

2577.1 DESCRIPTION
This work shall consist of installing vegetation in conjunction with geosynthetic or natural materials for stabilizing areas susceptible to erosion. Soil Bioengineering may be used as a permanent soil stabilization system in ditches, along stream banks, on shorelines or on slopes. The work shall consist of furnishing and installing a composite system by the Contractor on site.

2577.2 MATERIALS
A. Seed, mix as specified ......................................................... 3876
B. Mulch, Type as specified.................................................... 3882
C. Erosion control blankets .................................................... 3885
D. Erosion control netting....................................................... 3883
E. Nursery plant stock ............................................................ 3861
F. Fiber log .............................................................................. 3895
G. Riprap .................................................................................. 3601
H. Concrete Armor Units........................................................ 3608

2577.3 CONSTRUCTION REQUIREMENTS
A. General
The installation locations and layouts shown in the Plans are approximate only. The exact locations and layout shall be as determined by the Engineer.

The harvest and installation of plant material shall be performed by qualified nurserymen or landscape specialists, or shall be performed by experienced crews working under the direct supervision of a qualified nurseryman or landscape specialist.

Planting operations shall not be started, nor shall any planting stock be delivered to the Project site, until it has been determined by the Engineer that weather and soil conditions are suitable for planting and that all necessary preparations have been made.

During placement, the Contractor shall install all components consecutively without significant lapse of time between each phase of the operation. On slopes, installation of material shall start at the
bottom of slope and proceed in horizontal lifts upward. On shorelines and banks, installation of material shall start below the water line and proceed up the bank.

During the work, the Contractor shall take all necessary precautions and actions to prevent siltation and turbidity of flowing or impounded waters of the State. When working in water, the Contractor shall protect the work site if necessary with curtains, barriers or other containment devices so that sediment and debris does not enter the receiving water body.

B Harvesting Plant Stock

Plant stock and cuttings shall be obtained from the regions and/or zones indicated in the Plans.

At least 3 days prior to harvesting of planting stock for the Project site, the Contractor shall notify the Engineer of the contemplated harvest date to allow for inspection.

C Season of Placement

The approximate dates for season of placement are listed in Table 2577-1. The Engineer may adjust a specified date by up to 20 days depending on prevailing weather conditions.

Plant material must be in dormant stage, prior to buds bursting open in spring or after leaves have changed color and dropped in fall.

<table>
<thead>
<tr>
<th>TABLE – 2577-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPROXIMATE SEASON OF PLACEMENT</td>
</tr>
<tr>
<td>SYSTEM</td>
</tr>
<tr>
<td>Wattling</td>
</tr>
<tr>
<td>Brush Layering</td>
</tr>
<tr>
<td>Live Stake</td>
</tr>
<tr>
<td>Root-Rap</td>
</tr>
</tbody>
</table>

D Wattling

This work shall consist of making trenches along the contours of the slope, placing bundles of dormant plant cuttings into the trenches, and tamping loose soil over the bundles. Prior to trenching, the Contractor shall drive wooden stakes 50 mm (2 inches) in diameter x ½ m (2 foot) long, 0.4 m (16 inches) on center along each trench location. The stakes shall be driven to a firm hold with the tops about 150 mm (6 inches) above grade. Trenching shall not precede installation of plant materials by more than 1 hour to minimize drying of soils. The overall soil surface shall be left in a rough condition with clods, and ridges left in place for maximum resistance to erosion. Immediately following trenching, the Contractor shall place bundles of dormant plant cuttings into the trench. Bundles shall have cuttings laid together with the buttends located at alternate ends of the bundle and tightly tied with binder twine at a minimum of three points along the
bundle. Bundles shall consist of 9.5-50 mm (3/8-2 inch) diameter, 1-2.4 m (3-8 foot) length dormant woody cuttings. The bundle should be approximately 150-200 mm (6-8 inches) in diameter. Wattle ends shall overlap in the trench. Additional stakes shall be driven through the bundles at a maximum spacing of ½ m (2 feet) on center. During placement of the bundles, the Contractor shall cover the bundles with loose soil working it into the wattles leaving a uniform fringe of plant material that is exposed approximately 50 to 80 mm (2-3 inches) high.

E  Brush Layering

This work shall consist of making horizontal slots the length of the slope and embedding dormant green plant cuttings into the slots and tamping loose soil over the cuttings. The slots are 0.61 m (2 feet) in depth angled downward into the slope. The plant cuttings shall consist of stems approximately 1 m (3 feet) long, 10 to 50 mm (½ - 2 inches) in diameter. Cuttings shall be placed in containers of water to transport until installed. As soon as practical after the slots are made, the Contractor shall place the plant cuttings into this slot with the butt end placed as far into the slot as possible with a minimum of 150 mm (6 inches) protruding out of the slot. The stems shall be placed randomly with some crisscrossing. As the plant cuttings are being placed, the Contractor shall immediately backfill the slot cuttings with soil and firm the backfill to the satisfaction of the Engineer.

F  Live Stakes

This work involves the insertion of dormant live cuttings into the soil. Cuttings shall consist of stems at least 1 m (3 feet) in length and 25-50 mm (1-2 inch) in diameter. Materials should be cut and placed in a container of water to be transported to the site and kept in water until installed. Tamp the cutting with the bottom end going into the ground at right angles to the slope face, 2/3 - 3/4 of their length. Care shall be taken not to split the ends or damage the bark of the cuttings. Placement shall be .67 m (2 feet) on center using a triangular spacing. Density of the installation will range from 2-4 stakes/m² (square yard).

Rip rap can be staked (joint planting) if it is not too thick (less than 0.67 m (2 feet). The Contractor shall make a pilot hole by driving a tool, as a pry bar or rebar, through the rip rap and filter layer, reaching the ground soil. Tamping can best be done with a dead blow hammer, avoiding damage to the bark. Place the cuttings in a random configuration 0.67 m (2 feet) on center.

G  Placing Fiber log

This work shall consist of placing biodegradable fiber log for stabilizing a shoreline. Prior to installing the fiber log, the Contractor shall drive wooden stakes 50 mm (2 inches) in diameter x 1 m (3 feet) long, 0.3 m (1 foot) on center along the proposed alignment of the fiber
The stakes shall extend 200 to 250 mm (8-10 inches) above the elevation of the water surface indicated on the plans. After the stakes are placed, the Contractor shall install the fiber log so that the upper surface of the fiber log is parallel to the water surface with 50 mm (2 inches) protruding above the normal water level. Fiber logs shall be laced together end to end with woven nylon twine 3 mm (1/8 inch) in diameter to create a continuous length. The Contractor shall bury both ends of the fiber rolls 1 ½ m (5 feet) laterally into the bank.

H  Root-Rap

This work shall consist of placing a gravel channel lining or riprap, and over-seeding or planting the completed channel. The Contractor shall conduct this work in conformity with the details, typical sections and elevation controls shown in the contract. Actual alignment shall be as staked by the Engineer. During the work, the Contractor shall place the granular channel lining or riprap and shape the channel to completed section as a continuous operation. Seeding or planting shall be initiated within 48 hours.

I  BLANK

J  BLANK

K  Acceptance of Work

Except as otherwise provided for in the Contract, the Engineer will accept soil bioengineered systems upon satisfactory placement.

2577.4  METHOD OF MEASUREMENT

A  Wattling

Wattling will be measured by the meter (linear feet) of each trench made and planted. When several trenches are made and planted, each length of trench acceptably planted shall be added to the total. Plant cuttings, bundles and stakes shall be incidental.

B  Brush layering

Brush layering will be measured by the meter (linear feet) of each horizontal slot made and planted. When several slots are made and planted, each length of slot acceptably planted shall be added to the total. Plant cuttings and stakes shall be incidental.

C  Fiber log

Fiber log will be measured by the meter (linear feet) furnished and installed including buried portions. Stakes and rope to fasten logs in place shall be incidental.

D  Granular channel liner

Granular channel liner will be measured by volume in cubic meter (cubic yard) placed and in its final configuration.

E  Concrete Armor Units

Concrete Armor Units will be measured by surface area covered by each size furnished and acceptably installed including the buried
portions. The outermost extremity of the units shall be used in the measurement. On small projects, concrete armor units will be accepted by the number of complete units (two individual halves) assembled and installed.

2577.5 BASIS OF PAYMENT
Payment for bio-engineered system items will be compensation in full for all labor, materials, equipment, and other incidentals necessary to complete the work as required by the Contract. The Contractor will receive compensation at the appropriate Contract prices, or in the absence of a Contract bid price as Extra Work.

A Pay Items
Payment for bioengineered system items will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2577.501</td>
<td>Wattling</td>
<td>meter (linear feet)</td>
</tr>
<tr>
<td>2577.502</td>
<td>Brush Layering</td>
<td>meter (linear feet)</td>
</tr>
<tr>
<td>2577.503</td>
<td>Fiber Log</td>
<td>meter (linear feet)</td>
</tr>
<tr>
<td>2577.504</td>
<td>Granular channel Liner</td>
<td>cubic meter (cubic yard)</td>
</tr>
<tr>
<td>2577.505</td>
<td>Live Stakes</td>
<td>Each</td>
</tr>
<tr>
<td>2577.506</td>
<td>Concrete Armor Units (1)</td>
<td>Each</td>
</tr>
<tr>
<td>2577.507</td>
<td>Concrete Armor Units (1)</td>
<td>square meter (square yards)</td>
</tr>
</tbody>
</table>

(1) Specify Size

2581 Removable Preformed Plastic Pavement Marking

2581.1 DESCRIPTION
This work shall consist of furnishing, placing and removing temporary pavement marking material on those pavements open to traffic where traffic markings are necessary and temporary lane markings are not appropriate.

2581.2 MATERIALS
Removable Preformed Plastic Pavement Marking for Traffic Lane Delineation and Legends ......................................................... 3355

2581.3 CONSTRUCTION REQUIREMENTS
Removable preformed plastic pavement marking shall be furnished and placed by the Contractor at locations and with proper dimensions as indicated in the Plans or as directed by the Engineer immediately prior to modification of traffic flow. Placement shall be on a clean and dry surface in accordance with the contract documents. Removed marking material shall be disposed of properly.
2581.4 METHOD OF MEASUREMENT
Removable preformed plastic pavement marking will be measured by the actual length of pavement marking furnished, placed, and removed as specified.

The measurement is based on a 100 mm (4 inches) wide marking, regardless of color or type. Measurement for marking widths differing from the 100 mm (4 inches) width will be adjusted by the ratio of the actual width to the 100 mm (4 inches) width. Broken line marking will be measured by the actual length of material used and will not include gaps between the broken lines.

2581.5 BASIS OF PAYMENT
Payment for removable preformed plastic pavement marking at the Contract price per unit of measure will be compensation for all costs of furnishing, placing, maintaining, replacing, and removing the marking.

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2581.501</td>
<td>Removable Preformed Plastic Marking</td>
<td>meter (linear foot)</td>
</tr>
</tbody>
</table>

2582 Permanent Pavement Markings

2582.1 DESCRIPTION
A Pavement Messages
Pavement messages are word and symbol pavement markings installed in the roadway. These markings include all word and symbol messages that are not line segments.

B Linear Pavement Markings
Linear pavement markings are those pavement markings installed in the roadway that are line segments of various widths. These markings include lane lines, center lines, no passing zone lines, and edge lines, airplane markings, and stop lines. These markings do not include crosswalk markings or messages.

C Crosswalk Markings
These markings include crosswalk blocks that are installed parallel to the direction of travel on the roadway. Crosswalk markings are blocks installed in the roadway parallel to the direction of travel in a pattern that is transverse to the direction of travel.

2582.2 MATERIALS
Qualified materials can be found on Mn/DOT's Qualified Products List on the Office of Traffic, Security and Operations website. Other materials may be used on a provisional basis as detailed in the QPL
process and as approved by the Engineer. Type of material used will be as specified by contract documents.

2582.3 CONSTRUCTION REQUIREMENTS

A Prequalification

This Pavement Marking Qualification and Acceptance Program has been developed and implemented to insure that quality materials and workmanship are used on Mn/DOT pavement marking projects.

A1 Certification of Materials

Acceptance of pavement marking materials under the Pavement Marking Qualification and Acceptance Program is based on the product's certification and quality control testing verified by Mn/DOT Laboratory testing of verification samples and spot checks on samples obtained from contractor stock or from project sites. Products meeting the requirements of the Pavement Marking Qualification and Acceptance Program will be placed on the Qualified Products List. Products can be removed from the Qualified Products List due to poor field performance.

A2 Approved Contractors

Only contractors approved through Mn/DOT’s Pavement Marking Qualification and Acceptance Program will be awarded contracts. Contractors may be removed from the approved contractor list due to poor performance.

B Application

Place markings on roadways in accordance with contract documents.

C ACCEPTANCE

Pavement markings in Minnesota shall retain a satisfactory level of retroreflectivity, demonstrate good adhesion, resisting chipping, and exhibit consistency of color in all lighting conditions.

C1 Alignment

Minimum linear pavement marking shall not be less than the specified width and shall not vary by more than 6 mm (.25 in). The width will not vary by a rate more than 6 mm / 3 m (.25 in/10 ft). The length of broken line segments shall not vary by more than 75 mm (3 in) and the number of broken line segments shall be between 102 and 108 per mile of marked pavement. Alignment deviations from the control guide or existing lines specified by the Engineer shall not exceed 50 mm (2 in). The transverse position of linear markings shall not vary more than the rate of 25 mm / 3 m (1 in/10 ft). Pavement marking material shall not be applied over a longitudinal joint.

C2 Color

The color of white pavement marking shall be a pure flat white and free of tints. The color of the yellow epoxy shall match Color Number
33538 of Federal Standard 595 and shall conform to the following CIE Chromaticity limits using illuminant "C".

C3 Retroreflectivity – minimum initial pavement marking retroreflectivity using 30 m geometry shall be:

<table>
<thead>
<tr>
<th>Material</th>
<th>White</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape</td>
<td>600 mcd</td>
<td>500 mcd</td>
</tr>
<tr>
<td>Epoxy</td>
<td>300 mcd</td>
<td>200 mcd</td>
</tr>
<tr>
<td>Latex</td>
<td>275 mcd</td>
<td>180 mcd</td>
</tr>
</tbody>
</table>

D **Pavement Marking Warranty**

All warranties shall be transferred to Mn/DOT after construction.

E **Correction of Defects**

Pavement markings that do not conform to the requirements of the contract shall be replaced or repaired to the satisfaction of the Engineer. Removal of unacceptable work shall be accomplished using suitable methods as approved by the Engineer.

F **Penalties**

Penalties will be assessed by the Engineer where initial retroreflectivity fall below the minimum acceptable levels. If the retroreflectivity deficiency is greater than 20% the work shall be removed or repaired to the satisfaction of the Engineer. If the deficiency is 20% or less, the Engineer may require satisfactory repair or may accept the work at a reduced unit price. The unit price will be reduced by the percent of retroreflectivity deficiency.

G **Striper Operations Daily Form**

Contractors applying pavement markings for Mn/DOT under a contract are required to fill out the "Construction Striper Operations Daily Log" form which is shown in the special provisions and as approved by the Engineer. No payment for pavement markings shall be made until the form is completed and submitted to the Engineer.

2582.4 **METHOD OF MEASUREMENT**

A **Pavement Messages**

Pavement messages of each type will be measured by the number of each type installed as specified.

B **Lines**

Pavement markings will be measured by the length of each type constructed in place as specified. Broken lines will be measured by the actual length of line marked and will not include the gap between the broken lines.

C **Crosswalk Blocks**

Crosswalks shall be measured by area of material sq m (sq ft) installed as specified and by type.
2582.5 **BASIS OF PAYMENT**

Payment for pavement markings installed at contract prices per unit of material shall be compensation in full for all costs incurred in materials, traffic control, installation, surface preparation, use of primers, in accordance to contract documents or as approved by the Engineer.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2582.501</td>
<td>Pavement Message (1) (2)</td>
<td>Each</td>
</tr>
<tr>
<td>2582.502</td>
<td>Linear Markings __ mm (__ inch) width (2) (3) (4)</td>
<td>meter (linear foot)</td>
</tr>
<tr>
<td>2582.503</td>
<td>Crosswalks (2)</td>
<td>square meter (square foot)</td>
</tr>
</tbody>
</table>

(1) Specify Message
(2) Specify Material
(3) Specified Type of Line (Solid, Broken or Dotted)
(4) Specify Color