STANDARD

SPECIFICATIONS

FOR

CONSTRUCTION

2020 EDITION

VOLUME 2

Changes from the 2018 Edition

Vertical change lines have been added to indicate text that has changed from the 2018 Edition. These change lines are intended as a courtesy to the reader, and MnDOT does not guarantee that all text changes are indicated by change lines.

- Change lines are in the left and right margins bordering paragraphs with change(s). The change lines border the whole paragraph, even if only one line in the paragraph has changed.
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MINNESOTA

DEPARTMENT OF TRANSPORTATION

ST. PAUL, MINNESOTA

STANDARD SPECIFICATIONS FOR CONSTRUCTION

2020 EDITION

VOLUME 2

ORDER NUMBER 98833

It is hereby ordered that these Minnesota Department of Transportation Standard Specifications for Construction, 2020 Edition, be adopted for application of State and Federal Aid construction Contracts awarded in Minnesota.

Upon being published and made available for distribution, these Standard Specifications shall become effective by reference in the Contract Plans, Supplemental Specifications, or Special Provisions.

Nancy Daubenberger Digitally signed by Nancy Daubenberger Date: 2021.02.22 14:12:51 -06'00'

Nancy J. Daubenberger
Deputy Commissioner of Transportation
Chief Engineer

These Minnesota Department of Transportation Standard Specifications for Construction, 2020 Edition, are hereby approved for application on Highway, Street and related construction Contracts as referenced in the Contract Plans, Supplemental Specifications, or Special Provisions and they shall apply as noted and amended by those documents.

Thomas Ravn Digitally signed by Thomas Ravn Date: 2021.02.22 14:02:25 -06'00'

Thomas D. Ravn
State Construction Engineer

I hereby certify that the changes contained in these Minnesota Department of Transportation Standard Specifications for Construction, 2020 Edition, were prepared by me or under my general supervision and that I am a duly registered professional engineer under the laws of the State of Minnesota.

Mark Gieseke Digitally signed by Mark Gieseke Date: 2021.02.22 13:58:32 -06'00'

Mark Gieseke
Assistant Commissioner
Reg. No. 18962

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DIVISION II

CONSTRUCTION DETAILS

General

2021 MOBILIZATION

2021.1 DESCRIPTION

This Work consists of preparatory Work and operations, including the movement of personnel, Equipment, supplies, and Incidentals to the Project to establish Contractor's offices and buildings or other facilities. This Work may also include obtaining bonds, permits, and demobilizing.

2021.2 MATERIALS — BLANK

2021.3 CONSTRUCTION REQUIREMENTS — BLANK

2021.4 METHOD OF MEASUREMENT — BLANK

2021.5 BASIS OF PAYMENT

The Department will provide partial payments for mobilization in accordance with the following table:

Table 2021.5-1
Mobilization Partial Payments

When	Contract Unit Price for mobilization is less than 5 percent of the total Contract amount, pay	Contract Unit Price for mobilization exceeds 5 percent of the total Contract amount, pay
Percent of Original Contract Amount Completed*	**Percent of Mobilization**	**Percent of Original Contract Amount ***
5	50	3
15	75	5
25	100	5
95	100	—

* The percent of original Contract amount = the amount earned by the Contractor, excluding money earned for mobilization and Material on hand, divided by the total value of the original Contract (all Contract Items).

If the Contract Unit Price for mobilization exceeds 5 percent of the total original Contract amount, the Department may withhold (on any partial estimate) the portion in excess of 5 percent until the Contractor earns at least 95 percent of the original Contract amount.

The Department will not pay more than the original Contract Unit Price for the mobilization item, even if the Contractor shuts down Work on the Project or moves Equipment away from the Project and then back again.

If the Contract does not contain a lump sum item for mobilization, all costs incurred by the Contractor for mobilization shall be Incidental.

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

Item No.	Item	Unit
2021.501	Mobilization	lump sum

2031 FIELD LABORATORY AND OFFICE

2031.1 DESCRIPTION

This Work consists of providing, maintaining, and removing field laboratory, field office and combination field laboratory-office facilities for the exclusive use of Department personnel.

2031.2 MATERIALS — BLANK

2031.3 CONSTRUCTION REQUIREMENTS

Furnish safe, sanitary, mold-free, weatherproof buildings or trailers in good condition. Obtain the Engineer's approval of facilities and services before installing on the Project Site. The facilities shall remain the property of the Contractor. Provide, maintain, and service the facilities with fuel, electrical power, sanitary services, access Roads, and other items required by the Contract. Suitable commercial or private facilities located near the Project Site may be provided.

Locate, relocate, and maintain the facilities as approved by the Engineer unless otherwise specified by the Contract. Locate the field laboratory, field office, and combination field laboratory-office facilities within the Right-of-way if possible. If a facilities location within the Right-of-way is not possible, arrange for a facilities site adjacent to the Right-of-way. If facilities site rental is necessary, the Department will compensate the Contractor for rental costs as Extra Work. The Engineer will notify the Contractor when to deliver a unit to the Project, ready it for occupancy, and relocate or remove it. Do not relocate or remove any unit from the Project unless otherwise directed by the Engineer.

The Engineer may use field office units for the full life of the Contract including periods of Work suspension and until the execution of the certificate of final acceptance. The Engineer will not use the laboratory units during periods of authorized winter suspension without the Contractor's permission or unless otherwise required by the Contract.

The Engineer will release field laboratory units upon completion of field inspection Work and acceptance in accordance with 1516.2, "Project Acceptance," unless otherwise required by the Contract.

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

A Facilities

Perform site Work to accommodate facilities and restore to its original condition upon removal. Do not place field offices, laboratories, Equipment, or supplies within 26 feet outside of the dripline of specimen trees or other vegetation designated for preservation. Restrict traffic movement from this protected area. Provide temporary fence and other protection measures as specified in 2572, "Protection and Restoration of Vegetation.

Provide facilities conforming to applicable ordinances, safety codes, regulations, and in accordance with Table 2031.3-1.

Table 2031.3-1
Facility Requirements

Property	**Field Office**	**Laboratory***	**Combination Field Laboratory-Office**
Floor space, based on exterior dimensions	230 square feet	150 square feet	256 square feet ‖
Exterior width (minimum)	8 feet	8 feet	8 feet
Floor to ceiling height (minimum)	7 feet	7 feet	7 feet
Locking outside door, deadbolt with keys, one with opening at least 30 inches x 76 inches	2 †	2 ‡	2†
Steps with slip-proof thread and handrails	X	X	X
Windows with locks, insect screening, and blinds; Total window area	20 percent of unit floor area	20 percent of unit floor area	20 percent of unit floor area
Electric lighting	X	X	X
Fire extinguisher: one multipurpose extinguisher meeting the requirements of applicable Federal and State safety and health regulations	1	1	1
Artificial Lighting system with fixtures providing adequate illumination over each desk and all work areas	X	X	X
Furnishings			
Desk with supply drawers (dimensions = minimum)	2 – 60 inches x 30 inches	1 – 60 inches x 30 inches	1 – 90 inches x 30 inches
Desk chairs: swivel-type	4	1	3
File drawers, letter or legal size	3	2	2
Drafting desk (dimensions = minimum)	1 – 72 inches x 30 inches		1 – 48 inches x 30 inches
Drafting stool	1	1	1
Storage cabinet or closet with space for outdoor garments, office supplies	1	1	1
Shelving	20 Linear Feet x 12 inches	12 Linear Feet x 12 inches	8 Linear Feet x 12 inches 8 Liner Feet x 8 inches
Workbench		120 inches X 24 inches	84 inches x 30 inches
Service sink with potable water supply, capacity of 20 gallons, at least 12 inches deep		1	1
Electric stove, standard 30 – 36 inches		1 §	1 §
Electric exhaust fan		1	1
Services			
Electrical power supply, including duplex outlet receptacles capable of providing adequate amperage for electric lighting and other appliance needs	X	X	X

Property	Field Office	Laboratory*	Combination Field Laboratory-Office
Thermostatically controlled heating and cooling system capable of maintaining a uniform temperature of at least 70°F in all zones	X	X	X
Toilet/lavatory facilities	X	X	X
Drinking water cooler with water supply	X	X	X
Trash containers and disposal service	X	X	X
Pressurized water supply of sufficient capacity to meet Material testing and cylinder curing needs for the Project. If pressurized water supply is not available, provide a 50 gallon water storage tank, installed to produce sufficient gravity pressure to maintain constant flow through the sink faucet.		X	X
Curing tank with adequate capacity and in dimensions that allow installation below a laboratory workbench for concrete test cylinder curing when the Work involves casting of standard concrete test cylinders. The Contractor may place the tank outside when used at the facilities site of a field office.		X	X
Electrically powered mechanical Sieving apparatus meeting the following characteristics and requirements to determine particle size distribution of fine Aggregate (−No. 4 Sieve [−4.75 millimeters]): (1) Capable of accommodating six Department-provided full height 4 inches [200 millimeters] round Sieves with pan and cover (2) Equipped with an automatic timing device of at least 15 minute duration (3) Meeting the requirements of the *AASHTO T 27*, "Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates," Sieving sufficiency.		X	X
* Rigidly support the field laboratory to eliminate floor and workbench vibrations for accurate weighing on a bench-supported Scale. ‖ Minimum total exterior dimensions for the field laboratory area shall not be less than 160 square feet; minimum total exterior dimensions for the field office area shall not be less than 96 square feet; field laboratory and field office areas shall be separated by a wall to effectively isolate the field laboratory from the field office. † Ensure the exterior doors provide convenient and safe egress from the ends of the facility(s). ‡ The Contractor may install a smaller auxiliary door on field laboratory units if it fulfills the basic needs for an emergency exit. Ensure the doors and passageways provide easy access to all areas of the unit. § The Contractor may substitute separate heating plates.			

2031.4 METHOD OF MEASUREMENT

The Engineer will separately measure accepted field office, field laboratory, and combination field laboratory-office units by the number provided and used as required by the Contract, regardless of the duration of its use at any one or different locations on the Project Site.

2031.5 BASIS OF PAYMENT

The Contract Unit Price for field office, field laboratory, or combination field laboratory-office unit includes the cost of providing, placing, maintaining, and servicing the complete facility as required, including removal.

The Department will pay for field office, field laboratory, and combination field laboratory-office on the basis of the following schedule:

Item No.	Item	Unit
2031.502	Field Office, Type ___	Each
2031.502	Field Laboratory, Type ___	Each
2031.502	Combination Field Laboratory-Office	Each

2051 HAUL ROAD MAINTENANCE AND RESTORATION

2051.1 DESCRIPTION

This Work consists of the maintenance, repair, and restoration of Designated Haul Road for Materials hauled for the Work covered by the Contract.

A Definitions

For the purpose of the Work specified in section 2051, "Haul Road Maintenance and Restoration," the Department defines "Designated Haul Road" as any public Road or Street officially designated as a haul Road, except for a Minnesota trunk Highway or Road officially designated by the Commissioner as a Detour around a construction Project, over which any of the following Materials are hauled:

(1) Soil or other Material for embankment construction
(2) Sand, gravel, or other Material for backfill
(3) Sand, gravel, or crushed rock for base or surfacing courses
(4) Aggregates for bituminous surfacing, including hauling bituminous mixtures from the mixing plant
(5) Aggregates for concrete base or pavement, including hauling concrete batches from batch plants
(6) Bituminous Materials and Portland cement for paving mixtures

The Contractor may haul Materials to the Project or to other locations outside the Project if required to complete the Work specified in the Contract.

2051.2 MATERIALS — BLANK

2051.3 CONSTRUCTION REQUIREMENTS

A Designation and Use of Haul Roads

If the Contract specifies Maintenance and Restoration of haul Roads as a Contract Item, do not haul Material from any source until the Commissioner designates the haul Road from that source as a Designated Haul Road. After the Commissioner designates the haul Road from a source, haul all Materials from that source over that Road.

Make all vehicle trips, both loaded or unloaded, between Material sources and the Project on a Designated Haul Road.

If the Contract is with Department for State trunk Highway Projects, select a proposed haul Road and notify the Engineer of the selection. Within 15 Calendar Days after receipt of notification of the proposed haul Road, the Commissioner will determine whether the proposed Road is acceptable for use as a Designated Haul Road. The Commissioner may designate the Road as a temporary trunk Highway haul Road.

If the Contract is with or for a governmental agency other than Department, select a proposed haul Road and notify the engineer representing that governmental agency of the selection. Within 15 Calendar Days after receipt of notification of the proposed haul Road, the Engineer will determine whether the proposed Road is acceptable for use as a Designated Haul Road. If the Road is acceptable, the Engineer may approve the Road as a Designated Haul Road.

After a haul Road is officially designated, the Contractor may select a different Road for official designation using the same procedure specified in this section. If the haul Road designation changes and any of the above described Materials were hauled over the previously Designated Haul Road, the Contractor shall restore the previously Designated Haul Road to the original condition.

A.1 Bituminous Roadways

Reimburse local government agencies for Designated Haul Road use on bituminous Roadways in accordance with the following:

(1) Verify spring load capacities of proposed haul Roads with the local government agencies
(2) For a Designated Haul Road with a bituminous surface and a spring load capacity less than 9 tons, reimburse the local government agency for Designated Haul Road use at a rate of $0.01 per ton per mile of Material hauled
(3) Make full payment to the local government agency upon receiving notice of payment due and computations from the Engineer
(4) Provide the Engineer with confirmation of payment to the local agency

The Department will not require payment if the amount due to an individual local government agency is less than $500.00.

The Department will not require the Contractor to reimburse local government agencies for concrete surfaced Roadways.

A.2 Maintenance and Restoration

While hauling operations are in progress, maintain the Designated Haul Road as approved by the Engineer. This work includes application of water, bituminous Material, or calcium chloride to the Road surface as necessary to alleviate dust nuisance and eliminate traffic hazards.

After the completion of hauling operations over a Designated Haul Road, perform one of the following:

(1) Restore that Designated Haul Road to a condition at least equal to the condition existing at the start of the hauling operations
(2) Compensate the local government agency in the amount approved by the local government agency and the Engineer for the restoration of that Designated Haul Road by the local government agency

The fact that other traffic used the Designated Haul Road concurrently with the Contractor’s Material hauling operation does not relieve the Contractor of the obligation to maintain and restore the Designated Haul Road as required in this section. If other contractors, performing Highway construction under a contract with the same governmental agency, haul Materials over the same Road concurrently with the Contractor’s Material hauling operation, the

Engineer will determine the amount of maintenance and restoration obligation to be shared by each.

The Engineer will determine the kind and amount of maintenance and restoration Work required to restore the Designated Haul Road to a condition equal to the condition existing at the time the hauling operations started. The Engineer's decision is final, binding, and conclusive.

When hauling over any Designated Haul Road is completed and the Contractor has restored the Road or has compensated the governmental agency for the restoration as required, the Engineer will accept such restoration or concur in such financial settlement for the restoration of the Designated Haul Road in writing, and such acceptance shall relieve the Contractor of additional obligation in connection with the restoration of the Designated Haul Road.

2051.4 METHOD OF MEASUREMENT— BLANK

2051.5 BASIS OF PAYMENT

The Contract lump sum amount for Maintenance and restoration of haul Roads includes the cost of maintenance, restoration, and the reimbursement to any local government agencies as specified in this section for use of haul Roads officially designated and used in conjunction with the Contract Work.

The Department will not make payment for Maintenance and restoration of haul Roads unless one or more haul Roads were officially designated and used for hauling Materials. The Department will make payment at the Contract lump sum amount if these two conditions were met and regardless of the amount of maintenance and restoration Work required, provided Work was completed or the local government agency certified receipt of payment for such restoration.

If the Contractor fails or refuses to perform Designated Haul Road restoration or to make satisfactory financial settlement for such restoration as required within the period specified by the Engineer in writing, the Department will complete the restoration Work and deduct the costs from any moneys that are or may become due the Contractor or require reimbursement from the Contractor's Surety.

The Department will pay for Maintenance and restoration of haul Roads on the basis of the following schedule:

Item No.	Item	Unit
2051.501	Maintenance and Restoration of Haul Roads	lump sum

Grading

2101 CLEARING AND GRUBBING

2101.1 DESCRIPTION

This Work consists of removing and disposing of the trees, Brush, stumps, roots, and other plant life, including dead and decayed matter, within the construction area, unless otherwise designated to remain by the Contract or as directed by the Engineer.

2101.2 MATERIALS - BLANK

2101.3 CONSTRUCTION REQUIREMENTS

The Engineer will establish the Right-of-way lines and construction limits confining the clearing and grubbing operations. The Engineer will designate those trees, Brush, and other vegetation for preservation and those for removal. Remove and dispose of the trees, Brush, stumps, and roots from the limits designated for clearing and grubbing.

Follow all requirements of MN Statutes §18.82 with regards to treatment and movement of woody noxious weeds located within the construction limits. The State noxious weed list is determined by the Minnesota Department of Agriculture (MDA). The Contractor may visit the MDA "Noxious Weeds List" website to find information about control requirements and transportation restrictions.

Adhere to all plant pest quarantine orders imposed by the MDA and the United States Department of Agriculture. Contractor may contact MDA at 1-888-545-6684 or visit the MDA "Noxious Weeds List" website to find information about all existing plant pest quarantines active in Minnesota.

Use wood chips within the construction limits for erosion control, construction exit pads, or other Project related needs prior to removing the chips from the Project Site and dispose of quarantined wood in accordance with existing quarantine requirements.

The Department will not pay for compliance with these requirements.

Salvage topsoil in accordance with 2106, "Excavation and Embankment – Compacted Volume Method."

Cleared and grubbed areas are subject to partial payment withholdings of erodible surface Areas in accordance with 2574, "Soil Preparation."

Protect the items designated to remain in accordance with 1712, "Protection and Restoration of Property," and 2572, "Protection and Restoration of Vegetation," place temporary fence, prune branches, and perform clearing and grubbing operations in a manner that will not damage or jeopardize the surrounding plant life and property.

A Clearing and Grubbing Operations

Cut off, remove, and dispose of the trees, Brush, stumps, and roots as clearing and grubbing operations from designated areas as shown on the Plans within the construction limits or as directed by the Engineer.

B Clearing Operations

Cut off, remove, and dispose of trees and Brush in the areas identified as a clearing operation on the Plans or as directed by the Engineer. If the Contract does not require grubbing or if the Engineer directs the Contractor not to perform grubbing, cut off at a point within 6 inches of the ground.

C Grubbing Operations

Remove and dispose of the Brush, stumps, roots, and other remains in the areas designated as a grubbing operation on the Plans, or as directed by the Engineer. Completely remove stumps unless otherwise approved by the Engineer. If the Engineer approves of a stump to remain, cut the stump no greater than 6 inches above the ground, and flush with or below the ground surface if directed by the Engineer.

Fill depressions resulting from the grubbing operations with suitable Material in accordance with 2106.2B.7, "Topsoil," and compact the Material as approved by the Engineer, except in those areas to be excavated as part of the Work.

D Disposal Limitations

Dispose of trees, Brush, stumps, roots, and other debris or byproducts by chipping, tub grinding, or marketing. The Contractor may chip the wood through a chipping machine or tub grinder to create Type 6 mulch, for use within the construction limits. If the construction Project is within a Plant Pest Quarantine imposed or enacted by MDA and wood will leave the site, provide to the Engineer a compliance agreement from MDA. Dispose of any quarantine regulated wood products as directed by the MDA regulations or non-quarantine regulated items as forestry standards dictate to prevent the spread of insects and disease.

D.1 Marketable Trees

Trees designated for removal may be marketed to wood-utilizing industries. Do not market any wood from a quarantined area to wood-using industries or individuals without a compliance agreement from the MDA.

For the purpose of the Work specified in 2101.3D, "Disposal Limitations," the Department defines marketable trees as all trees except elm trees, oak wilt infected oak trees, and ash trees greater than 6 inches in diameter measured at 24 inches above the ground.

D.2 Elm, Oak Wilt Infected Oak, Pine, and Quarantined Wood

D.2.a Elm Trees

Dispose of elm trees, Brush, stumps, roots, and debris by chipping or tub grinding and using the mulch within the construction limits for erosion control, construction of exit pads, or landscaping purposes.

D.2.b Oak Wilt Infected Oak Trees

Dispose of stumps, roots, and debris from oak wilt infected oak trees by chipping or tub grinding and using the mulch within the construction limits for erosion control, construction of exit pads, or landscaping purposes.

D.2.c Elm and Oak Wilt Infected Oak Tree Disposal Deadlines and Locations

Dispose of elm and oak wilt infected oak trees within 20 Calendar Days of notification. Dispose within the Right-of-way by tub grinding or chipping then use mulch for erosion control or other Project related needs prior to removing the chips from the Project Site.

D.3 Pine

Dispose of all non-marketable pine trees, Brush, stumps, roots, and slash debris by chipping, tub grinding, or debarking within 20 Calendar Days of being cleared during the growing season to prevent the infestation and spread of pine bark beetles.

D.4 Quarantined Wood

Follow all species specific quarantine regulations posted by MDA. Do not market quarantined trees to the wood-using industries or individuals without having a compliance agreement from MDA. Do not make wood with bark attached available to the public for use as firewood from the quarantined area. Do not take any part of the quarantined tree, including roots, outside of a quarantined County without fulfilling the requirements of a compliance agreement from MDA. Contact the MDA to speak with a regulatory official and visit the MDA Plant Pest Quarantine website to determine the quarantine areas. Quarantined wood may be chipped through a chipping machine or tub grinder to create Type 5 or Type 6 mulch for use within the construction limits.

D.5 Burning 2104.3D

D.6 Burying 2104.3D

2101.4 METHOD OF MEASUREMENT

The Engineer will measure Clearing and Grubbing by area, lump sum, or individual unit as required by the Contract. The Engineer will measure tree diameter by measuring the circumference of the tree at 4.5 feet above the ground and dividing the circumference by 3.14, or by measuring the diameter or the tree stump after removal.

A Qualifying Trees and Stumps

The Engineer will only measure trees for payment having a diameter greater than 3 inches at a point measured 24 inches above the ground surface.

The Engineer will only measure stumps for payment having a diameter greater than 3 inches when measured at one of the following points:

(1) Two feet above the ground surface for a tree cleared under the Contract
(2) The point of cutoff for an existing stump not cleared under the Contract

The Engineer will not measure for the removal and disposal of stumps and Brush with a diameter equal to or less than 3 inches at the point of cutoff.

B Area Basis

If the Contract specifies the unit as a hectare, the Engineer will determine quantities by measuring, to the nearest 0.05 acre, all areas cleared and all areas grubbed within the limits as shown on the Plans or staked by the Engineer. The Engineer will make all measurements horizontally to points 10 feet outside the trunks of qualifying trees or stumps on the perimeter of the area being measured. The Engineer will measure separate areas less than 0.05 acre as 0.05 acre.

If isolated trees or stumps require removal outside the areas designated for clearing or grubbing by the acre, and no Unit Price is provided in the Contract for clearing and grubbing individual trees or stumps, the Department will pay based on the following:

(1) The Engineer will consider each isolated qualifying tree less than 40 inches in diameter when measured at a point 2 feet above the ground surface, and each isolated qualifying stump measuring less than 40 inches at the point of cutoff as 0.05 acre.
(2) The Engineer will consider each isolated tree or stump at least 40 inches in diameter when measured at the points described in (1) above as 0.1 acre.

C Individual Unit Basis

When the Contract specifies “each” as the unit, the Engineer will count the number of qualifying trees cleared and the number of qualifying stumps grubbed to determine the quantity.

D Lump Sum Basis

The Engineer will not measure an individual area, tree, or stump if the Contract specifies clearing and grubbing as a lump sum item.

2101.5 BASIS OF PAYMENT

The Contract Unit Prices for the accepted quantities of clearing and grubbing includes the cost for removal and disposal; securing outside disposal sites in accordance with 2104.3D, “Disposal of Materials and Debris”; bringing in a chipper/grinder if necessary; securing a compliance agreement from the MDA; and performing the required treatment for disposing of elm, oak wilt infected oaks, pine, quarantined wood, and marketable trees.

The Contract lump sum price for Clearing and Grubbing, regardless of the sizes of the trees and stumps, includes the cost of all clearing and grubbing required by the Contract.

The Department will include the costs for removing and disposing of Brush and stumps with a diameter equal to or less than 3 inches at the point of cutoff in the Contract Unit Prices of other relevant Pay Items.

The Department will not pay for pruning except as specified in 2572.5, "Protection and Restoration of Vegetation, Basis of Payment."

If the Contract does not specify a Pay Item for Clearing and Grubbing, the Department will pay for clearing and grubbing of qualifying trees and stumps as specified in 2101.4, "Clearing and Grubbing, Method of Measurement," as Extra Work in accordance with 1402, "Contract Revisions."

The Department will pay for clearing and grubbing items on the basis of the following schedule:

Item No.	Item	Unit
2101.501	Clearing and Grubbing	lump sum
2101.502	Clearing	each
2101.502	Grubbing	each
2101.505	Clearing	acre
2101.505	Grubbing	acre

2102 PAVEMENT MARKING REMOVAL

2102.1 DESCRIPTION

This Work consists of removing temporary and permanent pavement markings, except for removable preformed pavement marking tape, that conflict with revised traffic patterns.

2102.2 MATERIALS — BLANK

2102.3 CONSTRUCTION REQUIREMENTS

Before making a change in traffic pattern, remove conflicting pavement markings to a degree that they are unrecognizable and as directed by the Engineer minimizing damage to the Pavement Structure or surface texture. Repair damaged areas as directed by the Engineer at no additional cost to the Department.

Remove irregular shaped pavement messages with a rectangular shape of least dimensions as determined by the Engineer.

Control or restrict operations to avoid exposing traffic to hazardous conditions in accordance with 1701, "Laws to be Observed," 1707, "Public Convenience and Safety," and 1717, "Air, Land, and Water Pollution." Remove expended Materials or agents used in the pavement marking removal process from the pavement surface as the Work progresses. Dispose of all waste generated by pavement marking removal process in accordance with 1701, "Laws to be Observed," and 1717, "Air, Land, and Water Pollution."

Removed pavement marking Material shall become the property of the Contractor.

2102.4 METHOD OF MEASUREMENT

The Engineer will measure Pavement marking removal by area or length of the original markings as removed.

The Engineer will measure removal areas on the basis of Nominal widths and actual lengths as originally applied and still visible at the time of pavement marking removal. The Engineer will enclose irregularly shaped markings within rectangular boundaries of least dimensions as determined by the Engineer.

The Engineer will measure removal length by the actual length of each 4 inch wide pavement marking removed. The Engineer will measure longitudinal pavement marking removal quantities greater than 4 inches wide based on a ratio of actual pavement marking width relative to 4 inches. The Engineer will not include the gap between line segments in the removal length measurement.

2102.5 BASIS OF PAYMENT

The Contract Unit Price for Pavement marking removal includes the cost of obliterating the markings as required by the Contract and for restoring the pavement texture as directed by the Engineer.

The Department will include the cost of removing removable preformed pavement marking tape with the relevant Contract Unit Prices in accordance with 2581, “Removable Preformed Pavement Marking and Message Tape.”

The Department will pay for pavement marking removal on the basis of the following schedule:

Item No.	Item	Unit
2102.503	Pavement Marking Removal	linear foot
2102.518	Pavement Marking Removal	square foot

2103 BUILDING REMOVAL

2103.1 DESCRIPTION

This Work consists of removing unsalvageable and vacated buildings from the Right-of-way, making sewer and water service disconnections, and removing Sidewalks, driveways, or miscellaneous Structures, unless otherwise required by the Contract.

2103.2 MATERIALS— BLANK

2103.3 CONSTRUCTION REQUIREMENTS

A General

Perform building removals as required by the Contract. The Contract will provide a general description and the street addresses or references to a survey station for the buildings and miscellaneous items requiring removal.

Remove buildings, including fixtures such as wires, pipes, valves, etc., except those owned by public or private utilities, by demolition before removal from the Right-of-way.

The Contractor is responsible for any damage caused to the Street or adjacent property during the building removal process. Temporary or permanent Easements will be acquired by the Department if required to do the Work.

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

B Removal

Remove buildings and Structures, including steps, basement floors and walls, floor slabs, and footings from the Right-of-way. If the building rests on a concrete surface slab, remove the entire slab and related footings.

C Utilities.. 1507

C.1 Disconnection of Sewer and Water Services

Locate, expose, cut off, and plug sewer and water service connections at the sewer and water mains. Plug sewers leading from the building using watertight plugs at no additional cost to the Department.

Abandon wells in accordance with 2104, “Removing Pavement and Miscellaneous Structures.”

C.2 Other Utilities

The utility owners will disconnect telephone, electric power, other wire services, and gas service pipes outside the buildings. The utility owners will also remove utility-owned fixtures in accordance with 1507, "Utility Property and Service."

D Disposal of Materials and Debris

Dispose of the demolished building in accordance with 2104.3D, "Disposal of Materials and Debris," at a demolition landfill permitted by the Minnesota Pollution Control Agency. Recycle parts of the building as permitted if approved by the Engineer. Do not dispose of buildings at permit-by-rule landfills, transfer stations, or waste storage facilities.

E Filling Basement Excavations

If the building was removed by another contract, ensure that basement floors and walls have been removed. Fill basement excavations and other excavations previously made as required by the Contract. Fill the excavation to the level of the existing ground surface using backfill that matches the existing soil conditions. Provide the fill Material in accordance with 1405, "Use of Materials Found on the Project." Compact the fill in accordance with the Quality Compaction requirements in 2106, "Excavation and Embankment – Compacted Volume Method."

If the building removal is included with the grading in this Contract, remove the foundations in accordance with 2103.3B, "Removal." Fill basement excavations in accordance with 2106.3I, "Finishing Operations."

2103.4 METHOD OF MEASUREMENT

A Building Removal

The Engineer will measure buildings listed for removal as a single lump sum.

B Basement Excavation Fill

The Engineer will measure the volume of fill provided by the Contractor by the volume of the basements below the ground surface as required by the Contract.

C Disconnection of Sewer and Water Services

The Engineer will measure each sewer and water service connection cut off and plugged at the main.

2103.5 BASIS OF PAYMENT

The Contract Unit Price for the Disconnect sewer service and Disconnect water service includes the cost of the restoration of Street and property surfaces.

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

Item No.	Item	Unit
2103.501	Building Removal	lump sum
2103.502	Disconnect Sewer Service	each
2103.502	Disconnect Water Service	each
2103.507	Basement Excavation Fill	cubic yard

2104 REMOVING PAVEMENT AND MISCELLANEOUS STRUCTURES

2104.1 DESCRIPTION

This Work consists of removing and disposing of pavement, sewers, Culverts, guardrails, abandoned Structures, and other obstructions on the Right-of-way, except as specified in 2442, "Removal of Existing Bridges," and 2103, "Building Removal." This Work also consists of salvaging Material and backfilling trenches, holes, and depressions.

2104.2 MATERIALS — BLANK

2104.3 CONSTRUCTION REQUIREMENTS

A General

Remove and dispose of Structures and obstructions as required by the Contract.

B Salvage Operations

Remove, dismantle, and store salvaged Materials to allow reuse.

When salvaging guardrail and fences, coil the wire and cable, pull posts from the ground, and remove nails and staples from posts and boards.

Stockpile Materials designated for salvage by the Department on the Right-of-way at locations approved by the Engineer. Remove, dismantle, and clean Materials as required by the Contract before stockpiling.

C Removal Operations

C.1 Removing Portion of Structure

Do not damage existing Structures to be retained for use during the removal operations. Ensure a length of at least 40 bar diameters from the face of the cut for existing reinforcement bars for concrete Structures left in place.

C.2 Pavements and Sidewalks

Saw the existing concrete pavement or Sidewalks or bituminous pavement at the locations as shown on the Plans and as staked by the Engineer to establish a neat line for extending the new Work.

C.3 Concrete and Masonry Structures

Remove concrete and masonry Structures to the excavation limits as shown on the Plans.

Remove septic tanks, cisterns, and cesspools.

Rebuild and reconnect live sewers after removing related manholes, catch basins, and drop inlets. Provide a by-pass and maintain the service during the removal operations.

Use concrete or masonry plugs to plug pipes draining into abandoned basements, manholes, or similar Structures.

C.4 Timber Structures and Underground Tanks

Remove timber Structures and underground tanks in accordance with applicable laws and regulations.

C.5 Wells and Borings

Refer to MN Administrative Rules, Chapter 4725, “Wells and Borings,” for the definition of “wells” and “borings.” Construct and seal wells and borings to meet the requirements of MN Administrative Rules, Chapter 4725, “Wells and Borings.”

Seal wells and borings taken out of service meeting the requirements of MN Administrative Rules Chapter 4725, “Wells and Borings.” Protect wells and borings until permanently meeting the requirements of MN Administrative Rules Chapter 4725, “Wells and Borings,” during the Work to prevent surface drainage from entering the opening. Cut and remove casing in the well or boring to the elevation as shown on the Plans or as directed by the

Engineer after sealing. Submit one copy of the sealing record to the Minnesota Department of Health and one copy to the Engineer within 30 Calendar Days after sealing a well or boring.

C.6 Miscellaneous Items

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

D Disposal of Materials and Debris

D.1 Disposal Plan

Provide the Engineer with information and documentation substantiating proper disposal arrangements and operations. The Department will not pay for removal before acceptance of the initial disposal Plan or, if required, a modified disposal Plan.

D.2 Disposal Within Right-of-Way

Do not dispose of Material or debris within the Right-of-way. Do not burn or bury treated or untreated wood, including but not limited to dimensional lumber, Brush, trees, and roots, within the Right-of-way.

D.3 Disposal Outside Right-of-way

Dispose of Materials and debris, resulting from removal or demolition operations having no specific disposal provisions, outside the Right-of-way.

Assume full responsibility for acceptable disposition of the Material and for damages resulting from the disposal operations.

The Engineer may not give final acceptance of the Work:

(1) Unless disposal is made at a publicly controlled dumping site, or
(2) Until the disposal areas are in acceptable condition with respect to the Contractor's obligations.

E Backfilling Depressions

Backfill depressions with Material in accordance with 2106, "Excavation and Embankment – Compacted Volume Method."

2104.4 METHOD OF MEASUREMENT

A Area

The Engineer will measure pavements, Sidewalks, surfacing, and other uniform thickness items by area without specifying the thickness.

The Engineer will classify pavement removal by kind of paving Material when the Material is comprised entirely of Portland cement concrete (remove concrete pavement) or entirely of bituminous-Aggregate mixtures (remove bituminous pavement). If the pavement is comprised of a combination of different paving Materials, such as a concrete base or pavement overlaid with bituminous surfacing, the Engineer will measure the removal of the entire Structure as the unclassified item of "remove pavement." Regardless of classification, the Engineer will include the removal of integrant curb removed as a part of pavement removal.

The Engineer will separately measure the removal of pavement as part of the excavation of trenches for installation of drainage Structures or utility items as the Pay Item for remove trench pavement. Remove trench pavement will include the removal of paving courses including unclassified Materials.

B Length

The Engineer will measure the length along the longitudinal centerline of the Structure, parallel to the base or foundation supporting the Structure, and from end to end of the removed Structure. The Engineer will measure pipe from center to center of junction fittings, catch basins, or manholes. The Engineer will include the length of aprons removed as shown on the Plans with the pipe measurements.

The Engineer will measure sawing of concrete and bituminous pavements by length along the saw cut lines as staked by the Engineer, if included as Contract Items.

C Volume

The Engineer will determine the volume of concrete or masonry Structures by taking measurements on the in-place Structure as it is being uncovered and removed, except if otherwise established.

D Number (Complete Unit)

The Engineer will measure Contract Items with a Contract "each" price by counting the number of individual units removed, salvaged, or abandoned, including all appurtenances.

E Lump Sum

The Engineer will measure portions of completed Work.

2104.5 BASIS OF PAYMENT

The Contract Unit Prices for remove, salvage, or abandon includes the cost of the following:

(1) Removing the Material or portions of the Material as specified by the Contract
(2) Disposing of the Materials removed
(3) Salvaging of parts as specified by the Contract
(4) Backfilling depressions and other restoration Work as specified by the Contract
(5) Performing well abandonment procedures
(6) Other Work of a special nature as specified in the Contract or imposed by laws, ordinances, and regulations

The Contract Unit Prices for sawing only includes sawing of concrete and bituminous pavements using a saw. Use of any other method, approved by the Engineer, at the option of the Contractor, will be at no additional cost to the Department. The Department will include the cost of sawing with other relevant Contract Pay Items if the Contract does not include a Contract Pay Item for sawing.

The Contract Unit Price for fence removal includes the cost of removing abandoned fences. The Department will include the cost of removal of abandoned fences with other relevant Contract Pay Items, if the Contract does not include a Contract Pay Item for fence removal.

For salvage items, the Department will only pay for units removed in a condition acceptable for reuse. The Department will include the cost of the necessary removal of damaged or deteriorated units with other relevant removal Contract Pay Items or as Extra Work in accordance with 1402, "Contract Revisions."

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

The Department will pay for the removal of the ends of old box Culverts preparatory to extending the Structure by the cubic yard or by each unit.

The Department will pay for backfilling depressions resulting from the removal of Structures as embankment construction.

The Department will pay for removing pavement and miscellaneous Structures on the basis of the following schedule:

Item No.	Item	Unit
2104.501	Remove*	lump sum
2104.502	Abandon*	each
2104.502	Remove*	each
2104.502	Salvage*	each
2104.503	Remove*	linear foot
2104.503	Salvage*	linear foot
2104.503	Sawing Bituminous Pavement	linear foot
2104.503	Sawing Concrete Pavement	linear foot
2104.504	Remove*	square yard
2104.507	Remove*	cubic yard
2104.518	Remove*	square foot

* Specify item name, such as: Culvert pipe, sewer pipe, drain pipe, curb and gutter, curb, Sidewalk, fence, concrete or masonry Structures, railroad track, manholes or catch basins, integrant curb, concrete pavement, bituminous pavement, pavement, trench pavement, guardrail, water well, etc.

2106 EXCAVATION AND EMBANKMENT – COMPACTED VOLUME METHOD

2106.1 DESCRIPTION

This Work consists of excavating, placing, compacting, testing, finishing, and disposing of embankment Materials.

Materials are classified as either excavation or embankment Materials.

No shrinkage or swell factors have been applied or will be applied to any Excavation or Embankment items.

2106.2 MATERIALS

A Excavation

A.1 Excavation – Common

Material not classified in any other category. Excavation-common includes topsoil excavation.

A.2 Excavation – Subgrade

Material in the Road Core below the Grading Grade exclusive of Excavation – rock, Excavation – muck, Excavation – channel and pond, Excavation – rock channel.

A.3 Excavation – Rock

Material that requires drilling, blasting, or ripping before excavation. This includes boulders and other detached rock larger than 1 cubic yard.

A.4 Excavation – Muck

Organic Soils and other unstable soils, and below the natural ground level of marshes, swamps, or bogs, regardless of the moisture content. Muck excavation is limited to areas over which the Roadway embankment or a Structure is to be constructed.

A.5 Excavation – Channel and Pond

Material from channel changes, waterways, and ponds outside of the Roadway embankment not classified as rock channel excavation.

A.6 Excavation – Rock Channel

Material classified as rock excavation from channel changes and waterways outside of the Roadway embankment.

B Embankment

B.1 Common Embankment

Select Grading Material, mineral soils found in the Triaxial Chart in the *Grading and Base Manual*, excluding Silt. Organic Soils and Marl are also excluded.

Select Grading Material may contain up to 100 percent recycled Materials composed of recycled concrete (maximum of 75 percent), and recycled asphalt.

B.2 Granular Embankment.. 3149.2B

Table 3149.2-1, Granular Material

B.3 Select Granular Embankment 3149.2B

Table 3149.2-1, Select Granular Material

B.4 Select Granular Embankment Super Sand.. 3149.2B

Table 3149.2-1, Select Granular Material (Super Sand)

B.5 Select Granular Embankment Modified 10 percent 3149.2B

Table 3149.2-1, Select Granular Material Modified 10 percent

B.6 Stabilizing Aggregate 3149.2C

B.7 Topsoil

Topsoil is the existing Material within the construction limits that is suitable for plant growth and that originates from the A and/or B horizon soils. Peat and other Organic Soils may be used to supplement the existing topsoil, if approved by the Engineer. Topsoil is included as a portion of the total common embankment outside of the Road Core.

B.8 Non-structural Embankment

Mineral soils, excess topsoil, and Organic Soils capable of supporting construction Equipment. Non-structural embankment is included as a portion of the total common embankment outside of the Road Core.

2106.3 CONSTRUCTION REQUIREMENTS

A General

Before beginning excavation and embankment operations, comply with the requirements of 2101, “Clearing and Grubbing.”

Comply with the erodible surface requirements of 2574, “Soil Preparation.”

Strip, stockpile and reuse in-place topsoil in areas to be disturbed by construction.

For Road Core embankment, below granular or base Layers, use Material meeting the requirements of 2106.2B.1, “Common Embankment.”

Non-structural grading Materials may be used as embankment outside the Road Core.

Perform excavation and embankment operations within the Plan excavation limits as required by the Contract.

Maintain drainage in excavations and embankment operations. Provide and maintain temporary drainage facilities until the permanent facilities are complete and operational.

Do not leave undrainable depressions.

Provide and maintain temporary preparation and erosion control on embankment and stockpiles until finishing operations per 2106.3I, "Finishing Operations," are complete.

Repair or replace settlement plates damaged by Contractor operations or negligence.

Protect Structures during construction operations. Repair Structures damaged by Contractor operations.

Excavated Material from within the Project limits shown on the Plans that meet Project requirements and complies with 1405, "Use of Materials Found on the Project," may be used for embankment Material.

Place stabilizing Aggregate in accordance with 2211, "Aggregate Base."

Forms and the *Grading and Base Manual* are available on the Department Grading and Base Website.

B Contractor Quality Control (QC) Testing and Aggregate Certification

Test according to the *Schedule of Materials Control*.

Certify Materials on Form G&B-104.

Material placed without certifications is unauthorized Work in accordance with 1512, "Unacceptable and Unauthorized Work."

C Moisture Control

Meet the moisture content requirements during compaction listed in Table 2106.3-1.

Table 2106.3-1
Moisture Content Requirements

For Compaction Requirements	Relative Moisture Content Requirements*
Minimum of 100 percent of Maximum Density	65 – 102 percent
Minimum of 95 percent of Maximum Density	65 – 115 percent
Quality compaction	65 – 102 percent
* As determined on Form G&B-105	

Correct moisture content in areas where moisture content test fails. Compaction tests taken in areas represented by failing moisture tests are not valid.

D Preparation of Embankment Foundation

When slopes are steeper than 1:4 (Vertical:Horizontal), construct steps before placing embankment Material. Construct the steps with a minimum width of 12 inches and a maximum height of 24 inches.

Compact the bottom of the excavation according to Table 2106.3-2.

Table 2106.3-2
Required Compaction for Bottom of Excavation

Excavation Depth Below Grading Grade *	Material Type	Required Compaction
< 30 inches	non-granular	100 percent of Maximum Density, LWD, and Quality Compaction
≥ 30 inches	non-granular	95 percent of Maximum Density or four passes of a roller ‖
Any depth	granular	100 percent of Maximum Density, LWD, penetration index, and Quality Compaction
For Structures any depth	non-granular	100 percent of Maximum Density, LWD, and Quality Compaction
For Structures any depth	granular	100 percent of Maximum Density, LWD, penetration index, and Quality Compaction

* Excavation below the planned Subgrade may be subject to 1402, “Contract Revisions”

‖ Use a pad foot roller weighing at least 25,000 pounds. The Engineer may waive the four pass requirement if the Subgrade will not support the roller or direct the Contractor to repair the Subgrade. Repairs are subject to 1402.5, “Extra Work.”

Remove surfacing and excavate an existing Road Core in accordance with the Contract. Then perform Subgrade preparation on the excavated portion and the new Road Core in accordance with 2112, “Subgrade Preparation,” before placing new embankment Material.

E Excavating Operations

Obtain the Engineer’s written approval before excavating beyond the limits and elevations established by the Contract.

Remove topsoil and stockpile separately.

Remove rock outcroppings from within the excavation limits as shown on the Plans.

Remove loosened rock from the backslopes.

Presplit rock back slopes steeper than 1:1 (Vertical:Horizontal). Control blasting operations to eliminate flying rock or debris.

Excavation below the planned Subgrade to correct unstable conditions may be subject to 1402, “Contract Revisions.”

F Placing Embankment Materials

Remove snow, ice, and frozen soils from Road Core before placing embankment.

Install settlement plates, if required by the Contract. Do not disturb settlement plates.

Place embankments in uniform Lifts, parallel to the Plan Profile Grade, over the full width of the Roadway.

Construct each Lift of Material using uniform soil.

Protect Structures during placement of embankments.

Place granular Materials in the uppermost portion of the Subgrade.

Embankment Materials may not increase the moisture content of the underlying Material beyond the specified limit.

Maximum Lift thicknesses are controlled by the capability of the Equipment to uniformly compact the entire Lift in accordance with the following:

(1) For areas, except Structural backfill, the Engineer will restrict Lift thickness to no greater than 12 inches (loose thickness), when uniform results are not achieved.
(2) For Structural backfill, the maximum Lift thickness is 6 inches compacted (8 inches loose).
(3) The Engineer may allow thicker Lifts over saturated foundation soils. The top of the thicker Lift must be at least 4 feet below the Grading Grade.

Uniformly blend the entire thickness of each Lift before testing moisture content and compaction.

Disc soils with greater than 20 percent passing the No. 200 Sieve.

Stagger construction traffic uniformly over the full width of the Roadway embankment.

Use embankment Material with particle sizes no larger than specified in Table 2106.3-3:

Table 2106.3-3
Maximum Particle Size in Road Core

Location	Maximum Particle Size (Inches)
< 12 inches from Grading Grade	3
1 foot – 3 feet from Grading Grade	6
> 3 feet – 6 feet from Grading Grade	12
> 6 feet from Grading Grade	24
≤ 2 feet from a non-plastic Structure	3
≤ 2 feet from a plastic Structure	1
Areas where piling is to be placed	6

Remove surcharges as directed by the Contract.

Remove debris and stones exceeding 3 inches in its greatest dimension on the soil surface at the time of performing the final finishing and turf establishment operations. Dispose of debris and stones in accordance with 2104.3C, “Removal Operations.” Removal of pre-existing debris and stone encountered in the undisturbed topsoil on the Project will be paid for as Extra Work in accordance with 1402, “Contact Revisions,” as long as the Material was not contaminated or altered by the Contractor.

G Compacting Embankments and Backfills

Compaction tests taken in areas represented by failing moisture tests are not valid.

Uniformly compact each Lift according to Table 2106.3-4.

Table 2106.3-4
Required Compaction

Material Type	Location	Required Compaction *
Materials meeting the requirements of 3149.2B, “Granular and Select Granular Materials”	All depths and locations	100 percent specified density, Quality Compaction, penetration index, and LWD
Materials not meeting the requirements of 3149.2B, “Granular and Select Granular Materials”	> 3 feet below Grading Grade of Road Core, trails, or Sidewalks	95 percent specified density, and LWD when the Engineer performs a correlation test between 95 percent specified density, and an LWD.
Materials not meeting the requirements of 3149.2B, “Granular and Select Granular Materials”	≤ 3 feet below Grading Grade of Road Core, trails, or Sidewalks	100 percent specified density, Quality Compaction, and LWD
All Materials	All depths within an excavation trench and backfill of Structures, 2451, “Structure Excavations and Backfills”	100 percent specified density, Quality Compaction, and LWD
*See 2106.3G.1, “Specified Density,” 2106.3G.2, “Quality Compaction,” 2106.3G.3, “Penetration Index,“ and 2106.3G.4, Light Weight Deflectometer (LWD) Method” for compaction requirements.		

Compact Roadway embankment outside of the Road Core to the Quality Compaction requirements per 2106.3G.2, “Quality Compaction.”

Compact the entire length and width of each Lift with a roller. Construction traffic does not replace the rolling requirement.

Compaction requirements on swamp backfills start when the Road Core embankment is 4 feet above the water elevation at the time of construction operations.

The Engineer may waive mechanical compaction requirements on embankment containing predominately rock.

Compact soils around Structures with appropriate Equipment or hand methods to prevent damage to adjacent Structures.

Correct or replace Materials in areas represented by a failing test.

Maintain the required compaction until the next Layer is placed.

G.1 Specified Density

Compact to meet the requirements of Table 2106.3-4.

G.2 Quality Compaction

Compact each Lift until there is no evidence of consolidation during compaction or under traffic, with no:

(1) Pumping – vertical displacement of the top surface of the compacted Layer, not directly under the vehicle tire
(2) Reaction – a movement back to a former or less advanced condition
(3) Yielding – giving under pressure (flexible)

(4) Cracking – cracking of Material on visible surface
(5) Lateral movement – sideways movement of the top surface

G.3 Penetration Index (PI)

Compact the entire Lift to achieve a dynamic cone penetration index (DPI) value per Table 2106.3-5.

Table 2106.3-5
Maximum Allowable Penetration for DCP

Grading Number *	Moisture Content ‖	Maximum Allowable DPI, millimeter/blow
3.1 – 3.5	< 5.0	10
	5.0 – 8.0	12
	> 8.0	16
3.6 – 4.0	< 5.0	10
	5.0 – 8.0	15
	> 8.0	19
4.1 – 4.5	< 5.0	13
	5.0 – 8.0	17
	> 8.0	21
4.6 – 5.0	< 5.0	15
	5.0 – 8.0	19
	> 8.0	23
5.1 – 5.5	< 5.0	17
	5.0 – 8.0	21
	> 8.0	25
5.6 – 6.0	< 5.0	19
	5.0 – 8.0	24
	> 8.0	28

* As determined by Department Form G&B-203

‖ Percent of dry weight

Note that a moisture test is not required if the Material meets the toughest requirements for the grading number.

G.4 Light Weight Deflectometer (LWD) Method

Compact the entire Lift to achieve an LWD target value as required per the LWD procedure in the *Grading and Base Manual*.

H Department Quality Assurance Testing (QA)

Test according to the *Schedule of Materials Control*.

H.1 Material Testing

Select Aggregate quality samples using the random sampling method in the *Grading and Base Manual*; additional samples and tests may be taken to delineate visually indicated Material failures. Select gradation samples from locations that are at risk of not meeting the Specification requirements.

H.2 Compaction Testing

Test for compaction using:

(1) Quality Compaction, and specified density or the LWD for Materials not meeting the requirements of Table 3149.2-1, Granular Material, or

(2) Quality Compaction, and specified density or penetration index or LWD for Materials meeting the requirements of Table 3149.2-1, Granular Material

Test for compaction in areas with the greatest rutting or deflection, near Structures, and in an area at least 1 foot from an unconfined edge.

After Contractor's correction of areas represented by failing tests, retest in areas with the greatest rutting or deflection.

For granular Materials with less than 6 percent passing the No. 200 Sieve, the Engineer may elect to only use the Quality Compaction method, 2106.3G.2, "Quality Compaction."

Use the specified density method for virgin Materials only.

The following method may be used in lieu of point testing (penetration index, specified density, or LWD) for Materials meeting Table 3149.2-1, Select Granular Material when the Material thickness is 18 inches or less and when not adjacent to Structures per 1103, "Definitions."

The Engineer may elect, with the concurrence of the Contractor, to have the Contractor test roll per 2111, "Test Rolling," Material meeting the requirements of Table 3149.2-1, Select Granular Material, in lieu of point compaction testing. If this method is adapted, the Contractor would be required to first place 3 inches of base on top of the Material meeting Table 3149.2-1, Select Granular Material before Test rolling. For areas failing Test rolling the Contractor is required to remove the base and recompact the Material meeting Table 3149.2-1, Select Granular Material, then place the base back, and retest roll. There is no additional compensation to the Contractor, if this method is adapted. Additionally, the Material meeting Table 3149.2-1, Select Granular Material, is not accepted, until acceptable Test rolling has occurred.

I Finishing Operations

Shape and maintain the Road Core to the required grade and cross-section and within the tolerance in accordance with 2112.3E, "Tolerances" until the next Layer is placed.

Perform earthwork finishing and topsoil placement operations concurrently to allow for timely placement of erosion control items. Shape and maintain disturbed areas outside the Road Core to final grade before placing erosion control items. Scarify the surface to a minimum depth of 3 inches before placing topsoil. Complete topsoil preparation, erosion control, and turf establishment, as required by 2574, "Soil Preparation" and 2575, "Establishing Vegetation and Controlling Erosion."

J Disposition of Excavated Material

Excavation and embankment Material not utilized on the Project becomes the property of the Contractor, except obtain written authorization from the Engineer before removing topsoil or granular Material from the Project.

Dispose of these Materials in accordance with a disposal Plan approved by the Engineer. The disposal Plan must comply with applicable environmental regulations, permit requirements, and 2104, "Removing Pavement and Miscellaneous Structures." Disposal of Materials before acceptance of the disposal Plan is unauthorized Work in accordance with 1512, "Unacceptable and Unauthorized Work."

2106.4 METHOD OF MEASUREMENT

A Excavation Material

The Engineer will measure and calculate excavated Material quantities according to 1901.5A "Excavated Volume (EV) – Cubic Yard."

Quantities are limited to measurements within specified construction limits and variances authorized by the Engineer.

The Engineer will take measurements to determine the limits of excavation Material.

A.1 Rock Excavation

The Engineer will include the following in the measurement for rock excavation:

(1) Overbreakage if the plane of the bottom of the excavation falls within a Layer or stratum of rock
(2) 6 inches overbreak allowance outside the grading section or as indicated in the Plans
(3) 24 inches measured horizontally, overbreak allowance outside the backslopes for hard rock types

The Engineer will not provide an allowance for overbreak of pre-split backslopes.

B Embankment Material

The Engineer will measure embankment Material quantities by volume in accordance with 1901.5B, “Compacted Volume (CV) – Cubic Yard.”

C Stabilizing Aggregate

The Engineer will measure Stabilizing Aggregate quantities by volume in accordance with 1901.5B, “Compacted Volume (CV) – Cubic Yard” or by the ton, in accordance with 1901.8, “Mass.”

2106.5 BASIS OF PAYMENT

The Contract Unit Price for accepted quantities of Excavation and Embankment – compacted volume method items includes: the costs of production, testing, disposal, delivery, placement, drying, water and watering, compaction, and finishing.

The Department will pay for stripping and stockpiling topsoil as excavation – common.

The Department will pay for placing topsoil as common embankment.

The cost for Subgrade preparation under 2106.3D, “Preparation of Embankment Foundation,” is included in the excavation 2106, “Excavation and Embankment – Compacted Volume Method,” bid items.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Excavation and Embankment – Compacted Volume Method. The amounts of these adjustments are deemed reasonable.

The Department will pay an additional $2.00 per cubic yard when the Engineer reclassifies Excavation - common to Excavation - channel and pond.

The Department will pay an additional $200.00 per cubic yard when the Engineer reclassifies Excavation - common, Excavation - Subgrade, or Excavation - channel and pond to Excavation - rock. The Department can only apply this price adjustment if the Contract does not contain Rock excavation and cannot exceed 250 cubic yard.

The Department will pay an additional $200.00 per cubic yard when the Engineer reclassifies Excavation - channel and pond to Excavation - rock channel. The Department can only apply this price adjustment, if the Contract does not contain Rock channel excavation and cannot exceed 25 cubic yard.

The Department will pay for Excavation - muck deeper than the depth shown on the Plans, in accordance with Table 2106.5-1.

Table 2106.5-1
Monetary Deductions for Excavation - Muck

Depth Below Natural Surface	Compensation
0 feet – 15 feet	muck excavation Unit Price
> 15 feet – 20 feet	muck excavation Unit Price plus $0.60 per cubic yard
> 20 feet – 25 feet	muck excavation Unit Price plus $1.00 per cubic yard
> 25 feet	negotiated price
Note: These price adjustments are payment in full for all additional costs incurred. Exception: Compensation for additional muck excavation may be subject to the provisions of 1402, “Contract Revisions.”	

B Schedule

The Department will pay for Excavation and Embankment – compacted volume method on the basis of the following schedule:

Item No.	Item	Unit
2106.507	Excavation – Common	cubic yard
2106.507	Excavation – Rock	cubic yard
2106.507	Excavation – Muck	cubic yard
2106.507	Excavation – Subgrade	cubic yard
2106.507	Excavation – Channel and Pond	cubic yard
2106.507	Excavation – Rock Channel	cubic yard
2106.507	Granular Embankment (CV)	cubic yard
2106.507	Select Granular Embankment * (CV)	cubic yard
2106.507	Select Granular Embankment Super Sand (CV)	cubic yard
2106.507	Common Embankment (CV)	cubic yard
2106.507	Stabilizing Aggregate (CV)	cubic yard
2106.509	Stabilizing Aggregate	Ton

Notes:
* Specify basis of percent modification (e.g. 5 percent, 7 percent, 10 percent, etc.)

2108 GEOSYNTHETIC CONSTRUCTION MATERIALS

2108.1 DESCRIPTION

This Work consists of providing and placing geosynthetics used for one or more of the following:

(1) Separation of dissimilar or softer soils to prevent mixing, pumping, and contamination.
(2) Provide stability during compaction.
(3) Provide reinforcement and minimize differential movement.
(4) Promote and enhance filtration and drainage in embankment.
(5) Provide confinement of granular or topsoil to construct walls, slopes, stabilize Aggregate base course, or promote turf establishment.

2108.2 MATERIALS

Provide the type(s) of geosynthetics as shown or allowed in the Plans.

A Geotextiles **3733**

B Geogrids **3733**

2108.3 CONSTRUCTION REQUIREMENTS

A General

Submit the proposed construction sequence for geosynthetics and fill placement to the Engineer for review at least 21 Calendar Days prior to beginning of this element of construction. Place geotextiles, as required in the Plan or as directed by the Engineer.

Prepare a smooth surface, free of ruts, stones, sticks, or other debris or irregularities that may puncture or tear the geosynthetic or prevent intimate contact with the subsurface soil. Place the geosynthetic oriented as shown in the Plan.

Secure geosynthetics so that they will not be displaced during subsequent construction. No loose or wrinkled geosynthetics are permitted. Permit no traffic or construction Equipment to operate directly on the geosynthetics. Repair any damage to the satisfaction of the Engineer by patching and/or sewing. Replace any geosynthetic that is exposed to the sun for more than seven Calendar Days. Place fill onto the geosynthetics in uniform Lifts as required by the applicable Specifications, but in no case exceed 12 inches. Use fill Material as shown in the Plan.

B Geotextile

If multiple pieces of geotextile are required, sew adjacent strips. Use a "double spool" machine capable of sewing a Federal Type 401 locking stitch (*ASTM D6193-16, Standard Practice for Stitches and Seams*) or approved better stitch. Sew a flat, "J," or butterfly seam type (*ASTM D6193-16*), using thread with a minimum strength of 25 pounds, with 1-2 rows of stitching and 5-7 stitches per inch. Meet the required seam strength for the specified geotextile type.

Approved adhesives listed on the *Approved/Qualified Products List* may be used in lieu of sewing for Types 3, 4, 5, 6, 9 and 10 geotextiles. The approved list for adhesives is found under the geosynthetics sub-heading on the *Approved/Qualified Products List*. Install per the Adhesive Seams Guidelines found on the geosynthetic/adhesive seams links on the *Approved/Qualified Products List*.

C Geogrid

Overlap all geogrids a minimum of one foot or the minimum required in the Contract. Do not use fasteners, such as hog rings or zip ties, unless required in the Contract. Seams are not allowed in the high strength direction.

Place Type 1 Geogrid used for Aggregate base reinforcement parallel to the centerline of the Roadway unless specified otherwise.

2108.4 METHOD FOR MEASUREMENT

The Engineer will measure geosynthetics by area based on the actual surface dimensions installed, with no allowance for overlaps or seams.

2108.5 BASIS OF PAYMENT

The Contract Unit Price for geosynthetics includes the cost of providing, placing, seaming or gluing, testing, anchoring, and any needed repairs.

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

Item No.	Item	Unit
2108.504	Geotextile Fabric Type *	square yard
2108.504	Geogrid Type ‖	square yard
Notes:		
* Specify Type: 3, 4, 5, 6, 7, 9 or 10.		
‖ Specify Type: 1 or 2		

2111 TEST ROLLING

2111.1 DESCRIPTION

This Work consists of providing and operating Equipment to test roll Roadway embankments.

2111.2 MATERIALS — BLANK

2111.3 CONSTRUCTION REQUIREMENTS

A Equipment

Provide test roller(s) meeting the following requirements:

A.1 Test Roller – 30 (TR30)

A.1.a Pneumatic Tires

Two pneumatic tires spaced at least 6 feet apart, center to center.

Tire sizes of 18 inches by 24 inches or 18 inches by 25 inches.

Inflate tires to 95 pounds per square inch ±2 pounds per square inch.

A.1.b Load

Provide a mass load on each tire from 14.9 ton to 15.1 ton.

A.2 Test Roller – 10 (TR10)

A.2.a Pneumatic Tires

Tire width maximum of 17 inches for the front axle tires, and a maximum of 11 inches for the rear axle tires.

Inflate tires to within 2 psi of tire or vehicle manufacturer's maximum psi rating; the minimum psi rating is 80 psi.

A.2.b Load

Provide a tandem truck with a minimum legal capacity of 52,000 pounds, and a minimum front axle capacity of 18,000 pounds. Load the truck such that the front axle is loaded to a minimum of 16,000 pounds, and the total weight of the truck and load is a minimum of 50,000 pounds.

A.3 Deflection Measurement

Provide a deflection recording device mounted over the center of the front axle and offset 12 inches from the outside edge of each tire. The deflection will be measured from the top of the unrolled embankment to the bottom of the rut at the time of rolling.

The Engineer may allow alternate deflection recording devices.

B Testing

Weigh the test roller at an independent certified Scale facility. Provide documentation to the Engineer.

Protect Structures from damage that may be caused by the test roller.

Repair Structures damaged by Contractor operations or negligence.

Do not cross over a Bridge using TR30 test roller loaded to greater than 18,000 pounds (gross weight).

Provide a blister of fill of at least 4 feet in depth when Test rolling with a loaded TR30 test roller over other Structures.

Follow the Test rolling procedures in the *Grading and Base Manual*.

Use TR10 when test roller is not designated in the Contract.

Construct the embankment surface to within 4 inches of the design cross-section and profile in accordance with 2112, “Subgrade Preparation.”

Perform Test rolling before tolerancing for base or non-stabilized full depth reclamation surface.

Compact surface with a smooth-drum compactor immediately before Test rolling.

Ensure the surface is free of marks, tracks, rutting, or ridged Material to prevent collection of false readings.

Keep roller parallel to grade when testing.

After Test rolling, repair and maintain the surface per 2112, “Subgrade Preparation” before placement of the next Layer.

Test roll the entire length and width at the top of Layers designated in the Contract, from Shoulder point of intersection to Shoulder point of intersection or width of the subcut. Roll the first pass at the PI, roll subsequent passes with one wheel centered between the wheel paths of the previous pass, until the entire surface is covered at approximately a four foot interval between the center of each pass.

Make two passes for non-granular Materials, and one pass over granular Materials. Granular Materials meet the requirements of Table 3149.2-1.

Test roll at a speed from 2.5 miles per hour to 5 miles per hour.

Engineer will observe testing from behind the roller, mark, and record failing areas.

Engineer may require a Layer be retested if the next Layer is not placed within the same construction season.

Correct areas that fail Test rolling.

C Acceptance

Meet the criteria listed in Table 2111.3-1 for TR30.

Table 2111.3-1
Acceptance Criteria – Maximum Deflection
Granular & Non-Granular Materials
(2106, "Excavation and Embankment – Compacted Volume Method")

Material Type	Maximum Deflection
Granular Materials not covered by Stabilizing Aggregate	3 inches
All other Materials, including Granular Materials covered by Stabilizing Aggregate	2 inches

Meet the criteria listed in Table 2111.3-2 for TR10, and the criteria for 2106.3G.2, "Quality Compaction."

Table 2111.3-2
Acceptance Criteria – Maximum Deflection

Material Type	Maximum Deflection
Granular and Non-granular Materials	0.6 inches
Non-stabilized full-depth reclamation and Aggregate Base	0.4 inches

D Testing Corrected Areas

Retest corrected areas.

Engineer may waive retesting on corrected areas that are less than two Road stations in length.

2111.4 METHOD OF MEASUREMENT

Engineer will measure Test rolling by length for the entire width.

Engineer will separately measure Test rolling on each Roadbed for Divided Highways.

Combine Test rolling into one quantity, regardless of width or test roller used.

2111.5 BASIS OF PAYMENT

The Department will pay for repairs to failing sections constructed under a previous Contract in accordance with 1402, "Contract Revisions."

The Department will pay for Test rolling embankment constructed under a previous Contract.

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

Item No.	Item	Unit
2111.519	Test Rolling	Road station

2112 SUBGRADE PREPARATION

2112.1 DESCRIPTION

This Work consists of shaping, mixing, and compacting the Subgrade, as defined in 1103, "Definitions," Subgrade. The work is not intended to repair embankment below the 6-inch Subgrade Preparation Layer.

2112.2 MATERIALS — BLANK

2112.3 CONSTRUCTION REQUIREMENTS

A General

Repair Structures damaged by Contractor operations or negligence.

Scarify, mix, dry or add moisture (if necessary), and compact the top 6 inches of the Subgrade. Correct areas represented by failing tests.

Comply with the drainage requirements of 2106.3A, "General" and any other additional drainage or dewatering requirements of the Contract.

Remediation below the planned 6-inch Subgrade Preparation Layer to correct unstable conditions may be subject to 1402, "Contract Revisions."

As determined by the Engineer, the Contractor's requirements to meet moisture and compaction Specifications for Subgrade Preparation are waived, if during subgrade compaction excess moisture is drawn up into the subgrade preparation Layer from below. Failure of the Contractor to comply with drainage and/or dewatering requirements which impact subgrade moisture will not relieve them of the moisture or compaction requirements.

B Contractor QC Testing

Test according to the *Schedule of Materials Control*.

C Compaction Compliance

Meet the requirements of Table 2106.3-1 and Table 2106.3-4.

Achieve and maintain the compaction requirements, until placement of the next Lift.

D Department Quality Assurance (QA) Testing

Test according to the *Schedule of Materials Control*.

Test for compaction in areas with the greatest rutting or deflection.

Retest failing areas after correction.

E Tolerances

Finish the surface of each Layer within 0.05 feet above to 0.10 feet below the cross-section shown on the Plans before placing the next Layer.

2112.4 METHOD OF MEASUREMENT

Engineer will measure Subgrade preparation by length, along the centerline of the embankment.

Engineer will separately measure Work on each embankment on Divided Highways.

2112.5 BASIS OF PAYMENT

The Contract Road station price for Subgrade preparation includes costs of testing and Subgrade preparation on embankment constructed as required by this Contract.

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

Item No.	Item	Unit
2112.519	Subgrade Preparation	Road station

2118 AGGREGATE SURFACING

2118.1 DESCRIPTION

This Work consists of placing Aggregate surfacing on Roadways and Shoulders.

2118.2 MATERIALS

A Aggregate **3138**

Provide the class of Aggregate as required by the Contract with the following exceptions:

(1) Class 1 with a minimum recycled bituminous percentage of 25 percent may be substituted for class 2
(2) Bituminous millings meeting a gradation of 100 percent passing the 1.5 inch Sieve and 95-100 percent passing the 1 inch Sieve may be used for the 1-2 foot fillet/rollover outside of a paved Shoulder

2118.3 CONSTRUCTION REQUIREMENTS

Forms and the *Grading and Base Manual* are available on the Grading and Base Website.

Unless otherwise designated, test procedures are in the *Grading and Base Manual*.

Repair Structures damaged by Contractor operations or negligence.

Construct Aggregate surfacing in accordance with 2211, “Aggregate Base.” Meet the Quality Compaction method specified in 2106.3G.2, “Quality Compaction.” Maintain the moisture content at or above 5 percent by dry weight during compaction.

A Contractor Quality Control (QC) Testing

Test according to the *Schedule of Materials Control*.

Certify Materials on Form G&B-104.

Material placed without certifications is unauthorized Work in accordance with 1512, “Unacceptable and Unauthorized Work.”

B Department Quality Assurance (QA) Testing

Test according to the *Schedule of Materials Control*.

2118.4 METHOD OF MEASUREMENT

The Engineer will measure the Aggregate surfacing in accordance with 1901, “Measurement of Quantities.”

The Engineer will not make deductions for the mass or volume of water and admixtures.

Mass and volume conversion tables are in the *Grading and Base Manual*.

2118.5 BASIS OF PAYMENT

The Contract Unit Price for the accepted quantities of Aggregate surfacing includes the costs of production, testing, placement, watering or drying, and compaction.

Aggregate surfacing placed before the Engineer accepts the Contractor’s certification is unauthorized Work in accordance with 1512, “Unacceptable and Unauthorized Work.”

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

Item No.	Item	Unit
2118.507	Aggregate Surfacing (LV), Class ___	cubic yard
2118.507	Aggregate Surfacing (CV), Class ___	cubic yard
2118.509	Aggregate Surfacing, Class ____	ton

2123 EQUIPMENT RENTAL

2123.1 DESCRIPTION

This Work consists of providing laborers and operating Equipment for Work required by the Contract, directed by the Engineer, and paid by the Department.

2123.2 MATERIALS — BLANK

2123.3 CONSTRUCTION REQUIREMENTS

Provide Equipment as approved by the Engineer.

Provide Equipment with rubber tires or smooth street plates when operating on bituminous or concrete surfaces.

Provide towing Equipment with sufficient power to tow Equipment required by the Contract and not damage the Work.

Provide rental Equipment in accordance with the following specific requirements regarding type, size, capacity, power, and dimensions.

(1) Motor Grader: Provide a self-propelled Motor grader with the following characteristics:

- (a) Pneumatic-tired wheels
- (b) Power-assisted controls
- (c) A mass of at least 19,000 pounds
- (d) Moldboard at least 12 feet long with a suitable cutting edge
- (e) A suitable scarifier

(2) Dozer: Provide a crawler-type Dozer with at least 75 horse power at the tow bar and power assisted controls, equipped with an angle or fixed Dozer blade at least 90 inches wide. When providing an angle blade, ensure that the blade will adjust to an angle of 90 degrees with the direction of travel of the tractor.

The Department will consider the dozer blade and tractor as a single unit.

(3) Scraper: Provide Scrapers which have a volumetric capacity as required by the Contract that shall correspond with the manufacturer’s rated heaped capacity.

(4) Dragline: Provide a full-revolving type Dragline equipped with a bucket of at least the size required by the Contract.

- (a) Provide 1 cubic yard Draglines with at least a 45 foot boom and a working radius of at least 35 feet
- (b) Provide 2 1/2 cubic yard Draglines with at least an 80 foot boom and a working radius of at least 60 feet
- (c) Provide Draglines in other sizes with the boom length and working radius as required by the Contract

(5) Power Shovel: Provide a full-revolving, crawler-type Power shovel with a bucket in the size recommended by the manufacturer. Provide the shovel in the size required by the Contract in accordance with the bucket capacity.

(6) Tractor: Provide a crawler type Tractor with the power at the draw-bar as required by the Contract. Measure the power in horsepower.

(7) Pneumatic-Tired Roller: Provide Pneumatic-tired rollers meeting the following characteristics:

(a) Compacting width of at least 5 feet
(b) Constructed to allow the gross mass to vary, as directed by the Engineer, from 100 pounds per inch to 250 pounds per inch of rolling width
(c) Tires arranged to obtain compaction over the full compacting width with each pass of the roller
(d) Self-propelled or provided with suitable tractive Equipment, unless otherwise required by the Contract
(e) If a single tractive unit propels more than one roller, the Engineer will count the combination as a single roller unit

(8) Tamping Roller: Provide a Tamping roller meeting the following characteristics:

(a) Consists of two sections, each with a drum at least 48 inches in diameter
(b) A gross mass and number of pads as approved by the Engineer

(9) Steel-Wheeled Roller: Provide a self-propelled Steel-wheeled roller meeting the following characteristics:

(a) A total mass of at least 8 tons unless otherwise required by the Contract
(b) Capable of reversing without backlash
(c) Equipped with spray attachments for moistening rolls on both the front and back
(d) Either tandem type or three-wheeled type, unless otherwise required by the Contract
(e) If using vibratory rollers, use rollers that produce 250 pounds per inch of width

(10) Truck: Provide a Truck meeting the following characteristics:

(a) A manufacturer's rated capacity of at least 1.5 ton
(b) A volumetric capacity of at least 5 cubic yards
(c) A power-operated hoist
(d) An end dump type metal dump box
(e) A rear axle equipped with dual wheels and tires at least 8 inches wide in accordance with the manufacturer's designated size

(11) Rotary Tiller: Provide a Rotary tiller at least 54 inches wide and adjustable to depths up to 9 inches.
(12) Front End Loader: Provide a crawler type or rubber-tired Front end loader meeting the following characteristics:

(a) Equipped with a power-operated loader bucket with the minimum struck capacity required by the Contract
(b) Capable of excavating at least 10 inches deep below the bottom of the treads or tires
(c) Capable of loading the excavated Material on the trucks used for hauling

(13) Disc Harrow: Provide a Disc harrow of sufficient size and mass to manipulate the soils to 12 inches deep as approved by the Engineer.

2123.4 METHOD OF MEASUREMENT

A Equipment Hours

The Engineer will measure rental of each unit of Equipment by the number of hours of actual working time and necessary traveling time within the Project.

B Common Laborer Hire

The Engineer will measure Common laborer hire by the hours of actual working time and necessary traveling time within the Project.

2123.5 BASIS OF PAYMENT

The Contract price per hour for Equipment rental includes the cost of the use and operation of Equipment, the operators and any tractive Equipment and required accessories. The Contract price per hour is subject to the requirements of this section for additional compensation if the Contractor is obligated to pay overtime wages for Work performed on Sundays, Holidays, or during overtime periods.

The Contract price per hour for common laborers includes the cost of hand tools used by laborers. The Contract price per hour is subject to the requirements of this section for additional compensation if the Contractor is obligated to pay overtime wages for Work on Sundays, Holidays, or during overtime periods.

The Department will only compensate the Contractor in addition to the Contract price per hour for Equipment rental or Common laborer hire for Work performed during overtime periods or on Sundays or Holidays if the Work is directed by the Engineer. If the Engineer directs the use of Equipment or Common laborers during overtime periods or on Sundays or Holidays, the Department will pay the Contractor only the increased wages that the Contractor is obligated to pay under the terms of wage agreements. The Department will pay the increased wages to the Contractor by increasing the Contract price per hour for the Equipment or Common laborers used by an amount equal to the difference between the normal hourly wage for straight time Work and the overtime hourly wage actually paid the laborers for operating the Equipment or performing the labor, based on the Contractor’s payroll.

The Contract price per hour for Equipment rental includes the cost of supervision by the Contractor necessary to accomplish the Work, as directed by the Engineer.

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

Item No.	Item	Unit
2123.510	Common Laborers	hour
2123.510	Motor Grader	hour
2123.510	___ Cu Yd Dragline	hour
2123.510	___ Cu Yd Shovel	hour
2123.510	___ Cu Yd Scraper	hour
2123.510	Dozer	hour
2123.510	___ Cu Yd Truck	hour
2123.510	___ HP Tractor	hour
2123.510	Rotary Tiller	hour
2123.510	Disc Harrow	hour
2123.510	___ Cu Yd Front End Loader	hour
2123.510	Pneumatic-Tired Roller	hour
2123.510	Pneumatic-Tired Roller (Tractor Drawn)	hour
2123.510	Pneumatic-Tired Roller (Self Propelled)	hour
2123.510	Tamping Roller	hour
2123.510	___ ton Steel-Wheeled Roller	hour

2130 APPLICATION OF WATER FOR DUST CONTROL

2130.1 DESCRIPTION

This Work consists of providing and applying Water to control dust created by the traveling public within the Project as directed by the Engineer.

2130.2 MATERIALS

Provide reasonably clean Water.

2130.3 CONSTRUCTION REQUIREMENTS

Use a Water supply and Equipment capable of applying the quantity of Water required to abate dust and avoid unwarranted loss of Water through evaporation, absorption, or drainage. Apply the Water at the time and in the quantity approved by the Engineer.

2130.4 METHOD OF MEASUREMENT

The Engineer will measure Water for payment by volume. The Engineer may deduct payment for Water wasted if the Contractor fails to coordinate the Water application with other operations as directed by the Engineer.

2130.5 BASIS OF PAYMENT

The Contract Unit Price for Water includes the cost of providing, transporting, and applying the Water as directed by the Engineer. The Department will only pay for Water applied for dust control for the Project as approved by the Engineer.

The Department considers the cost of Water used for the following as included in the Contract Unit Prices for the relevant Contract Pay Items:

(1) Water used for sprinkling
(2) Water used in the construction of concrete pavements
(3) Water used in the production or curing of concrete
(4) Water used to maintain plant life
(5) Water used in compacting soil and Aggregate
(6) Water used for dust control on Contractor-selected haul Roads, Detours, or Work sites outside of the Project
(7) Water applied for dust control or pavement cleaning caused by the Contractor's Equipment and operations, including abatement of nuisance dust for adjacent landowners and dust conditions detrimental to the safety of the traveling public, as directed by the Engineer

The Department will pay for Water applied to Aggregate surfaces for dust control caused by the traveling public on portions of the Project open to traffic as directed or approved by the Engineer at a Unit Price of $20 per 1,000 gallons (M gallon) in the absence of the Contract Pay Item 2130.523.

The Department will pay for application of Water for dust control on the basis of the following schedule:

Item No.	Item	Unit
2130.523	Water	M gallon

2131 APPLICATION OF CALCIUM CHLORIDE

2131.1 DESCRIPTION

This Work consists of applying Calcium chloride as a surface treatment or as an admixture while grading or placing Aggregate base or surface courses.

2131.2 MATERIALS

A Calcium Chloride 3911

B Water

Provide water meeting the water quality rules established by the State of Minnesota.

2131.3 CONSTRUCTION REQUIREMENTS

Forms and the *Grading and Base Manual* are available on the Grading and Base Website.

Unless otherwise designated test procedures are in the *Grading and Base Manual*.

Repair Structures damaged by Contractor operations or negligence.

A Surface Application

Apply a uniform Layer of dry or liquid calcium chloride following the rates listed in the *Grading and Base Manual*.

B Admixture Application

Use one of the following calcium chloride application methods:

(1) Mix the calcium chloride with the Aggregate during Aggregate production; use a separate conveyor or metering device to add calcium chloride to the Aggregate
(2) Apply dry calcium chloride as a surface application and mix with the specified Layer
(3) Apply calcium chloride solution as a surface application

2131.4 METHOD OF MEASUREMENT

The Engineer will measure dry calcium chloride by weight and calcium chloride solutions by volume.

2131.5 BASIS OF PAYMENT

The Department will pay for the application of water used with dry calcium chloride in accordance with 2130, "Application of Water for Dust Control."

The Department will pay for the application of calcium chloride on the basis of the following schedule:

Item No.	Item	Unit
2131.506	Calcium Chloride Type ____	gallon
2131.509	Calcium Chloride Type ___	ton

Base Construction

2211 AGGREGATE BASE

2211.1 DESCRIPTION

This Work consists of providing, placing, and compacting Aggregate base.

2211.2 MATERIALS

A Aggregate 3138

2211.3 CONSTRUCTION REQUIREMENTS

Forms and the *Grading and Base Manual* are available on the Grading and Base Website.

Unless otherwise designated, test procedures are in the *Grading and Base Manual*.

A General

Remove Aggregate base, placed under the Contract that saturates Subgrade soils. Dry and recompact the Subgrade.

Repair Structures damaged by Contractor operations or negligence.

Compact and shape the Aggregate base, to the Plan dimensions, before suspending operations.

B Contractor Quality Control (QC) Testing
Test according to the *Schedule of Materials Control*.

Certify Materials on Form G&B-104.

Material placed without certifications is unauthorized Work in accordance with 1512, “Unacceptable and Unauthorized Work.”

C Placing and Compacting
Ensure the underlying Layer meets QC and QA requirements before the next Layer is placed.

Comply with the moisture content requirements per Table 2211.3-1 during compaction.

Table 2211.3-1
Moisture Required for Base Compaction

Classification	Moisture Content (percent by dry weight)
Class 3 and 4 (< 50 percent recycled bituminous content)	≥ 7 percent
Class 5 and 6 (< 50 percent recycled bituminous content)	≥ 5 percent
Classes 3, 4, 5 and 6 (≥ 50 percent recycled bituminous content)	3 percent ≤ moisture content ≤ 7 percent

Place and compact Lifts using Equipment per Table 2211.3-2.

Table 2211.3-2
Rollers Required for Compaction

Base Lift Thickness/Recycled Bituminous Content	Required Rollers
≤ 3 inches / any recycled bituminous content	Use Pneumatic rollers only
> 3 inches to ≤ 6 inches / recycled bituminous content ≤ 50 percent	Use both Vibratory and Pneumatic rollers
> 3 inches to ≤ 6 inches / recycled bituminous content > 50 percent	Use both Vibratory pad foot roller weighing at least 25,000 pounds and 25 ton Pneumatic roller

Place and compact the base to support traffic, while allowing no greater than 1/2 inch of surface deviation, when measured using a straightedge. Construct the Aggregate Layer to ±0.05 feet of the profile and cross-section as required by the Contract in accordance with 2112, “Subgrade Preparation.” Maintain the compaction, quality, integrity, and properties of the Aggregate Material in each Lift until the next Lift or Layer is placed.

Uniformly compact each Lift to meet the requirements of 2211.3D.2.a, “Specified Density Method,” 2211.3D.2.b, “Quality Compaction Method,” 2211.3D.2.c, “Penetration Index Method,” and 2211.3D.2.d, “Light Weight Deflectometer (LWD) Method.”

Correct, blend, and recompact Material represented by failing tests.

D Department Quality Assurance (QA)

Test according to the *Schedule of Materials Control*.

D.1 Gradation and Aggregate Quality Sampling and Testing

Sample according to the *Grading and Base Manual*.

Test the area of corrected Material.

Test Materials for the Contract Item Stockpile Aggregates before delivery and stockpiling.

D.2 Compaction

Test for compaction in the areas with the greatest rutting or deflection, and in an area at least 1 foot from an unconfined edge.

Test corrected areas with the greatest rutting or deflection.

Test for compaction using Quality Compaction per 2211.3D.2.b, “Quality Compaction Method,” and one of the following methods:

(1) specified density per 2211.3D.2.a, “Specified Density Method”
(2) penetration index per 2211.3D.2.c, “Penetration Index Method”
(3) LWD method per 2211.3D.2.d, “Light Weight Deflectometer (LWD) Method”

D.2.a Specified Density Method

Use the specified density method on virgin Aggregates only.

Verify by testing that each Lift is compacted to at least 100 percent of Maximum Density.

D.2.b Quality Compaction Method

Comply with the requirements of 2106.3G.2, “Quality Compaction.”

D.2.c Penetration Index Method

Verify that each Lift meets the penetration index and seating value per Table 2211.3-3.

Table 2211.3-3
Penetration Index Method — Maximum Seat and DPI

Grading Number *	Moisture Content‖	Maximum Allowable SEAT, [millimeter]	Maximum Allowable DPI, [millimeter/blow]	Test Layer, [inches]†
3.1 – 3.5	< 5.0	40	10	4 – 6
	5.0 – 8.0	40	12	
	> 8.0	40	16	
3.6 – 4.0	< 5.0	40	10	4 – 6
	5.0 – 8.0	45	15	
	> 8.0	55	19	
4.1 – 4.5	< 5.0	50	13	5 – 6
	5.0 – 8.0	60	17	
	> 8.0	70	21	
4.6 – 5.0	< 5.0	65	15	6 – 12
	5.0 – 8.0	75	19	
	> 8.0	85	23	
5.1 – 5.5	< 5.0	85	17	7 – 12
	5.0 – 8.0	95	21	
	> 8.0	105	25	
5.6 – 6.0	< 5.0	100	19	8 – 12
	5.0 – 8.0	115	24	
	> 8.0	125	28	

* As determined by Form G&B-204.

‖ Percent of dry weight.

† If Layer to be placed is thinner than the Test Layer, use 2211.3D.2.b, “Quality Compaction Method.”

Note: When recycled bituminous content is ≥ 50 percent, compact to achieve a penetration index value of 10 millimeter and a seating value of 40 millimeter, as determined by Form G&B-205.

Note that a moisture test is not required if the Material meets the toughest requirements for the Grading Number.

D.2.d Light Weight Deflectometer (LWD) Method

Compact the entire Lift to achieve an LWD target value as required per the LWD procedure for 2211, “Aggregate Base” in the *Grading and Base Manual*.

D.3 Test Rolling

Observe and document Test rolling, per the *Schedule of Materials Control* and Contract.

D.4 Moisture Testing

Test for moisture content in areas that appear least likely to meet Specifications.

E Aggregate for the Contract Item Stockpile Aggregate

Produce and certify the class of Material required by the Contract using Form G&B-104.

Deliver and stockpile certified Material to the designated sites listed in the Contract.

2211.4 METHOD OF MEASUREMENT

The Engineer will measure the Aggregate base per 1901, “Measurement of Quantities.” The Engineer will not deduct the mass or volume of water and admixtures.

Mass and volume conversion tables are in the *Grading and Base Manual*.

2211.5 BASIS OF PAYMENT

The Contract Unit Price for the accepted quantities of Aggregate base includes the costs of production, testing, placement, watering or drying, and compaction.

The Contract Unit Price for the accepted quantities of Stockpile Aggregate includes the costs of production, testing, delivery, and stockpiling at the designated site.

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

Item No.	Item	Unit
2211.507	Aggregate Base (CV) Class ___	cubic yard
2211.507	Aggregate Base (LV) Class ___	cubic yard
2211.507	Stockpile Aggregate (SV) Class ___	cubic yard
2211.507	Stockpile Aggregate (LV) Class ___	cubic yard
2211.509	Aggregate Base Class ___	ton
2211.509	Stockpile Aggregate Class ___	ton

2212 DRAINABLE AGGREGATE BASE

2212.1 DESCRIPTION

This Work consists of constructing a Drainable Aggregate base on a finished base or filter Layer.

2212.2 MATERIALS

A Drainable Bases 3136

2212.3 CONSTRUCTION REQUIREMENTS

Forms and the *Grading and Base Manual* are available on the Grading and Base Website.

Unless otherwise designated, test procedures are in the *Grading and Base Manual*.

Repair Structures damaged by Contractor operations or negligence.

A General

Before placing the Drainable base, shape the underlying surface in accordance with the Contract and 2112.3E, "Tolerances."

Maintain a uniform gradation during placement.

B Contractor Quality Control (QC) Testing

Test according to the *Schedule of Materials Control*.

Certify Materials on Department Form G&B-104.

Material placed without certifications is unauthorized Work in accordance with 1512, "Unacceptable and Unauthorized Work."

C Placing and Compacting

Provide moisture for compaction for Drainable stable base (DSB).

Provide placement Equipment meeting the following requirements:

(1) Will not rut the in-place surface
(2) Will not displace or damage any geotextile
(3) Capable of placing the required thickness without creating segregation

Vibratory rollers are not allowed. Do not allow traffic on the Drainable base after final placement and compaction. Meet the Quality Compaction requirements of 2106.3G.2, “Quality Compaction.”

Maintain drainage.

Construct the Aggregate Layer to ±0.05 feet of the profile and cross-section as required by the Contract in accordance with 2112, “Subgrade Preparation.” Maintain the surface, quality, integrity, and properties of the Aggregate Material in each Lift until the next Lift or Layer is placed.

D Department Quality Assurance (QA) Testing

Test according to the *Schedule of Materials Control*.

Sample and test using the random sampling method in the *Grading and Base Manual*; additional samples and tests may be taken to delineate visually indicated Material failures.

Retest corrected Material.

Verify compaction per 2106.3G.2, “Quality Compaction.”

2212.4 METHOD OF MEASUREMENT

Measure the Material in accordance with 1901, “Measurement of Quantities.”

2212.5 BASIS OF PAYMENT

The Contract Unit Price for the accepted quantities of Drainable Aggregate Base includes the costs of production, testing, placement, and compaction.

The Department will pay for Drainable Aggregate base on the basis of the following schedule:

Item No.	Item	Unit
2212.507	Drainable Aggregate Base, Type (*) (CV)	cubic yard

* Specify Type either OGAB or DSB.

2215 RECLAMATION

2215.1 DESCRIPTION

This Work consists of construction Full depth reclamation (FDR) and/or Stabilized full depth reclamation (SFDR).

FDR consists of pulverizing and blending the in-place bituminous pavement with a portion of the underlying Material to produce a uniformly mixed Aggregate base.

SFDR consists of pulverizing and blending the in-place bituminous Pavement Structure with a portion of the underlying Material, and mixing it with bituminous Material and/or additional Materials. The process is performed in two steps: an initial pulverization and compaction, and a final pulverization, mixing with additives, and compaction.

Pulverized (un-stabilized) Material is produced by grinding the bituminous pavement with a portion of the underlying granular Material. It may also include additional Materials, such as additional rock.

Bituminous stabilized Material is pulverized Material that has had a bituminous stabilizing agent (emulsion or foamed asphalt) added to it. It may also include additional Materials, such as cement or additional rock.

Bituminous Material for mixture is the liquid bituminous Material added to RAP to produce SFDR.

2215.2 MATERIALS

A Materials

B SFDR

2215.3 CONSTRUCTION REQUIREMENTS

A General

Refer to *Grading and Base Manual* for all test procedures, unless otherwise designated.

Protect and avoid damaging Structures.

Correct and retest failing areas.

Remove all reclaimed pavement pieces that would be retained on a three inch Sieve, from the Right-of-way.

Process paving fabric encountered during milling operations to less than 5 inches in any dimension.

B Contractor Quality Control (QC) Testing

Test according to the *Schedule of Materials Control*.

C Department Quality Assurance (QA)

Test according to the *Schedule of Materials Control*.

D Equipment

D.1 FDR Equipment

D.1.a Reclaiming Machine

Use a Road reclaiming machine capable of uniformly pulverizing the pavement and the underlying Layer to the specified depth and gradation.

D.1.b Rollers

Use a Pneumatic-tired roller weighing at least 25 ton or 616 pounds per inch of rolling width. Ensure the tire arrangement allows compaction over the full width of the roller with each pass.

Use a pad foot vibratory roller if required in 2215.3E.3, “Placing and Compacting,” weighing at least 25,000 pounds.

D.2 SFDR Equipment

D.2.a Reclaiming Machine
Use a self-propelled reclaiming machine with the ability to:

(1) Uniformly pulverize the pavement and the underlying Layer to the specified depth and gradation requirements.
(2) Thoroughly mix the reclaimed pavement while injecting the liquid bituminous Material and automatically metering it with a variation of not more than ±0.1 percent by weight. It must be capable of adding an additional 6 percent asphalt by total weight.
(3) Automatically control cross-slope and control cutting depth to within ± 1/4 inch of the depth shown on the Plans.
(4) Maintain the designed asphalt content of overlapped mixtures by adjusting the application of bituminous Material for the width of pulverized Layer. Automatically maintain the designed asphalt content regardless of machine speed, depth of cut, and number of operating nozzles. Provide means for automatically cleaning nozzles and continual observation and measurement by the operator.
(5) For foamed asphalt applications, the reclaiming machine must also accurately foam bituminous Material and uniformly add specified water and provide samples of the foamed bituminous Material through a sampling nozzle.

D.2.b Rollers
Use a Pneumatic-tired roller meeting the requirements of 2360.3B.2.e(2), “Pneumatic Tired Rollers,” and having a minimum weight of 25 tons.

Use a pad foot vibratory roller weighing at least 12.5 ton.

Use steel-wheeled rollers equipped with a water spray system meeting the requirements of 2360.3B.2.e(1), “Steel-Wheeled Rollers.”

Use a double drum roller when using bituminous stabilizers.

Use a single drum roller when using cement only.

D.2.c Bituminous Material for Mixture Supply Tankers
Tankers must be equipped with a visible thermometer that measures the temperature of the liquid bituminous Material for mixture when foaming.

D.2.d Vane Feeder
Provide a vane feeder capable of uniformly spreading the cement on the Road surface before reclaiming when cement is required.

E FDR Requirements

E.1 Pulverizing Operation
Before beginning pulverization, remove vegetation and topsoil adjacent to the surface.

Pulverize to meet the gradation requirements of Table 2215.3-1.

Table 2215.3-1
FDR Gradation Requirements

Sieve Size	Percent Passing
3 inch	99 - 100
2 inch	90 – 100

Blend, add water, spread, compact, and shape pulverized Material by the end of the workday.

Correct reclaim sections represented by a failing gradation.

E.2 Incorporation of Additional Aggregates

Uniformly spread additional Aggregates across the Roadway surface to be reclaimed before incorporating it into the reclaim mixture, if required of the Contract.

E.3 Placing and Compacting

Uniformly mix reclamation Material before spreading.

Spread and compact the reclamation Material to the profile and cross-section shown on the Plans before placing the next Layer.

Compact when the moisture content is 3 to 7 percent by dry weight.

For Lifts 3 inches or less, place and compact reclamation Materials using a Pneumatic-tired roller in compliance with 2215.3D "Equipment."

For lifts 3 inches to 6 inches, compact using both a Pneumatic-tired and pad foot vibratory rollers in compliance with 2215.3D, "Equipment."

Place and compact Materials in maximum 6-inch Lifts.

The Contractor may use excess reclamation Material from other locations on the Project to attain the profile or cross-section as shown on the Plans.

Compact the full thickness to achieve a penetration index value of 10 millimeters and a seating value of 40 millimeters as measured by the Department standard Dynamic Cone Penetrometer (DCP) method, as determined by Form G&B-205.

Place and compact to support traffic, while allowing no greater than 1/2 inch of surface displacement, when measured using a straightedge.

Construct the Layer to ±0.05 feet of the profile and cross-section as required by the Contract in accordance with 2112, "Subgrade Preparation."

E.4 Workmanship, Quality, Repair and Maintenance

The Engineer will provide staking to reestablish the centerline, when Contractor-staking is not required by the Contract.

Maintain the compaction, quality, integrity, and properties of the Aggregate Material in each Lift until the next Lift or Layer is placed.

Repair ruts, potholes, wash-boarding, and other distortions by scarifying to a depth of 2 inches below the deepest distortion and recompact.

F SFDR Requirements

F.1 Pulverization

Pulverize (grind) and uniformly blend the in-place bituminous pavement with the underlying granular base to the gradation requirements of Table 2215.3-2.

Table 2215.3-2
SFDR Gradation Requirements

Unstabilized Portion	
Sieve Size	**Percent Passing**
3 inch	100
2 inch	90 – 100
Stabilized Portion	
Sieve Size	**Percent Passing**
1.5 inch	98 – 100

If required of the Contract, uniformly spread additional Material across the Roadway surface to be reclaimed before incorporating it into the reclaim mixture.

Correct reclaim sections that do not comply with gradation requirements by repulverizing.

F.2 Spreading & Compaction of the Unstabilized Material

Spread, shape, and compact the pulverized Material to the profile and cross-section shown on the Plans.

Compact when the moisture content is 3 to 7 percent by dry weight.

Place and compact pulverized (un-stabilized) Materials in maximum 6-inch Lifts.

Compact the initial pulverized Layer to a maximum penetration index value of 10 millimeters as measured by the Department standard Dynamic Cone Penetrometer (DCP) method.

Blend, add water, spread, compact, and shape pulverized Material by the end of each workday, and before any significant rainfall event occurs.

F.3 Spreading Cement

Spread cement using a vane feeder in a manner that minimizes dusting, i.e. do not spread when the wind is strong enough to coat vehicles and/or the surrounding environment.

Control the cement content to within ± 0.5 pounds per square yard, of the mix design target.

Start mixing operations, no longer than 1/2 hour after spreading cement.

F.4 Mixing/Injecting

Produce the SFDR Layer by mixing and injecting the liquid bituminous Material into the pulverized pavement.

Stabilize when: the atmospheric temperature is 50°F and rising when using emulsions, 60°F and rising when using foamed bituminous, or 40°F and rising when using cement only; it is not foggy or rainy; and freezing temperatures are not predicted within 48 hours after placement of SFDR. Atmospheric temperature and predicted weather requirements are determined by the Engineer.

Incorporate the bituminous Material for mixture at the rate designated on the mix design. However, after consultation with the Contractor, the Engineer may direct the Contractor to vary the application rate of bituminous Material for mixture compared to the mix requirements for areas of pulverized bituminous which the Engineer believes are either too rich or too lean.

Use a minimum 6-inch overlap between passes of the reclaimer.

Demonstrate that the asphalt stabilizing agent is uniformly blended into the in-place recycled pavement. If the first mixing fails to produce a uniform product, remix until it is uniform.

If using foamed asphalt, maintain bituminous Material within ±10°F of the optimum temperature recommended by the mix design (note that bituminous must also meet expansion ratio and half-life foaming tests). If the supplier does not provide a recommendation, maintain the foamed asphalt temperature between 305°F and 325°F.

F.5 Compaction of Bituminous Stabilized Material

Complete the initial compaction (i.e. a pad foot compactor “walks out”) of the bituminous stabilized Material before shaping.

F.6 Shaping and Compacting of Bituminous Stabilized Material

Remove any remaining pad foot marks and spread the Material.

Place and compact the Material to within ±0.05 feet of the profile and so that the cross-section has no variations greater than 1/2 inch within 10 feet.

Complete final shaping and compaction within 2 hours of bituminous Material injection.

Within 48 hours of SFDR, recompact areas represented by density measurements below 97 percent of the target density determined from the control strip and roll until ≥97 percent density is achieved. However, do not over-roll to the point where checking of the surface occurs, also note that some areas may not achieve 97 percent density due to field conditions.

F.7 Control Strip

Use a control strip to establish a rolling pattern. The control strip should represent a homogenous Roadway section, have a minimum area of 400 square yards and remain in-place and become a part of the completed Work.

Use the following to establish a rolling pattern after initial breakdown is complete and until a new control strip is required:

(1) Randomly select three test points in the control strip and use a nuclear density device (*ASTM D2950*, *Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods*, in back-scatter mode) to determine a wet density at each point after each finish (steel) roller pass

(2) Ensure that the nuclear gauge rests on a flat surface; the density at each point is defined as the average of two readings offset 180 degrees

(3) Continue compacting until additional roller coverage does not produce appreciable increase in density; provide documentation of the growth curve and maximum target density to the Engineer; use this for QA/QC process

(4) Roll the remainder of that course in accordance with the pattern developed in the control strip for that roller

(5) Discontinue and reevaluate the rolling operation (pattern and timing), if surface cracking or checking occurs

Establish a new rolling pattern by performing a new control strip when there are changes in the mixture that cause the original control strip to no longer be representative; changes may include: in-place Materials variation, including sections with varying thickness, construction history, etc.; if vehicles leave indents in the compacted surface; changes in RAP gradation; 97 percent of target density is not achieved on two consecutive density tests; and changes in the application rate of bituminous Material for mixture, greater than 0.2 percent for foaming or 0.3 percent for emulsion.

F.8 Workmanship, Quality, Repair and Maintenance

Maintain the compaction, quality, integrity, the profile and cross-section to within the criteria of 2215.3F.6, "Shaping and Compacting of Bituminous Stabilized Material" and properties of the SFDR Layer during the curing period until the placement of the next Layer.

The Engineer will provide staking to reestablish the centerline, when Contractor-staking is not required by the Contract.

Repair ruts, potholes, washboarding, and other distortions.

F.9 Fog Seal

If directed by the Engineer, apply a CSS-1h bituminous fog seal per 2355, "Bituminous Fog Seal" at a rate of 0.08 – 0.16 gallons per square yard.

F.10 Bituminous

Immediately before placement of the bituminous Layer, clean the SFDR surface and remove loose Aggregate.

Place bituminous:

(1) No sooner than 3 Calendar Days and no later than 14 Calendar Days after SFDR, at any location, has been injected and compacted (note that the 14 Calendar day requirement may be extended with concurrence of the Engineer, if large rainfall events hinder the curing of the SFDR).
(2) When the SFDR surface does not deflect under construction Equipment and meets Quality Compaction per 2106.3G.2, "Quality Compaction."
(3) When the SFDR is capable of meeting the required bituminous placement and compaction requirements.
(4) When the moisture content of the SFDR is low enough to not migrate into and damage the new asphalt.

2215.4 METHOD OF MEASUREMENT

Measure the Full depth reclamation by the square yard.

Measure the Stabilized full depth reclamation by the square yard.

Measure the Bituminous Material for mixture by the ton.

Measure Cement by the ton.

Measure additional Aggregates by the ton.

Measure the bituminous Material for fog seal in accordance with 2355, "Bituminous Fog Seal."

2215.5 BASIS OF PAYMENT

The Contract Unit Prices for reclamation includes the cost of production, testing, placement, occasional variations in the bituminous pavement thickness, removing vegetation and topsoil adjacent to the surface, repair to Structures damaged by Contractor's operations or negligence, and necessary maintenance.

The Department will pay for the correction of unstable areas through no fault of the Contractor's operations, if directed by the Engineer, as Extra Work in accordance with 1402, "Contract Revisions."

The Department will pay for bituminous Material for fog seal in accordance with 2355, "Bituminous Fog Seal."

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

Item No.	Item	Unit
2215.504	Full Depth Reclamation	square yard
2215.504	Stabilized Full Depth Reclamation	square yard
2215.507	Haul Full Depth Reclamation (LV)	cubic yard
2215.509	Bituminous Material for Mixture	ton
2215.509	Cement	ton
2215.509	Aggregate Base	ton

2221 SHOULDER BASE AGGREGATE

2221.1 DESCRIPTION

This Work consists of placing Shoulder base Aggregate adjacent to pavements.

2221.2 MATERIALS

A Aggregate 3138

2221.3 CONSTRUCTION REQUIREMENTS

A General

Forms and the *Grading and Base Manual* are available on the Grading and Base Website.

Unless otherwise designated, test procedures are in the *Grading and Base Manual*.

Repair Structures damaged by Contractor operations or negligence.

Comply with the requirements of 2211.3A, "General."

Shoulder base Aggregate placed before the Engineer accepts the Contractor's certification is unauthorized Work in accordance with 1512, "Unacceptable and Unauthorized Work."

B Contractor Quality Control (QC) Testing

Test according to the *Schedule of Materials Control*.

Certify Materials on Department Form G&B-104.

Material placed without certifications is unauthorized Work in accordance with 1512, "Unacceptable and Unauthorized Work."

C Shoulder Preparation

Comply with the requirements of 2211.3C, "Placing and Compacting"; however, compact the existing Material using the Quality Compaction method as specified in 2106.3G.2, "Quality Compaction."

Remove vegetation and replace contaminated Material as directed by the Engineer.

Immediately sweep spilled Material from the pavement surface.

D Department Quality Assurance Testing (QA)
Test according to the *Schedule of Materials Control*.

E Tolerances
Construct Aggregate shouldering in accordance with 2112.3E, “Tolerances.”

2221.4 METHOD OF MEASUREMENT
The Engineer will measure the Shoulder base Aggregate in accordance with 1901, “Measurement of Quantities.”

The Engineer will not deduct the mass or volume of water and admixtures.

Mass and volume conversion tables are in the *Grading and Base Manual*.

2221.5 BASIS OF PAYMENT
The Contract Unit Price for placing Shoulder base Aggregate includes the costs of removing vegetation, production, testing, placement, compaction, watering or drying, and shaping.

The Department will pay for Shoulder base Aggregate on the basis of the following schedule:

Item No.	Item	Unit
2221.507	Shoulder Base Aggregate (CV) Class ___	cubic yard
2221.507	Shoulder Base Aggregate (LV) Class ___	cubic yard
2221.509	Shoulder Base Aggregate Class ___	ton

2231 BITUMINOUS SURFACE RECONDITIONING

2231.1 DESCRIPTION
This Work consists of reconditioning the existing pavement surface before constructing a bituminous overlay or surfacing courses.

2231.2 MATERIALS

A Bituminous Patching Mixture
Provide bituminous patching Material matching the type of Material used in the first Layer of bituminous surfacing placed on the reconditioned surface.

B Mixture for Joints and Cracks
Provide a mixture for joints and cracks consisting of a prepared mix of fine Aggregate and bituminous Material in accordance with the requirements of Table 2231.2-1:

Table 2231.2-1
Joint and Cracks Mixture Requirements

Material	Requirement
1/2 inch Sieve	100*
No. 8 Sieve	45 – 80*
No. 200 Sieve	2.0 – 7.0*
Aggregate spall	< 5 percent
Bituminous Material‖	6.5 – 7.0†
* Percent passing requirement. ‖ Match PG grade to grade used on first Lift of plant mixed asphalt. † Percent by weight.	

C Joint and Crack Filler

Provide Joint and crack filler in accordance with the Special Provisions.

2231.3 CONSTRUCTION REQUIREMENTS

A Surface Repair

Remove loose, unstable, or deteriorated portions of the existing pavement to provide a stable surface after completion of the patching operation. Remove waste or surplus Material from the Project. Repair and fill the holes and depressions with mix in accordance with the Special Provisions. Compact the mix using conventional Pneumatic-tired roller or mechanical tampers in areas inaccessible to conventional roller Equipment.

B Joint Repair

B.1 Concrete Pavement

Clean and refill joints and cracks at least 1/4 inch wide.

B.2 Bituminous Pavement

Rout and seal cracks 1/4 inch to 3/4 inch wide. For cracks greater than 3/4 inch wide, fill with the Mixture for joints and cracks and tamp in place.

2231.4 METHOD OF MEASUREMENT

The Engineer will separately measure the accepted quantities of Bituminous patching mixture, Mixture for joints and cracks, and Joint and crack filler, as provided and placed, by the weight or by the loose volume of Material as shown on the Plans.

2231.5 BASIS OF PAYMENT

The Contract Unit Prices for Bituminous patching mixture, for Mixture for joints and cracks, and for Joints and crack filler include the cost of removing and disposing of the existing deteriorated Materials.

If the Contract does not specify a specific Contract Pay Item for removing concrete base or pavement in accordance with 2104, “Removing Pavement and Miscellaneous Structures,” the Department will pay for the removal of a concrete base or pavement to full depth and width between existing joints, or by sawing, as Extra Work in accordance with 1402, “Contract Revisions.”

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

Item No.	Item	Unit
2231.507	Bituminous Patching Mixture	cubic yard
2231.508	Mixture for Joints and Cracks	pound
2231.508	Joint and Crack Filler	pound
2231.509	Bituminous Patching Mixture	ton

2232 MILL PAVEMENT SURFACE

2232.1 DESCRIPTION

This Work consists of removing the existing pavement by cold milling.

2232.2 MATERIALS — BLANK

2232.3 CONSTRUCTION REQUIREMENTS

A Equipment

Mill the existing pavement with a power operated, self-propelled cold milling machine capable of removing concrete and bituminous Materials to the profile, cross-slope, grade, and elevation uniformly across the pavement surface as shown on the Plans. Use automatic controls to control grade, elevation, cross-slope, and profile. Use a machine with ski, matching shoe, or an independent grade control to reference the existing pavement and automatically establish Profile Grades along each edge of the machine within ±1/4 inch.

B Operations

Mill the pavement surface to the depth, width, grade, and cross-slope as shown on the Plans. Perform milling without tearing or gouging the underlying Material. Surface irregularities exceeding 1/2 inch under a 10 foot straightedge laid transversely and longitudinally after milling is complete are unacceptable. Reference the milling operation from an independent grade control in areas directed by the Engineer. Establish and maintain grade control as approved by the Engineer.

Mill the entire pavement width to a flush surface at the end of each Work period, when the pavement is open to traffic. If uncompleted operations result in a vertical or near vertical longitudinal face, reslope the longitudinal face to provide a taper, construct a temporary bituminous taper or provide protective measures, as approved by the Engineer. Taper transverse cutting faces at the end of each Work period where pavement is open to traffic. Construct temporary bituminous tapers at intersecting Streets, around utility appurtenances, and appropriated entrances during the milling operations, as directed by the Engineer.

Mill areas inaccessible to the milling machine using other Equipment or methods as approved by the Engineer.

The Contractor may recycle the surfacing removed by the milling operations and use on the Project in accordance with 3138, “Aggregate for Base and Surface Courses,” or 3139, “Graded Aggregate for Bituminous Mixtures,” or dispose of the millings outside the Right-of-way in accordance with 2104.3, “Removing Pavement and Miscellaneous Structures, Construction Requirements.”

After milling to the depth shown on the Plans, sweep or vacuum clean the milled area with Equipment approved by the Engineer. Clean the milled area as approved by the Engineer. Dispose of debris from milling and cleaning operations outside of the Right-of-way in accordance with 2104.3, “Removing Pavement and Miscellaneous Structures, Construction Requirements,” except as otherwise approved by the Engineer.

Mill previously patched areas to the specified depth below the pavement surface that existed before placement of the previous patch, and not from the surface of the patch.

Avoid disturbing or damaging existing drainage or utility Structures on the Project. Repair damage resulting from the milling operations at no additional cost to the Department.

Keep the milled pavement surface free of all loose Materials and dust.

2232.4 METHOD OF MEASUREMENT

The Engineer will measure pavement milling by the area of each type of surface removed. The Engineer will measure areas milled, based on actual finished dimensions of the Work.

2232.5 BASIS OF PAYMENT

The Contract Unit Price for pavement milling includes the cost of cleanup, and disposal operations.

The cost of constructing a temporary milled taper and providing, placing, and removing temporary bituminous tapers is included in the Contract Unit Price for other relevant Contract Items.

The Department will pay for mill pavement surface on the basis of the following schedule:

Item No.	Item	Unit
2232.504	Mill Bituminous Surface (___”)	square yard
2232.504	Mill Concrete Surface (____”)	square yard

Pavement Construction

2301 CONCRETE PAVEMENT

2301.1 DESCRIPTION

This Work consists of constructing Portland cement concrete pavement on a prepared base.

A Definitions

For the purpose of the Work specified in section 2301, “Concrete Pavement,” the Department defines:

Paving Concrete

Includes concrete mainline, Ramps, Loops, integrant curb, Shoulders, and curb and gutter placed adjacent to the concrete mainline with the same mixture used in the paving. Integrant curb is a curb constructed monolithically with the pavement.

Primary Concrete Plant

A concrete plant that provides the majority of the concrete to a paving Project. Use either a paving plant or a certified ready-mix plant as the Primary Concrete Plant. Only one Primary Concrete Plant per Project is allowed unless otherwise approved by the Engineer.

B Contracts with 3,500 cubic Yards or Greater of Paving Concrete

The Engineer will determine the quantity of Paving Concrete prior to the start of Concrete Paving operations. If the Contract does not include a cubic yard quantity for Paving Concrete, the Engineer will calculate the cubic yard quantity by multiplying the planned pavement area by the planned pavement thickness.

If the Contract includes 3,500 cubic yards or greater of Paving Concrete, 2301.3C.3, "Optimized Aggregate Gradation," and 2301.3C.7, "Coarse Aggregate Quality" apply for Paving Concrete provided by the Primary Concrete Plant.

If the Contract includes 3,500 cubic yards or greater of Paving Concrete, 2301.3C.6, "Water/Cement (W/C) Ratio Determination" applies for Paving Concrete (except High-early concrete) provided by the Primary Concrete Plant and hauled in dump trucks, agitator trucks, or both.

2301.2 MATERIALS

A Structural Concrete 2461

A.1 Slipform Placement .... Mix No. 3A21

A.2 Fixed Form Placement .... Mix No. 3A41

B Cementitious Materials

Provide only cementitious Materials from the *Approved/Qualified Products List*.

B.1 Portland cement 3101

Use Type I or Type I/II cement complying with the following:

(1) Total alkalis (Na_2Oe) no greater than 0.60 percent in the Portland cement
(2) Total alkalis (Na_2Oe) no greater than 3.0 pounds per cubic yard of concrete resulting from the Portland cement

B.2 Slag Cement 3102

B.3 Blended Hydraulic Cement 3103

Use Type IL, IS, or IP cement complying with the following:

(1) Total alkalis (Na_2Oe) no greater than 0.60 percent in the Portland cement
(2) Total alkalis (Na_2Oe) no greater than 3.0 pounds per cubic yard of concrete resulting from the Portland cement

B.4 Fly Ash 3115

The Concrete Engineer defines Class F fly ash for the purposes of ASR mitigation as having a maximum CaO content of 18.0 percent.

B.5 Ternary Mixes

Ternary mixes are defined as Portland cement or Type IL and two other supplementary cementitious Materials, Type IT blended cement, or blended cement (excluding Type IT) and one other supplementary cementitious Material.

C Concrete Aggregate Requirements

Provide Aggregates from sources listed on the MnDOT *Concrete Aggregate Properties* list and in accordance with the following:

Test each Aggregate fraction proposed for use in accordance with Table 2301.2-1.

Table 2301.2-1
Aggregate Testing Requirements

Aggregate Fraction	Testing Required
Tested by Department in the last 3 years	No additional testing unless required by the Concrete Engineer
Not tested by the Department in the last 3 years	Preliminary Aggregate testing in accordance with 2301.2C.1, “Required Preliminary Aggregate Testing.”
New source	New source concrete Aggregate testing in accordance with 3126, “Fine Aggregate for Portland Cement Concrete,” 3131, “Intermediate Aggregate for Portland Cement Concrete,” and 3137, “Coarse Aggregate for Portland Cement Concrete.”

C.1 Required Preliminary Aggregate Testing

After the Department awards the Contract and as soon as coarse and fine Aggregates are available for testing, contact the Engineer to coordinate preliminary sampling of Aggregate for Concrete Paving. The Engineer, in conjunction with the Concrete Engineer, will sample and test the Aggregate to verify specific gravity, absorption data, and Aggregate quality. The Department will perform other tests as determined necessary by the Engineer, in conjunction with the Concrete Engineer.

C.2 Fine Aggregate Requirements

Provide fine Aggregates complying with quality requirements of 3126.2B, “Quality.”

C.2.a Fine Aggregate Alkali Silica Reactivity (ASR) Testing Requirements

The Department will routinely test fine Aggregate sources for alkali silica reactivity (ASR) in accordance with the following:

(1) Multiple sources of certified Portland cement in accordance with *ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method),* MnDOT Modified

(2) Multiple combinations of certified Portland cement and supplementary cementitious Materials in accordance with *ASTM C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)*, MnDOT Modified

C.2.b Fine Aggregate Alkali-silica Reactivity (ASR) Requirements

The Concrete Engineer, in conjunction with the Engineer, will review the 14-Calendar Day fine Aggregate expansion test results to determine the acceptability of the proposed fine Aggregate and cement combination in accordance with the following:

(1) For fine Aggregate and cement combinations previously tested by the Department, the Concrete Engineer will use the average of 14-Calendar Day unmitigated test results for an individual fine Aggregate source to determine necessary mitigation in accordance with Table 2301.2-2.

(2) If the previously tested proposed fine Aggregate and cement combination requires less mitigation than the average 14-Calendar Day unmitigated test result, the Concrete Engineer will allow mitigation at the lesser rate in accordance with Table 2301.2-2.

(3) Alkali silica reactivity (ASR) *ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*, MnDOT Modified and *ASTM C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)*, MnDOT Modified test results are available on the MnDOT Concrete Engineering Unit website. The Concrete Engineer considers the average 14-Calendar Day expansion result to represent every fine and intermediate Aggregate from a single source.

Table 2301.2-2
Fine and Intermediate Aggregate ASR Mitigation Requirements

<table>
<tr><th rowspan="2">14-Calendar Day Fine and Intermediate Aggregate Unmitigated Expansion Limits</th><th rowspan="2">Class F Fly Ash</th><th rowspan="2">Class C Fly Ash</th><th rowspan="2">Slag</th><th colspan="4">Ternary (Maximum of 40 percent)</th></tr>
<tr><th>Slag/Class F Fly Ash</th><th>Slag/Class C Fly Ash</th><th>IS(20)/ Class F Fly Ash</th><th>IS(20)/ Class C Fly Ash</th></tr>
<tr><td>≤ 0.150</td><td colspan="7">No mitigation required</td></tr>
<tr><td>>0.150 –0.200</td><td>minimum 20 percent</td><td>minimum 20 percent</td><td>35 percent</td><td rowspan="2">20 percent Slag with a minimum of 15 percent Class F fly ash</td><td rowspan="2">20 percent Slag and 20 percent Class C fly ash</td><td rowspan="2">Type IS(20) with a minimum of 15 percent Class F</td><td rowspan="2">Type IS(20) with a minimum of 15 percent Class C</td></tr>
<tr><td>> 0.200 – 0.300</td><td>minimum 20 percent</td><td>minimum 30 percent</td><td>35 percent</td></tr>
<tr><td>> 0.300</td><td colspan="7">The Department will reject the fine Aggregate</td></tr>
</table>

The Concrete Engineer may reject the fine Aggregate if mortar bar specimens exhibit an indication of external or internal distress not represented by the expansion results. The Concrete Engineer will make the final acceptance of the Aggregate.

C.3 Intermediate Aggregate Requirements

Provide intermediate Aggregates complying with the quality requirements of 3131.2D, “Quality.”

For any intermediate Aggregate size not previously tested by the Department, the Concrete Engineer reserves the right to test for alkali silica reactivity, in accordance with *ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*, MnDOT Modified, before allowing incorporation into the concrete mix design.

C.4 Coarse Aggregate Requirements

Provide coarse Aggregates complying with the requirements of 3137, “Coarse Aggregate for Portland Cement Concrete,” for each individual fraction.

C.4.a Coarse Aggregate Alkali Silica Reactivity (ASR) Requirements

When using coarse Aggregate identified as quartzite or gneiss, the Concrete Engineer will review *ASTM C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction*, testing to determine the necessary ASR mitigation requirements in accordance with Table 2301.2-3.

Alkali silica reactivity (ASR) *ASTM C1293* test results are available on the Concrete Engineering Unit website.

Table 2301.2-3
Coarse Aggregate ASR Mitigation Requirements

ASTM C1293 **Expansion Results**	**Class F Fly Ash**	**Class C Fly Ash**	**Slag**	**Slag/Class F Fly Ash**	**Slag/Class C Fly Ash**	**IS(20)/Class F Fly Ash**	**IS(20)/Class C Fly Ash**
≤ 0.040	No mitigation required						
>0.040	minimum 30 percent	not allowed	35 percent	20 percent Slag with a minimum of 15 percent Class F fly ash	20 percent Slag and 20 percent Class C fly ash	Type IS(20) with a minimum of 15 percent Class F	Type IS(20) with a minimum of 15 percent Class C
** ASTM C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction*							

D Concrete Admixtures 3113

Provide admixtures from the *Approved/Qualified Products List* for concrete grades shown in Table 2301.2-4.

Use of any of the following admixtures are at the Contractor's discretion:

(1) Type A, Water-reducing Admixture
(2) Type B, Retarding Admixture
(3) Type D, Water-Reducing and Retarding Admixture
(4) Type S, Specific Performance Based Admixture

Use of Type F, High Range Water-Reducing; and Type G, High Range Water Reducing and Retarding Admixtures require approval from the Concrete Engineer.

D.1 Accelerating Admixtures

Use of the Type C, Accelerating Admixture; and Type E, Water-Reducing and Accelerating admixtures require approval of the Concrete Engineer, in conjunction with the Engineer, unless otherwise allowed in the Contract.

The Engineer will permit the use of Type C or Type E accelerating admixtures only when all of the following conditions exist:

(1) The ambient temperature is below 36°F
(2) An Engineer approved cold weather protection Plan is in-place
(3) Cold weather protection Materials are on-site and ready for use

L **Contractor Concrete Mix Design**

The Contractor assumes full responsibility for the mix design and performance of the concrete. The Engineer determines final acceptance of concrete for payment based on satisfactory field placement and performance.

L.1 **Concrete Mix Design Requirements**

The Department defines the concrete mix design requirements for Concrete Pavement in accordance with Table 2301.2-4.

Table 2301.2-4
Concrete Grade A Mix Design Requirements

<table>
<tr><th rowspan="2">Estimated Concrete Contract Quantity (cubic yard)*</th><th rowspan="2">Mix Number</th><th colspan="2">Maximum W/C ratio</th><th rowspan="2">Minimum Cement Content (pounds/ cubic yard)</th><th rowspan="2">Cementitious Content (pounds/ cubic yard) ‖</th><th rowspan="2">Air Content percent</th><th rowspan="2">Gradation Requirements</th><th rowspan="2">Minimum Aggregate Size Required</th><th rowspan="2">Maximum percent SCM (Fly Ash/Slag/ Ternary)†</th><th rowspan="2">Slump Range (inch)</th><th rowspan="2">3137, “Coarse Aggregate for Portland Cement Concrete”</th></tr>
<tr><th>Fly Ash</th><th>Slag/ Ternary</th></tr>
<tr><td rowspan="2">≥ 3,500</td><td>3A21</td><td>0.40</td><td>0.42</td><td rowspan="2">385</td><td rowspan="2">530 – 615</td><td rowspan="2">7.0</td><td rowspan="2">Job Mix Formula</td><td rowspan="2">1 1/2 inch Nominal</td><td rowspan="2">33/35/40</td><td>1/2 - 3‡</td><td rowspan="2">2.D.3</td></tr>
<tr><td>3A41</td><td>0.40</td><td>0.42</td><td>2 – 5</td></tr>
<tr><td rowspan="3">< 3,500 and Minor work and fill-ins not provided by the Primary Paving Plant #</td><td>3A21S</td><td>0.42</td><td>0.42</td><td rowspan="2">385</td><td rowspan="2">530 – 615</td><td rowspan="2">7.0</td><td rowspan="2">3126 and Table 3137.2-4 Or Job Mix Formula</td><td rowspan="2">3/4 inch Nominal</td><td rowspan="2">33/35/40</td><td>1/2 - 3‡</td><td rowspan="2">2.D.3</td></tr>
<tr><td>3A41S</td><td>0.42</td><td>0.42</td><td>2 – 5</td></tr>
<tr><td>3A42 §</td><td>0.42</td><td>0.42</td><td>385</td><td>530 – 615</td><td>7.0</td><td>3126 and Table 3137.2-4</td><td>3/4 inch Nominal</td><td>33/35/40</td><td>2 – 5</td><td>2.D.3</td></tr>
<tr><td rowspan="2">Engineer approved or Plan allowed High-early</td><td>3A21HE **</td><td>0.40</td><td>0.42</td><td rowspan="2">385</td><td rowspan="2">> 615 – 750</td><td rowspan="2">7.0</td><td rowspan="2">3126 and Table 3137.2-4 Or Job Mix Formula</td><td rowspan="2">3/4 inch Nominal</td><td rowspan="2">33/35/40</td><td>1/2 - 3‡</td><td rowspan="2">2.D.3</td></tr>
<tr><td>3A41HE **</td><td>0.40</td><td>0.42</td><td>2 – 5</td></tr>
</table>

* Determined by multiplying the planned pavement area by the planned pavement thickness.
‖ Provide additional cementitious Material to meet requirements in accordance with this section at no additional cost to the Department.
† Refer to Table 2301.2-2 and Table 2301.2-3 for ASR mitigation requirements.
‡ Adjust slump in accordance with 2301.3E.1, “Consistency.”
# The 5th digit “S” indicates the concrete is for a small concrete paving Project or delivered from a secondary concrete plant for minor Work or fill-ins. The Concrete Engineer considers minor Work or fill-ins as gaps in concrete pavement, Turn Lanes, Intersections or other pavement sections as determined by the Engineer, in conjunction with the Concrete Engineer.
§ The Concrete Engineer will allow a non-Project specific 3A42 mix design provided by a Department certified ready-mix plant submitted in accordance with the first two paragraphs of 2461.2E.3, “Submittal Requirements.” If the sand source requires mitigation with a minimum of 30 percent Class C fly ash in accordance with Table 2301.3-5, the Concrete Engineer will require a minimum of 30 percent Class C fly ash, 30 percent Class F fly ash, or 35 percent slag for all 3A42 mixes.
** The Contractor may use 100 percent Portland cement for High-early concrete, provided no mitigation is required for the fine Aggregate or intermediate Aggregate in accordance with Table 2301.2-2 or the coarse Aggregate in accordance with Table 2301.2-3. If mitigation is required, the Contractor is required to use a minimum of 15 percent of any supplementary cementitious Material when designing High early concrete.

L.2 Concrete Mix Design Submittal Requirements

Design Grade A concrete mixes based on an absolute volume of 27 cubic feet and a target air content of 7.0 percent.

Submit the concrete mixes using the appropriate Project specific mix design submittal form available on MnDOT's website at least 21 Calendar Days before the initial concrete placement. When required by Table 2301.2-4, include a job mix formula in accordance with 2301.2L.3, "Job Mix Formula." Use the most current forms available from the MnDOT Concrete Engineering website.

For mix design calculations, the Engineer, in conjunction with the Concrete Engineer, will provide specific gravity and absorption data.

The Concrete Engineer will review the mix design submittal for compliance with the Contract.

L.3 Job Mix Formula

A job mix formula (JMF) contains the following:

(1) Proportions for each Aggregate fraction
(2) Individual gradations for each Aggregate fraction
(3) Composite gradation of the combined Aggregates including working ranges on each Sieve in accordance with Table 2301.2-5

Table 2301.2-5
Job Mix Formula Working Range

Sieve Sizes	Working Range, percent *
2 inch	±5
1 1/2 inch	±5
1 inch	±5
3/4 inch	±5
1/2 inch	±5
3/8 inch	±5
No. 4	±5
No. 8	±4
No. 16	±4
No. 30	±4
No. 50	±3
No. 100	±2
No. 200	≤ 1.6
* Working range limits of the composite gradation based on a moving average of 4 tests (N=4).	

2301.3 CONSTRUCTION REQUIREMENTS

Use "slipform" as the standard construction method for concrete paving, unless otherwise allowed in the Contract or by the Engineer.

A Notice of Inspection

Notify the Engineer at least 24 hours before placing concrete to allow for inspection. Do not place concrete until the Engineer approves preparations for concrete placement. If the Contractor fails to notify the Engineer at least 24 hours before concrete placement, the Engineer may not allow concrete placement in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

B Contractor and Equipment Qualifications

Provide paving operations supervision in accordance with 1506, “Supervision by Contractor.” Provide an organizational chart listing names and phone numbers of individuals and alternates responsible for mix design, Quality Control administration, and inspection to the Engineer. Post the organizational chart in the Contractor's on-site facility.

B.1 Contractor Paving Plant Personnel

Provide the following personnel:

(1) QC Plant Technician(s) to perform all testing and Quality Control requirements of this section. The QC Plant Technician shall hold a current Department Concrete Plant Certification.
(2) Quality Control Supervisor responsible for oversight of all QC testing and daily paving batch plant operations. The Quality Control Supervisor shall hold a current Department Concrete Plant Certification and is required to remain on-site during concrete production or have cellular phone availability.
(3) Quality Control Manager responsible for oversight of the Quality Control Supervisor and all batch plant operations. The Quality Control Manager and Quality Control Supervisor can be the same person.

B.2 Contractor Flatwork Certification

The concrete Contractor, or Subcontractor, shall have at least two people with a current ACI concrete flatwork associate, concrete flatwork finisher, or advanced concrete flatwork finisher certification, and at least one of them must be on-site for concrete pours.

B.3 Concrete Paving Plant Certification

Provide notice 16 hours in advance of Concrete Paving production.

Calibrate and correlate the testing Equipment in accordance with 2461.3D, “Batching Requirements.”

In conjunction with the Engineer, perform a thorough on-site inspection of the concrete plant and complete MnDOT Form 2164, “*Contact Report 2014 - Paving*.” Sign the report to certify compliance with the paving requirements and to certify review of the continual maintenance of the plant.

Provide a separate combination plant lab – office for use during Concrete Paving in accordance with 2301.3B.3.a, “Combination Plant Lab – Office Requirements.”

If concrete is provided by a certified ready-mix plant, complete MnDOT Form 2164 *Contact Report 2014 - Paving* in accordance with 2301.3B.3.b “Certified Ready-mix Plant Lab - Office Requirements.”

B.3.a Combination Plant Lab – Office Requirements

The Concrete Paving Contractor QC technicians and the Department QA technicians will equally share a combination plant lab – office during Concrete Paving.

Provide a separate combination plant lab – office in accordance with 1604, “Plant Inspection – Commercial Facility,” except as modified by the following characteristics and requirements:

(1) Located at the plant site within 100 yards of the batch plant or other location, as approved by the Engineer
(2) Plant lab and plant office areas separated and isolated by a wall

(3) Total plant lab-office floor area, based on exterior dimensions, of at least 224 square feet
(4) Plant lab floor area, based on exterior dimensions, of at least 144 square feet
(5) Plant office floor area, based on exterior dimensions, of at least 80 square feet
(6) Heating and cooling system capable of maintaining a uniform temperature between 72° and 85°F
(7) Drinking water container or cooler with adequate supply of potable water
(8) Detached portable toilet conveniently located
(9) Electrical power supply that provides adequate amperage for electrical needs
(10) Water supply (storage tank with a capacity of 50 gallons or more, or pressurized water supply) connected to the sink faucet
(11) Provide a sample storage area to prevent contamination of the samples
(12) Plant lab furnished in accordance with the following:

(a) One sturdily-built workbench or countertop at least 30 inches by 144 inches
(b) One service sink located near one end of the workbench with a water supply, faucet, and an outside drain
(c) Shelf space above workbench or countertop or at other convenient locations, totaling at least 8 linear feet by 8 inches
(d) Electronic Scales of sufficient size to weigh the samples for required Materials testing
(e) A 4-burner 30 inch standard electric stove top or stove and at least 2 additional electric burners to perform required Aggregate testing per the *Schedule of Materials Control*
(f) Microwave oven with turntable or wave deflection fan (900 Watt), heat resistant glass pan (approx. 9 inches by 9 inches by 2 inches), plain weave fiberglass cloth (10 ounce per square yard and 14 mils thick), metal scrapper, and grinding pestle
(g) Metal bowls of sufficient size to perform required Material testing

(13) Plant office furnished in accordance with the following:

(a) Two desks, one for the Department and one for the Contractor, with total exterior dimensions of at least 30 inches by 60 inches
(b) At least 6 desk chairs
(c) A telephone capable of providing email
(d) A printer with scanning and copying capabilities

Do not begin Concrete Paving operations until the Engineer approves the combination plant lab–office.

B.3.b Certified Ready-mix Plant Lab – Office Requirements

For Concrete Paving Projects supplied by a certified ready-mix plant, provide the following:

(1) Electrical power supply that provides adequate amperage for electrical needs
(2) Water supply (storage tank with a capacity of 50 gallons or more, or pressurized water supply) connected to the sink faucet
(3) Electronic Scales of sufficient size to weigh the samples for required Materials testing
(4) At least 6 electric burners to perform required Aggregate testing per the *Schedule of Materials Control*
(5) Metal bowls of sufficient size to perform required Material testing
(6) If W/C Incentive and Disincentive apply, provide a microwave oven with turntable or wave deflection fan (900 Watt), heat resistant glass pan (approx. 9 inches by 9 inches by 2 inches), plain weave fiberglass cloth (10 ounce per square yard and 14 mils thick), metal scrapper, and grinding pestle

B.3.c Paving Plant Sampling and Testing

The Contractor and Engineer will perform testing in accordance with the *Concrete Manual* and determine testing rates in accordance with the requirements of the *Schedule of Materials Control*.

B.4 Contractor Project Documentation

Maintain and keep control charts current using the following MnDOT provided charts:

(1) *JMF Moving Average Summary*
(2) All Contractor plastic air content tests (including before and after consolidation) in the *Air Content Charting* chart

Provide batch tickets and test results to the Engineer daily. The Engineer may suspend plant operations if the Contractor fails to provide daily test results.

Provide reports, records, and diaries developed during the progress of construction Activities to the Engineer.

C Batching and Mixing

Batch and mix the concrete in accordance with 2461, “Structural Concrete,” and the following:

C.1 Batching Requirements

For a concrete paving batch plant, use an electronic meter approved by the Engineer to record the water, including Temper water, added to the mix that prints the amount of total water on each batch ticket.

For a ready-mix plant, record the total water added to the mix, including Temper water, on the computerized Certificate of Compliance.

Perform the initial spot check of the measuring Equipment in accordance with the *Concrete Manual* for accuracy and sensitivity before starting production operations. Provide a copy of the inspection certificate to the Engineer.

Provide to the Engineer a computerized batch ticket that includes the following:

(1) Date
(2) State Project number (SP) or (SAP)
(3) Time concrete was batched
(4) Quantity of concrete in this load
(5) Running total of each type of concrete, each day for each Project

(6) Mix number
(7) Labels identifying each Material that correlates with the Contractor mix design, including cementitious and admixture abbreviations or MnDOT 5 digit pit numbers
(8) Target weight of Materials
(9) Actual batched weights of Materials
(10) Temper water
(11) Total water weight

If satisfactory consolidation, finishing and curing of the pavement does not occur, as determined by the Engineer, suspend batching and mixing operations.

C.2 Job Mix Formula

The Engineer will determine the sampling location by using a random number chart and multiplying the random number by the sampling rate as defined in the *Schedule of Materials Control*.

Test and record the individual gradation results using the JMF *Weekly Concrete Aggregate Report*.

Calculate the moving average of 4 Contractor Aggregate gradation test results during production using the *JMF Moving Average Summary – Revised 2014* workbook.

C.2.a JMF Adjustments

If the Contractor expects a future JMF adjustment, submit a new mix design including JMF in accordance with 2301.2L.3, “Job Mix Formula.”

If, during concrete batching, the moving average of 4 Contractor Aggregate gradation tests falls outside the allowable JMF working range:

(1) Make immediate adjustments on the *JMF Adjustment Worksheet*, within the limits specified in Table 2301.3-1
(2) Review JMF adjustments with the Engineer. Provided the adjustments comply with Table 2301.3-1 both the Contractor and Engineer will sign the *JMF Adjustment Worksheet*. Once signed by both, resume paving
(3) If the moving average of 4 tests falls outside of the adjusted allowable working range, stop production and provide a new mix design including JMF to the Concrete Engineer

Table 2301.3-1
Allowable JMF Adjustments

Sieve Size	Allowable Adjustment percent
≥No. 4	±5
No. 8 – No. 30	±4
No. 50	±3
No. 100	±2

C.2.b Department Verification of JMF

The Engineer will randomly verify Contractor combined Aggregate gradation results as defined in the *Schedule of Materials Control*. Record the Department verification test results using the *JMF Moving Average Summary* workbook.

If the Engineer and Contractor's results on an individual fraction fall outside of the lab field tolerance established in Table 2301.3-2, the Engineer will test all split samples from that day's production.

If the gradation tests on any split samples from that day's testing result in a variation between the producer and the Engineer greater than that set forth Table 2301.3-2, the parties shall follow the procedures for test result dispute resolution available from the *Laboratory Manual*.

Table 2301.3-2
Allowable Variations on Percent Passing Sieves

Sieve Size	Allowable Percentage
2 inch – 1 inch	±8
3/4 inch – 3/8 inch	±6
No. 50	±3
No. 100	±2
No. 200	±0.6

C.3 Optimized Aggregate Gradation

The Engineer will use the Contractor's combined Aggregate gradation (JMF) test results documented in the JMF *Concrete Aggregate* worksheet - JMF, as verified by the Engineer in accordance with 2301.3C.2.b, "Department Verification of JMF," to determine eligibility for the incentive in accordance with 2301.5I.1, "Optimized Aggregate Gradation Incentive." The Department establishes the optimized Aggregate gradation band, on a percent retained per Sieve size basis and the coarse sand percent retained and fine sand percent retained in accordance with Table 2301.3-3.

Table 2301.3-3
Optimized Aggregate Gradation Band

Sieve Size	Percent Retained
2 inch	0
1 1/2 inch	≤ 5
1 inch	≤ 16
3/4 inch	≤ 20
1/2 inch	4 - 20
3/8 inch	4 - 20
No. 4	4 - 20
No. 8	≤ 12
No. 16	≤ 12
No. 30	4 - 20
No. 50	4 - 20
No. 100	≤ 10
No. 200	≤ 2
coarse sand percent retained (No. 8 to No. 30 Sieve)	>15
fine sand percent retained (No. 30 to No. 200 Sieve)	24 - 34

The Engineer will use statistical analysis of the Contractor's combined (averaged) Aggregate gradation samples for well-graded Aggregate on a per lot basis representing one day's paving. Each combined Aggregate gradation is considered a sublot. The lot will represent the cumulative average of the sublot values on each Sieve for the gradation band.

If the quantities of concrete produced results in no gradation testing for any given day, include the untested quantity of concrete into the next day's production and include that quantity of concrete in the sampling rate. If the untested quantity is on the last day of production, add that quantity to the previous day's production.

C.4 Aggregate Moisture Content

The Contractor and Engineer will perform Aggregate moisture content testing in accordance with the *Schedule of Materials Control*.

C.5 Water/Cement (W/C) Ratio

Provide and place concrete with a water/cement ratio not to exceed 0.40 when using cement only or fly ash and 0.42 when using slag or ternary. Make any adjustments immediately when the water/cement ratio exceeds 0.40 when using cement only or fly ash and 0.42 when using slag or ternary.

C.6 Water/Cement (W/C) Ratio Determination

For Projects with 3,500 cubic yard or greater of Paving Concrete, the Engineer will sample, test, and record the individual results in accordance with 2301.3C.6.a "Water Content Determination," and 2301.3C.6.c, "Cementitious Content Determination," at a rate defined in the *Schedule of Materials Control*. The Engineer will use the *W/C Ratio Calculation* worksheet for determining the Incentive/Disincentive in accordance with 2301.5I.2, "W/C Ratio Incentive/Disincentive."

C.6.a Water Content Determination

The Engineer will determine the water content for calculating the water/cement ratio using the average water calculated from 10 batch tickets or Certificates of Compliance surrounding the randomly selected batch ticket sample (4 previous tickets, ticket representing the random sample, and the 5 following tickets).

C.6.b Water Content Verification

The Engineer will use plastic concrete taken at the plant site to verify the water content in the mix as determined in accordance with 2301.3C.6.a, "Water Content Determination." Sample the plastic concrete as directed by the Engineer.

The Engineer will verify the water content in the plastic concrete mixture using the test procedure specified in *AASHTO T 318-15*, "Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying." The Engineer will begin the test within 15 minutes after the water has contacted the cement. Provide the microwave oven and the ancillary Equipment as required by the Engineer to perform this test.

C.6.c Cementitious Content Determination

The Engineer will determine the cementitious content for calculating the water/cement ratio using the average total cementitious calculated from 10 batch tickets or Certificates of Compliance surrounding the randomly selected batch ticket sample (4 previous tickets, the ticket representing the random sample, and the 5 following tickets).

C.7 Coarse Aggregate Quality

The Engineer will accept the coarse Aggregate for Paving Concrete by statistical methods and in accordance with other concrete Aggregate quality requirements of 2301, "Concrete Pavement."

C.7.a Sampling and Determination of Lots

The Engineer will use the *Coarse Aggregate Quality Workbook* to determine the random sampling locations in accordance with the *Schedule of Materials Control* and to calculate the Incentive/Disincentive in accordance with 2301.5I.3, "Coarse Aggregate Quality Incentive/Disincentive."

The Engineer will consider the entire Project as a single lot for each of the 2 fractions containing the highest percentage by weight. If the Project is planned for construction over multiple years and before placing any concrete pavement, request that the Engineer calculate the Incentive/Disincentive payment on a yearly basis. The Engineer, in conjunction with the Concrete Engineer, will modify the sampling and testing rates as necessary.

The Engineer will establish a new statistical family for each change in Aggregate source, fraction, or both.

The Engineer will divide a lot representing the Plan cubic yards of concrete by the number of samples to form sublots. The Engineer will multiply the number of cubic yards in a sublot by a random number to obtain the position in the sublot for the sample. The Engineer will split the samples and leave half of the samples for the Contractor. The Engineer's laboratory will test the samples and report the individual results.

The Engineer will calculate a Quality Index (QI) for each fraction in accordance with the following:

$$QI = X + k(s)$$

Where:

$$\mathrm{X} = \mathrm{mean} = \sum \frac{X_i}{n}$$

X_i = individual test results

$$\mathrm{s} = \text{standard deviation} = \sqrt{\sum \frac{(x_i - x)^2}{(n-1)}}$$

k = Adjustment Factor based on number of tests as shown in Table 2301.3-4:

Table 2301.3-4
Adjustment Factor "k"

k	No. of Tests
1.09	3
1.20	4
1.23	5
1.26	10
1.27	≥15

C.8 Concrete Ingredient Summaries

If delivering bulk cementitious Materials directly to the concrete batching plant in railroad cars or sealed transport trucks, submit copies of the bill of ladings to the Engineer on the same day received from the transporting company.

Advise the Engineer of the method and schedule of cementitious Material unloading. Do not unload cementitious Materials until the Engineer approves the operation.

Each day of Concrete Paving production, provide the Engineer with a production summary in an electronic format that includes the following:

(1) Daily total concrete produced in cubic yards for each concrete mixture type
(2) Daily total ingredient quantities (Aggregate, cementitious, and water) including the percent overrun/underrun

Provide final Project total quantities in electronic format for (1) and (2) to the Engineer at the end of the Project.

C.8.a Verification of Cement Usage

The Engineer will use the *Concrete Ingredient Summary* worksheet to verify the following:

(1) Individual daily cement quantity does not show an underrun in cement usage greater than 1.0 percent of the quantity specified
(2) The final cement quantity summary does not show an overall underrun greater than 1.0 percent

D Subgrade and Aggregate Base Preparations

Prepare the Subgrade and Aggregate base in accordance with 2106, "Excavation and Embankment – Compacted Volume Method," 2112, "Subgrade Preparation," and 2211, "Aggregate Base," and the following:

Fine grade the Aggregate base to the shape and grade shown on the Plans, allowing construction of the pavement to the thickness and cross-section shown on the Plans. Use an approved fine grading machine mounted on crawler tracks.

Complete base construction of a sufficient width outside the edge of the pavement to support the slipform paver treads without distortion of the alignment or grade line.

Shape and maintain the Shoulders to allow surface water to drain away from the pavement and off the Shoulders.

E Concrete Equipment and Paving Operations

Provide self-propelled spreading and finishing machines capable of consolidating and finishing the concrete, and producing a dense and homogenous finished surface meeting the requirements specified in 2301, "Concrete Pavement."

E.1 Consistency

Maintain the concrete at a uniform consistency. The Engineer will not allow an edge slump greater than 1/8 inch or irregular edge alignment.

For slipform concrete pavement placement, place the concrete with a slump value that optimizes placement, except ensure the concrete does not slough or slump and is adequately consolidated and meets all other requirements of 2301, "Concrete Pavement."

For fixed form placement, place the concrete with a slump no greater than the maximum allowable slump in accordance with Table 2301.2-4.

E.2 Slipform Construction

Place concrete using a slipform paver or combination of pavers designed to spread, consolidate, screed, and float-finish the freshly placed concrete with minimum hand finishing. Provide a slipform paver with a non-oscillating extrusion plate with an adjustable angle of entry.

Place the concrete pavement before placing curb and gutter.

If the sequence of operations includes placing the curb and gutter before the concrete pavement, submit a jointing Plan to the Engineer for approval. Submit the jointing Plan to the Engineer a minimum of 7 Calendar Days before placing the curb and gutter.

Equip the paver with automatic grade control capable of maintaining both the elevation and longitudinal line shown on the Plans on both sides of the paver.

Use an erected string line to achieve the line and grade reference. Tightly stretch a string line set parallel to the established grade for the pavement surface to achieve the grade reference. Set the control reference and support the line at intervals to maintain the established grade and alignment.

When constructing concrete overlays, set and use string lines for grade control on both sides of the Roadway during paving operations.

Operate the slipform paver with a continuous forward movement coordinating mixing operations, providing adequate concrete hauling units, and spreading concrete to provide uniform progress with minimal stopping and starting of the paver.

Consolidate the full width and depth of concrete pavement placed by a single pass of a series of internal vibrators. Operate full-width vibrators from 3,600 VPM to 7,000 VPM in concrete, and from 4,150 VPM to 8,000 VPM when checked in air. Deliver the vibrator impulses directly to the concrete and operate at an intensity to consolidate the concrete uniformly throughout the entire depth and width of the concrete. The Contractor may increase the vibrator frequency as approved by the Engineer. Perform additional testing as directed by the Engineer at no additional cost to the Department. If the vibrator fails, suspend operations and remove unconsolidated concrete.

Regulate the rate of progress of the vibratory Equipment and the duration of the application to fully, but not excessively, vibrate the concrete. If the forward progress of the paver stops, suspend the operation of vibrators.

Attach vibrators to spreading or finishing Equipment. Do not allow vibrators to come in contact with preset dowel basket assemblies, the grade, pavement reinforcement, or side forms. Do not allow the operation of vibrators to cause separation or segregation of the mix ingredients, including the downward displacement of large Aggregate or the accumulation of laitance on the concrete surface. The Contractor may reduce the vibration frequency within the specified range if reducing the forward progress of the paver to avoid segregation of the concrete mix. Connect the power to vibrators so that they cease when the machine motion is stopped. Stop paving operations if a vibrator fails to operate within the range specified above.

E.2.a Electronic Vibration Monitoring Device

For Projects with greater than 3,500 cubic yards, provide an electronic monitoring device meeting the following characteristics and requirements to display the operating frequency of each individual internal vibrator for concrete pavement placed by the slipform method:

(1) Contains a readout display near the operator's controls; visible to the paver operator and to the Engineer
(2) Operates continuously as the paving machine operates
(3) Displays the vibrator frequencies with manual and automatic sequencing for each of the individual vibrators
(4) Record the following at least every 25 feet of paving or at least every 5 minutes of time:

(a) Clock time
(b) Station location
(c) Paver track speed
(d) Operating frequency of individual vibrators, expressed as VPM

Provide an electronic copy containing the record of data after the completion of the concrete paving operation. Provide vibration data daily as directed by the Engineer.

E.3 Fixed Form Construction

E.3.a Setting Forms

Provide forms meeting the following requirements and characteristics:

(1) Steel, straight edge sides
(2) Depth equal to the pavement thickness shown on the Plans
(3) Smooth and free of localized indentations and deformities
(4) Top face with deviations no greater than 1/8 inch in any 10 foot section
(5) Faces of straight forms with deviations no greater than 1/4 inch in any 10 foot section
(6) Forms containing no damaged joint locks or pin pockets
(7) Form lengths at least 10 feet long with vertical joint

For pavements with radii no greater than 100 feet, use flexible or curved forms approved by the Engineer. Provide devices to securely set forms and withstand operation of the paving Equipment without springing, settlement, or lateral displacement. Provide forms with joint locks to tightly join the ends of abutting form sections. Connect individual form sections using methods that create a continuous form.

Set the forms to the alignment and grade shown on the Plans for a distance equal to at least 3 hours ahead of concrete placement. Remove and rest the forms as necessary to allow drainage.

Compact the foundation before placing the forms in accordance with 2301.3D, "Subgrade and Aggregate Base Preparations." Ensure the forms have a firm and uniform bearing over the entire base area, are tightly joined and securely staked, and are clean and free of accumulations of hardened concrete. Coat the contact faces of the forms with an approved form coating Material in accordance with 3902, "Form Coating Material," before placing the concrete.

E.3.b Fixed Form Placement

Place concrete using one or more machines to spread, screed, and consolidate between previously set side forms. Accomplish vibration of these areas using hand-held or machine-mounted internal vibrators.

If not using an electronic monitoring device, use a tachometer or similar device to demonstrate to the Engineer that the paving Equipment vibration meets the requirements in this section.

Use hand-held vibrators to consolidate concrete adjacent to side forms and fixed structures. Operate the hand-held vibrators at a speed of at least 3,600 VPM. Do not allow the vibrator head to contact the joints, load transfer devices, reinforcement, grade, or side forms. If the vibrator fails, suspend operations and remove unconsolidated concrete.

Continue vibration to achieve adequate consolidation, without segregation, for the full depth and width of the area placed.

Provide an adequate number and capacity of machines to perform the Work at a rate equal to the concrete delivery rate.

Strike-off concrete with a clary screed, unless otherwise approved by the Engineer. Finish small or irregular areas that are inaccessible to finishing Equipment using other methods as approved by the Engineer.

Discontinue any operation that causes displacement of the side forms from the line or grade or causes undue delay, as determined by the Engineer, due to mechanical difficulties.

E.3.c Removal of Forms

Do not remove side forms of pavement and back forms on integrant curb earlier than 12 hours after placing the concrete, unless otherwise approved by the Engineer. Remove forms without exerting shock or strain, including temperature variations, on the pavement or curb. Cure concrete in accordance with 2301.3M.1.a, “Membrane Curing Method.”

F Placing Concrete

Construct mainline pavement in a single Layer of concrete. Place the concrete pavement in one complete pass of the paving machine to minimize the need for hand finishing.

The Engineer will not allow the edges of the pavement, including longitudinal joints, to deviate from the line shown on the Plans by greater than 1/2 inch at any point.

Place concrete without any vertical surface deviations of the plastic concrete when matching into the beginning and end of the Project, Bridge approaches and decks, unless otherwise allowed by the Engineer. Correct high and low spots identified within the 10 foot straightedge.

Coordinate paving operations for mixing, delivering, spreading, and extruding the concrete to provide uniform progress of the paver. Use sufficient trucks to ensure a steady forward progress of the paver. If the forward movement of the paver stops for a period long enough to create a cold joint or honeycombing, construct a header joint in accordance with 2301.3F.5 “Constructing Headers.”

Do not add water to the surface of the concrete to aid in finishing without the approval of the Engineer. The Engineer will give 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 can request approval to add water to the surface when cutting bumps or filling dips in the plastic concrete each time additional water is needed. If the Contractor adds water to the pavement surface without approval by the Engineer, the Department will not pay Incentives for water/cement or pavement Smoothness on sections where the water is added. The Engineer may also reject the pavement in accordance with 1512, "Unacceptable and Unauthorized Work."

Set manhole and catch basin frames or rings to the elevation shown on the Plans during the paving operations. Do not form "box-outs" of castings unless approved by the Engineer.

Dump or discharge concrete without causing grade displacement or damage to the existing asphalt or bond breaker Layer. Protect the grade, asphalt, or bond breaker Layer as necessary for concrete trucks. Repair damage to the grade in accordance with 2301.3D, "Subgrade and Aggregate Base Preparations," and existing asphalt or bond breaker Layer as approved by the Engineer at no additional cost to the Department.

F.1 Placement on Aggregate Base

Maintain the base in a moist condition until placement of concrete.

F.2 Placement on Asphalt or Asphalt Bond Breaker

When placing concrete on asphalt or asphalt bond beakers, comply with the following:

(1) Do not place concrete on an asphalt surface with an asphalt surface temperature greater than 120°F
(2) Maintain the asphalt surface in a moist condition and at a surface temperature not greater than 120°F before placing the concrete; the Engineer will allow the Contractor to apply water, whitewash of hydrated lime and water, or both to cool the asphalt surface, or other methods allowed by the Engineer
(3) Before placing concrete on a milled asphalt surface, clean the milled surface by sweeping and patch as shown on the Plans in accordance with 2231, "Bituminous Surface Reconditioning," or as directed by the Engineer

F.3 Placement on Type 8 Non-woven Geotextile Interlayer

Furnish Type 8 Geotextile from the *Approved/Qualified Products List* in accordance with 3733, "Geosynthetic Materials."

When placing concrete on the geotextile interlayer, comply with the following:

F.3.a Handling and Placement Requirements

(1) Before the placement of the geotextile interlayer, remove loose or deteriorated surfacing in accordance with 2231.3, "Bituminous Surface Reconditioning, Construction Requirements" or as directed by the Engineer. The Contractor may propose a cementitious Material, or other equivalent patching Material as approved by the Engineer. The patch shall provide a flat, tight surface before placement of the geotextile interlayer.
(2) Roll geotextile out on underlying substrate. Ensure geotextile is tight without excess wrinkles and folds. Place the geotextile within 7 Calendar Days of concrete paving in such a way that free drainage of water within the geotextile is not impaired.

    (a) When covering the entire surface with the geotextile, the geotextile should overlap by 8 inches +/- 2 inches. In no location should more than 3 Layers of geotextile overlap.
    (b) When placing geotextile strips only under dowel bar basket assemblies, the geotextile width should extend longitudinally

2 to 3 inches outside each side of the bottom rungs of the dowel bar basket assembly for the entire width of the Roadway.

(3) Geotextile should extend at least 3 inches beyond the most outside edge of the new concrete or extended out to the location shown in the Plan.
(4) Geotextile must drain into subsurface drains or a drainable pavement Layer as shown in the Plan.
(5) Place the geotextile interlayer to a grade and tolerance such that the overlying PCC pavement thickness will meet minimum design requirements.
(6) Adhere the geotextile to the underlying substrate using manufacture recommended cylinder spray adhesive for geotextiles to attach the geotextile to the underlying concrete or asphalt. Apply a minimum 12 inch wide adhesive bond to attach any edge of geotextile to the underlying substrate or to another piece of geotextile. Apply pressure to the geotextile to set the adhesive before placing the concrete. The Contractor may propose and demonstrate, to the Engineer for approval, alternate methods for satisfactorily anchoring the geotextile.
(7) Slightly dampen, but not saturate, the geotextile before concrete placement.

F.3.b Maintenance Requirements

Maintain the geotextile interlayer during and after placement throughout its entire length until placement of the concrete overlay. During this maintenance period, correct any deficiencies to the satisfaction of the Engineer. The bond breaker Layer shall always drain properly. Do not place geotextile on areas subject to excess traffic until immediately before concrete placement.

During construction, keep the geotextile and associated drain trenches free of fine soils or other contaminates. If contamination of the geotextile interlayer occurs, remove and replace or clean the surface to the satisfaction of the Engineer to assure drainage capacity as designed at no cost to the Department.

If a rain event occurs after placement of the geotextile, remove excess water from the geotextile by use of rollers or any method acceptable to the Engineer.

F.4 Placement Adjacent to In-Place Concrete

Secure preformed joint filler Material for expansion joints in-place to maintain the position shown on the Plans during concrete placement.

Screed newly placed pavement to the same elevation as the in-place concrete to 1/4 inch or less.

When placing concrete adjacent to in-place concrete, protect the following:

(1) All ends of transverse joints 3/16 inch or wider to the satisfaction of the Engineer; the Engineer will allow sawing through the existing joint when sawing the newly placed concrete
(2) The in-place pavement to prevent damage

F.5 Constructing Headers

Use any approved construction header method as shown in the *Standard Plate 1150* when constructing construction headers, temporary headers, and permanent headers as shown on the Plans. The Contractor may propose and demonstrate alternative construction header methods to the Engineer for approval. In the plastic concrete, the Engineer may evaluate headers for vertical surface deviations with a 10 foot straightedge. Correct high and low spots identified within the 10 foot straightedge.

The Engineer will not allow incorporating any concrete accumulated in the grout box of the paver into the pavement. Construct headers such that the concrete contained in the grout box is removed from the Project.

Use internal vibration to consolidate the concrete along header joints before final finishing.

F.6 Air Content

Place Type 3 paving concrete meeting the air content requirements in the Work.

Sample and test the air content of the concrete in accordance with the *Schedule of Materials Control*. Using the MnDOT *Air Content Chart*, record air content test results.

F.6.a Air Content before Consolidation

Measure the air content of the plastic concrete after placement on the grade but before consolidation. Maintain the air content of Type 3 paving concrete at the specified target of 7.0 percent (plus 2.0 percent / minus 1.5 percent) of the measured volume. Make adjustments immediately to maintain the desired target air content, in accordance with Specification 1503, “Conformity with Contract Documents.”

F.6.b Air Content after Consolidation

If using the slipform paving method, determine the air content after consolidation. Place concrete with an air content of at least 4.5 percent after consolidation.

F.6.b(1) Air-Loss Correction Factor (ACF)

Determine the ACF by subtracting the air content after consolidation from the air content before consolidation. If the ACF exceeds 2.0 percent, take another test as soon as possible to verify/adjust for a new ACF.

F.6.b(2) ACF Adjustment to Air Content Tests before Consolidation

Each time an ACF is determined, apply the ACF to subsequent air content tests before consolidation and evaluate in accordance with 2301.3F.6.b(3), “Non-Conforming Air Content after Consolidation.”

F.6.b(3) Non-Conforming Air Content after Consolidation

If the Contractor or Engineer test results in an air content after consolidation of less than 4.5 percent, take the following actions:

(1) Immediately retest and verify the ACF is correct.
(2) If the results are still < 4.5 percent, make immediate adjustments to the concrete or the consolidation process, test any loads that have not been discharged or adjusted at the plant, and apply the ACF to determine compliance.

(3) Test every load of concrete until the air content test results are ≥ 4.5 percent.
(4) Test at least 3 additional trucks to ensure the concrete remains in compliance.
(5) Perform additional testing on the hardened concrete as required by the Engineer in conjunction with the Concrete Engineer.

G Pavement Reinforcement

Provide epoxy coated reinforcement in accordance with 2472, “Metal Reinforcement,” except pavement reinforcement bars are not required to have epoxy coated ends.

Place epoxy coated reinforcement bars including tie bars, taper steel, and stopper bars as shown on the Plans.

Construct tied longitudinal joints in accordance with the following:

(1) Provide and place tie bars on chairs, in stakes, utilizing tie bar basket assemblies, or by appropriate Equipment for depressing the bars to the specified location.
(2) For slipform paving, stake the tie bar steel to the Roadbed or use a mechanical device attached to the spreader or paver to place tie bar steel required for L1T joints as shown on the Plans. Space and depress the tie bar steel to the depth and location shown on the Plans. Do not place tie bars over transverse contraction joints.
(3) Keyway use is optional when placing fixed form construction of any thickness or when placing slipform construction with a pavement design thickness of 10 inches or greater.
(4) Use of keyway for any other applications requires approval by the Engineer.

In accordance with *Standard Plate 1070*, provide supplemental pavement reinforcement in single units for lane widths shown on the Plans, unless otherwise approved by the Engineer.

H Dowel Bars

Place dowel bars parallel to the substrate surface and parallel to the centerline of the pavement.

Before placing the concrete, mark the location on both sides of each transverse joint as approved by the Engineer. Ensure the proposed sawcut is centered on the dowel bars and that the dowels remain parallel to the Roadway centerline. Transfer the markings to the top surface of the fresh concrete immediately after completing the final finishing operations.

H.1 Dowel Basket Assemblies

Secure dowel bar assemblies with anchors to hold the dowel bars in the correct position and alignment while preventing movement during concrete placement. Fasten the baskets to the substrate surface so that they do not move vertically or horizontally more than 1/4 inch.

In accordance with *Standard Plate 1103*, provide dowel bar assemblies manufactured in single units for the lane widths shown on the Plans, unless otherwise approved by the Engineer. For non-typical lane widths, do not (splice) use more than two dowel bar assemblies in any one doweled joint.

Within 1 hour before covering with concrete, coat the dowel bars with a uniform coating of a form coating or other Material in accordance with 3902, “Form Coating Material.”

Provide a Quality Control Plan for anchoring dowel basket assemblies in accordance with 2301.3H.1.a, “Quality Control Plan for Anchoring Dowel Basket Assemblies.”

H.1.a Quality Control Plan for Anchoring Dowel Basket Assemblies

At least 7 Calendar Days before the beginning of concrete paving, provide a Quality Control Plan in writing to the Engineer for acceptance that provides a method for keeping the dowel basket assemblies anchored to the grade, the existing concrete, or into the asphalt or bond breaker Layer and into the underlying concrete.

The Quality Control Plan shall include the following at a minimum:

(1) Proposed type, location, number and length of fasteners
(2) Proposed installation Equipment
(3) Dowel basket assembly anchoring Plan (i.e. anchor all basket assemblies before concrete placement, one lane at a time, anchor all basket assemblies during the concrete placement operation, etc.)
(4) Action plan if misaligned baskets are identified during concrete pavement placement

Before the beginning of concrete pavement placement and each day before beginning paving, demonstrate the fastening method to the Engineer for approval.

The Engineer will suspend paving operations if the Contractor fails to comply with their Quality Control Plan.

H.2 Dowel Bar Inserter

The Contractor may use a mechanical dowel bar inserter to place dowel bars in the pavement as approved by the Engineer, in conjunction with the Concrete Engineer.

Immediately before inserting the dowel bars, coat the dowel bars with a uniform coating of a form coating Material in accordance with 3902, "Form Coating Material."

If using a dowel bar inserter, initially and on each production day, demonstrate to the Engineer that the inserted dowel bars in the completed concrete pavement are parallel to the surface and centerline slab and are located at mid-depth of the slab thickness.

I Definition of a Lot and Sublot for Concrete Field Testing

I.1 Lot Establishment

The Engineer will select random locations for locating dowel bars, reinforcement (L1T) steel, pavement texture, and concrete probing testing. Doweled concrete Shoulders less than 10 feet in paved width and undoweled concrete Shoulders are not included as part of the Lot.

For specification section 2301, "Concrete Pavement," the Department considers each of the following a single lane:

(1) From the pavement edge to the adjacent longitudinal joint
(2) From one longitudinal joint to the next
(3) In the absence of a longitudinal joint, between pavement edges
(4) Each Ramp and Loop ≤ 18 feet in width
(5) Doweled concrete Shoulder ≥ 10 feet in width

I.2 Sublot Establishment

Once established, the Engineer will divide the Lot into sublots, representing 1,000 linear lane feet. The Engineer will add partial sublots less than 500 linear lane foot to the previous sublot. The Engineer will consider partial sublots equal to or greater than 500 linear lane feet as individual sublots. If the Project results in less than four sublots, the Engineer will divide the Project into four sublots of equal length.

The Engineer will provide the sublot testing locations to the Contractor before pavement placement. The Engineer will utilize random numbers to locate specific testing locations within the sublots at the minimum rates defined in:

(1) 2301.3J.2, “Minimum Plastic Concrete MIT-SCAN Testing Rates”
(2) 2301.3K.1.a, “Texture Testing”
(3) 2301.3L.2, “Contractor Quality Control Probing or Scanning”

J Dowel Bar and Tie Bar Placement Testing in Plastic Concrete

For concrete paving Projects greater than 3,500 cubic yard, provide a MIT-SCAN non-destructive testing device in accordance with this section for concrete pavement placed by the slipform method.

J.1 MIT-SCAN-T2 or T3 (MIT SCAN) Non-Destructive Testing Device

The Contractor shall furnish a MIT-SCAN non-destructive testing device or approved equal, as determined by the Concrete Engineer, having the ability to locate pavement reinforcement and dowel bars, and measure concrete pavement thickness in a single device. Department and Contractor personnel shall mutually use this non-destructive testing device to locate dowel bar and tie steel placement in the plastic concrete during pavement construction.

Department observations do not relieve the Contractor of the requirement to properly place the concrete reinforcement and dowel bars as shown in the Plans. In addition, the Engineer reserves the right to reject the pavement in accordance with 1503, “Conformity with Contract Documents” and 1512, “Unacceptable and Unauthorized Work.”

The Engineer will not provide additional payment for furnishing the above Equipment for the Department's use.

J.2 Minimum Plastic Concrete MIT-SCAN Testing Rates

The Engineer will identify the MIT-SCAN random testing locations using the MnDOT *Thickness, Texture and MIT-SCAN* workbook in accordance with the *Schedule of Materials Control*.

Offset the location of the dowel bar test to the closest contraction joint.

Before the start of paving, the Engineer will provide the MIT-SCAN report generated from the MnDOT *Thickness, Texture and MIT-SCAN* workbook to the Contractor.

Unless otherwise approved by the Engineer, perform testing with the MIT-SCAN device in the presence of the Engineer.

Locate the entire span of the dowel bar and machine placed tie bar (L1T) steel in the plastic concrete, utilizing a walk Bridge that spans the width of the pavement and perform the following:

(1) Verify the adequacy of the dowel bar basket anchoring by locating both the upstream and downstream edges of the dowel bar baskets
(2) Verify the presence and alignment of tie bar (L1T) steel by locating both ends of the tie bar

J.3 Alignment Tolerances

Ensure the dowel bar and tie bar placement complies with the following tolerances:

(1) For dowel bars, the proposed sawcut is centered on the dowel bars (± 3 inches) and the dowels remain anchored parallel to the Roadway centerline
(2) For tie bars, the proposed saw cut is centered on the tie bar (± 5 inches)

J.4 Non-conforming Placement

If a dowelled contraction joint has dowel bars out of acceptable alignment during placement in accordance with 2301.3J.3, “Alignment Tolerances,” and *Standard Plate 1103*, scan both upstream and downstream from the misaligned transverse doweled joints, from concrete placed in the same operation, until at least 3 joints comply with *Standard Plate 1103*.

If a panel along the tied longitudinal (L1T) joint is found to have 2 or more tie bars missing or out of acceptable alignment tolerances specified in 2301.3J.3, “Alignment Tolerances,” scan joints on both ends until 3 consecutive panels meet the correct number of tie bars installed and acceptable tie bar alignment tolerances.

If at any time the Engineer determines the dowel bar anchoring or tie bar placement processes are unacceptable due to alignment/tolerance issues, the Engineer may request the Contractor amend the placement process for the operation in question to achieve satisfactory placement of the dowel bars and tie bars.

The Engineer will consider concrete pavement that fails to comply with the alignment tolerances as unacceptable Work in accordance with 1512, “Unacceptable and Unauthorized Work.” The Engineer, in conjunction with the Concrete Engineer, will evaluate the defective concrete pavement in accordance with 2301.3Q “Workmanship and Quality.”

K Surface Finishing

Use a 3/8 inch radius edging tool to finish edges of the pavement. Do not add water to the surface of the concrete to aid in finishing without the approval of the Engineer.

If satisfactory finishing of the pavement does not occur, as determined by the Engineer, suspend batching and mixing operations.

After consolidating, screeding, and floating the concrete, give the pavement surface a final finish texture in accordance with 2301.3K.1, “Pavement Texture.”

K.1 Pavement Texture

Pull the carpet drag longitudinally over the finished surface to produce a uniform final finish textured surface. Provide a texture depth of at least 1.00 millimeters in accordance with *ASTM E965-87, Test Method for Measuring Surface Macrotexture Depth Using a Sand Volumetric Technique.*

Provide artificial grass type carpeting for the carpet drag meeting the following characteristics and requirements:

(1) Molded polyethylene pile face
(2) Blade length from 5/8 inch to 1 inch
(3) Total weight of at least 70 ounces per square yard

Mount the drag on a Bridge having external alignment control. Provide a drag as wide as the concrete placed without causing edge slump. Maintain continual contact between the drag and the pavement surface during texturing. Apply down pressure on the pavement surface as necessary to achieve uniform texturing.

The Contractor may use manual methods including brooms to achieve similar results on the edges of the pavements and Ramps and other locations as approved by the Engineer.

The Contractor may use other texturing Equipment to obtain an equivalent texture as approved by the Engineer in conjunction with the Concrete Engineer.

For concrete pavements with a posted vehicle speed less than or equal to 45 miles per hour, use either a carpet drag or broom drag longitudinally to achieve a uniform final finish textured surface.

K.1.a Texture Testing

The Engineer will identify the texture testing locations in accordance with 2301.3I, "Definition of a Lot and Sublot for Concrete Field Testing," and the following:

(1) Use the MnDOT *Thickness, Texture and MIT-SCAN* workbook to determine the random testing locations
(2) Provide the Concrete Texture report generated from the MnDOT *Thickness, Texture and MIT-SCAN* workbook to the Contractor before the start of paving
(3) Offset the texture test at a point located transversely in the outside wheel path
(4) For concrete roundabouts (not including the truck apron), perform a minimum of 3 texture tests

Perform surface texture testing of the concrete pavement and provide the test results to the Engineer no later than 48 hours after pavement placement unless otherwise approved by the Engineer.

K.1.b Non-conforming Texture

The Engineer will evaluate the texture results in accordance with Table 2301.3-5 and the following:

(1) If any texture test results fall below the minimum required, correct the operation immediately to achieve the minimum required texture.
(2) If the Engineer determines by visual inspection that areas not represented by random testing appear to not meet the minimum texture required, the Engineer reserves the right to require additional testing in those specific areas to determine compliance.
(3) Run additional tests at 100 foot intervals before and after the failing test location to determine the limits of any individual failing test until an acceptable minimum texture of 1.00 millimeters is obtained.

Table 2301.3-5
Pavement Texture Depth

Texture Depth Test Results for Individual Tests	Resolution
≥ 1.00 millimeter	Meets requirements – no action required
<1.00 millimeter to ≥0.80 millimeter	The Engineer will accept the Work if the Contractor amends the operation to achieve the required depth of at least 1.00 millimeter as approved by the Engineer. If the Contractor fails to correct the operation, the Engineer will suspend the paving operation until corrections produce the required results.
< 0.80 millimeter	Perform concrete grinding of the pavement represented by this test to attain the minimum texture of 1.00 millimeter as required by the Engineer.

L Pavement Thickness Requirements

Provide pavement with a finished pavement thickness as shown on the Plans or as modified, in writing, by the Engineer.

L.1 Thickness Evaluation Procedure

The Engineer will evaluate each differing concrete pavement thickness required on the Project. The Engineer will evaluate the concrete pavement through random probing or scanning and core measurements in accordance with the following:

(1) Quality Control Probe (QCP) or Quality Control Scan (QCS)
(2) Probe Verification Core (PVC)
(3) Quality Acceptance Core (QAC)

The Engineer will identify the thickness measurement using the MnDOT *Thickness, Texture and MIT-SCAN* workbook to determine the random testing locations.

Adjust the location to ensure no measurements are taken within 1 foot of the pavement edge and within 4 feet of any transverse or longitudinal joint or other obstructions.

Before the start of paving, provide the field probing or scanning report generated from the MnDOT *Thickness, Texture and MIT-SCAN* workbook to the Contractor.

L.2 Contractor Quality Control Probing or Scanning

Perform QCP on concrete paving Projects 3,500 cubic yards or less and concrete overlays Projects where the underlying pavement at any depth is concrete.

Perform QCS on concrete paving Projects greater than 3,500 cubic yards when the concrete is placed directly on grade or the concrete overlay is placed on an existing asphalt pavement with no underlying concrete.

Measure the pavement thickness of freshly finished concrete pavement at a rate of at least one thickness measurement per sublot.

Perform the thickness measurements in the presence of the Engineer unless otherwise approved by the Engineer. Record the results on the field probing or scanning report.

Provide daily summary reports listing the results of the day's QCP or QCS thickness measurements and additional probing or scanning results to the Engineer.

L.2.a Contractor Probing

L.2.a(1) QCP Probing Equipment

Provide the following Equipment as approved by the Engineer to perform probing:

(1) Probing rod meeting the following characteristics and requirements:

(a) Non-flexing
(b) Length capable of completely penetrating the pavement for measuring
(c) Utilizes a circular or square top plate
(d) Contains a centrally located hole in the top plate with a diameter allowing for easy maneuvering along the length of the probing rod
(e) Fitted with a locking device fixing the angle between the top plate and the probing rod at 90 degrees when locked

(2) Base plate meeting the following characteristics and requirements:

(a) 30 centimeter ± 0.1 millimeter diameter, 660 micrometer ± 10 micrometer thick, steel (*ASTM A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*, Type 2 Commercial 1 Grade, G90) circular plate supplied by Kessler Soils Engineering Products, Inc. or approved equal
(b) Rigid when in place, allowing the probing rod to be pushed against it without flexing

(3) Work Bridge meeting the following characteristics and requirements:

(a) Spans the full width of the freshly laid concrete
(b) Supports a person
(c) Height above the concrete allows for the use of the probing device

(4) Tape measure accurate to nearest 1/8 inch and with a length capable of measuring the depth of penetration of the probing device into the plastic concrete pavement

L.2.a(2) QCP Probing Method
Perform probing in accordance with the following:

(1) Place the base plates at the randomly selected locations and anchor the plates to prevent movement during concrete placement. Mark the locations of the base plates to ensure ease of locating the plates after the paver has passed.
(2) Position the Bridge at the selected locations to reach and locate each point.
(3) Assemble the probing device. Keeping the probing rod perpendicular to the pavement surface, insert the rod into the plastic concrete until the rod strikes the base plate.
(4) Slide the top plate down the probing rod until it contacts the pavement surface then lock to the probing rod.
(5) Withdraw the probing device.
(6) Measure the length of the probing rod inserted into the plastic concrete from the underside of the top plate to the end of the probing rod. Record this measurement to the nearest 1/8 inch.

L.2.b Contractor Scanning

L.2.b(1) QCS Scanning Equipment
Provide the following Equipment as approved by the Engineer to perform scanning:

(1) MIT-SCAN-T2 or T3 (MIT-SCAN) device, and
(2) 30 centimeters ± 0.1 millimeter diameter, 660 micrometer ± 10 micrometer thick, steel (*ASTM A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*, Type 2 Commercial 1 Grade, G90) circular plate supplied by Kessler Soils Engineering Products, Inc. or approved equal.

L.2.b(2) QCS Scanning Method

Perform scanning in accordance with the following:

(1) Place the base plates at the randomly selected locations and anchor the plates to prevent movement during concrete placement. Mark the locations of the base plates to ensure ease of locating the plates after the paver has passed.
(2) Base plates should be positioned such that metal objects (e.g. reinforcement, dowel bar baskets) should not be within 4 feet of the base plate. The base Material should be level under the base plate.
(3) Locate the base plate with the MIT-SCAN device by pressing the search button and moving the sensor head over the base plate.
(4) For proper scan measurement, all the MIT-SCAN wheels must be in contact with the concrete during the test. Before starting the measurement, position the MIT-SCAN sensor head approximately 1 foot centrally in front of the base plate. A measurement is performed by pressing the measurement button and passing the sensor head over the middle of the base plate. The measurement run is approximately 4.5 feet.
(5) Take 3 measurement runs in various directions across the base plate and average the 3 measurements to determine the final individual scan thickness.
(6) The scan measurements must be taken and recorded in millimeters and converted to inches.

L.2.c Individual Deficient Probe or Scan

If a final individual probe or scan measurement shows a thickness deficiency greater than 1/2 inch from Plan thickness, take a core (QC-Core) at the probe or scan location to determine if the pavement is defective.

The Engineer will use the QC-Core results in lieu of the QCP or QCS results.

L.3 Quality Acceptance Testing – Coring

After concrete pavement placement, the Engineer will mark the core locations identified on the field coring report generated from the MnDOT *Thickness, Texture and MIT-SCAN* workbook. The Contractor will core the designated PVC and QAC locations.

L.3.a Probe Verification Core (PVC)

Take the PVC at the same location as the probe measurement at the rate of one random core for every 4 probe measurements. If the probe measurements are not divided evenly by 4 for each Plan thickness take one additional core in the remaining probe locations.

The Engineer will compare PVC measurement in lieu of the initial QCP measurement.

L.3.b Quality Assurance Cores (QAC)

Take one random core every 8,000 linear lane feet for each Plan thickness. Add partial segments less than 4,000 lineal lane feet to the previous 8,000 linear lane feet and take one core. If partial segments are equal to or greater than 4,000 linear lane feet, take one random core. If the Plan thickness for the entire Project is less than 8,000 linear lane feet, take one random core.

L.3.c Coring Method

The Engineer will allow coring after the concrete meets the requirement of 2301.3O, "Opening Pavement to Traffic." Use 3U18 concrete or another concrete mix approved by the Engineer to fill the core holes within 72 hours of coring at no additional cost to the Department. Provide traffic control for coring.

Cut 4 inch Nominal diameter cores at marked locations. Lay the cores next to the holes in a curing condition. Take precautions to ensure the quality of cores. The Engineer will not accept cores out of round, not perpendicular, or containing ridges.

The Engineer will field measure the core thickness to the nearest 1/8 inch, verify (field ID number) the cores, and record the field measurement on the field coring report generated from the MnDOT *Thickness, Texture and MIT-SCAN* workbook.

The Engineer will pick up the cores from the pavement and store the cores in a water tank heated from 60°F to 80°F at the Department field office. The Engineer will not require the storage of cores in a curing condition for concrete older than 28 Calendar Days.

The Engineer will transport the cores in a curing condition, unless older than 28 Calendar Days, to the MnDOT Office of Materials and Road Research.

L.3.d Final Pavement Thickness Core Measurement

The MnDOT Office of Materials and Road Research will determine the final pavement thickness by measuring the length of the cores (PVC, QC-Core, and QAC cores) using nine probe testing devices to obtain the average length of the core in one operation.

Report the lab measured core length to the nearest 0.05 inch.

After Department thickness verification, the Department will test the cores for compressive strength at 60 Calendar Days of age for information only. The Department will test 3 of the cores from the entire Project for rapid chloride permeability (RCP) in lieu of compressive strength testing for information only.

L.4 Evaluation of Cores to Determine Acceptance

The Engineer will use lab-measured cores (PVC, QC-Core, and QAC) to determine acceptance and price adjustment based upon the following:

(1) Individual core thickness in accordance with Table 2301.3-6
(2) Final average core thickness for each Plan thickness (PT)

After coring (including exploratory coring) and scanning is completed; the Engineer will use the cores (QCP-Core, PVC, or QAC) and scans (QCS that were not cored) to determine the final average thickness for each Plan thickness.

If cores and scans meet the design Plan thickness requirements of the Project, the Engineer will consider the final average core thickness for each Plan thickness acceptable.

Table 2301.3-6
Acceptable Concrete Pavement Thickness

Individual Lab Measured Core (PVC, QC-Core or QAC)	Exploratory Coring Required	Resolution
< PT – 1/2 inch	No	2301.5I.5.b, "Final Average Thickness" The Department considers the pavement acceptable to remain in place in the remaining areas as the increment where the cores show a thickness deficiency no greater than Plan thickness minus 1/2 inch.
PT – 1/2 inch to 1 inch	2301.3L.5, "Exploratory Coring"	2301.5I.5.a(1), "Defective Pavement Area Between 1/2 inch and 1 inch
> PT – 1 inch	2301.3L.5, "Exploratory Coring"	2301.5I.5.a(2), "Defective Pavement Area > 1 inch

L.5 Exploratory Coring

The Engineer will require an exploratory core in the adjacent lane if placed in the same paving operation. If the length of the exploratory core in the adjacent lane is at least equal to the Plan thickness minus 1/2 inch, the Engineer will not require additional cores in the adjacent lane.

Take exploratory cores in accordance with the following procedure:

(1) At any location within 10 feet on each side of the deficient thickness location and at the same distance from the pavement centerline. If the length of each of the first exploratory cores is at least equal to the Plan thickness minus 1/2 inch, the Engineer will not require additional cores from this location.

(2) If any cores do not fall within the Plan thickness minus 1/2 inch, take additional exploratory cores at 25 foot intervals and at the same distance from the pavement centerline, as directed by the Engineer.

(3) Perform coring in the direction of the deficiency until obtaining a core with a length at least equal to the Plan thickness minus 1/2 inch in each lane separately. The Engineer will use exploratory cores to determine the extent of deficient pavement thickness for adjusting the Contract Unit Price or requiring pavement removal and replacement.

M Concrete Curing and Protection

After completing final finishing operations, cure exposed concrete surfaces. Use one of the following curing methods:

(1) In accordance with 2301.3M.1.a, "Membrane Curing Method," place the membrane curing compound conforming to 3754, "Poly-Alpha Methyl styrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 minutes of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2301.3M.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 minutes after

permanent removal of the forms or curing blankets, unless the Contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets in accordance with 2401.3G.2.b, “Curing Blanket Method,” as soon as practical without marring the surface.

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

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

M.1 Curing Methods

M.1.a Membrane Curing Method

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

The Engineer will only approve fully automatic, self-propelled mechanical power sprayer equipped with a recirculating bypass system that provides for continuous agitation of the reservoir Material, separate filters for the hose and nozzle, check valve nozzles, multiple or adjustable nozzle system that provides for variable spray patterns, a shield to control loss of Material by wind action, and a spray-bar drive system that operates independently of the wheels or track drive system.

When using the fully-automatic, self-propelled mechanical power sprayer to apply the curing compound operate the Equipment to direct the curing compound to the surface from two different lateral directions. Do not allow the sprayer to ride on the pavement surface. Ensure the sprayer covers the entire lane width and atomizes the curing compound. If puddling, dripping, or non-uniform application occurs, suspend the operation to perform corrections as approved by the Engineer.

Apply the curing compound in accordance with the following:

(1) At a minimum rate of 1 gallon per 150 square feet of surface curing area.

(2) Apply curing compound homogeneously to provide a uniform, solid, white, opaque coverage on exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some Department approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform, solid, opaque consistency meeting the intent of the above requirement.

(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by respraying.

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

For pavements that are 10 feet wide or less and irregular shaped surfaces, the Engineer will only approve airless spraying machines equipped with a recirculating bypass system that provides for continuous agitation of the reservoir Material, separate filters for the hose and nozzle, and multiple or adjustable nozzle system that provides for variable spray patterns.

M.1.b Curing Blanket Method

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

M.2 Protection against Rain

Protect the concrete from damage due to rain. Have available, near the site of the Work, Materials for protection of the edges and surface of the concrete. Should any damage result, the Engineer will suspend operations until corrective action is taken and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If corrective Work is performed to the satisfaction of the Engineer, the Department must pay Incentives provided the concrete meets all other requirements of 2301, "Concrete Pavement."

M.3 Protection against Cold Weather

If the National Weather Service forecast for the construction area predicts air temperatures of 36°F or less within the next 24 hours and the Contractor wishes to place concrete, the Contractor shall submit a cold weather protection Plan.

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

M.3.a Cold Weather Protection Plan

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

M.4 Vibratory and Backfilling Protection

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Resume vibratory and backfilling operations after the concrete has reached a minimum compressive strength of 2,000 pounds per square inch or a flexural strength of 250 pounds per square inch. Cast concrete control specimens in accordance with 2461.3G.5, "Concrete Strength." The Engineer will test the control specimens. If the Engineer discovers evidence of damaged concrete, the Engineer will suspend Work until the Contractor corrects the Work. The Engineer may reject damaged concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may use hand-operated concrete consolidation Equipment, walk-behind vibratory-plate compactors, rollers in "static" mode, and fine grading machines 24 hours after placing the concrete, and other Equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

N Joint Construction Operations

Unless otherwise shown on the Plans, construct joints perpendicular to the grade.

If the sequence of operations includes placing the curb and gutter before the concrete pavement, submit a jointing Plan to the Engineer for approval. Submit the jointing Plan to the Engineer a minimum of 7 Calendar Days before placing the curb and gutter.

Space contraction joints at the intervals shown on the Plans, except shorten the spacing at the following to provide panel lengths at least 5 feet:

(1) Adjacent to header joints
(2) Reinforced panels
(3) Railroad grade crossings
(4) Free ends of pavement

N.1 Joint Sawing Equipment

Provide wet-cut saws for joint establishment in the concrete.

If the Contractor would like to use lighter weight dry-cut saws, commonly referred to as “early entry,” submit a Quality Control Plan to the Engineer defining the intended use for the early-entry saws. The Engineer, in conjunction with the Concrete Engineer, will evaluate the QC Plan to determine if their use is acceptable.

When using early-entry saws, use saw blades and skid plates specifically designed for the type coarse Aggregate used in the concrete in accordance with the saw manufacturer’s recommendation.

N.2 Joint Establishment

Provide joint sawing as shown on the Plans. For concrete pavement 10 feet or less in width, the Concrete Engineer will allow tooling for initial joint establishment. Sawing of tooled joints is required.

Perform the sawing as soon as the concrete will support the joint sawing operation without raveling and before random cracking occurs. If raveling of joints occurs due to the sawing operations, review the sawing operation and make immediate correction to the sawing operations. The Engineer, in conjunction with the Concrete Engineer, will evaluate the raveled joints in accordance with 2301.3Q, “Workmanship and Quality.”

During sawing of joints, provide one or more backup saws and an adequate supply of blades.

Immediately after completing the joint sawing, use water under nozzle pressure to remove the sawing residue from each joint and the pavement surface.

If widening is necessary, do not widen the joints to full width until the concrete is at least 24 hours old, or longer if the sawing causes raveling of the concrete.

Extend transverse joints constructed in the pavement through the integrant curb.

N.3 Joint Sealing

When joint sealing is required by the Contract, provide a joint sealant in accordance with 3725, “Hot-Poured, Extra-Low Modulus, Elastic-Type Joint and Crack Sealer,” unless the type of sealant for contraction joints is otherwise specified in the Contract.

If the concrete mixture contains Class B coarse Aggregate as defined in 3137, "Coarse Aggregate for Portland Cement Concrete," do not seal joints with silicone.

Perform joint sealing as shown on the Plans and in accordance with the following:

(1) Seal joints after the Engineer inspects and approves the joints
(2) Perform joint sealing on surface dry concrete after cleaning the joints of debris, dirt, dust, and other foreign matter, including accumulations of concrete
(3) Lightly sandblast the joint walls before final compressed air cleaning
(4) Immediately before sealing the joints, clean the joints with a jet of compressed air under pressure of at least 85 pounds per square inch
(5) Seal transverse integrant curb joints and Shoulders with the same joint sealer used to seal the pavement joints
(6) Seal joints in accordance with the tolerances shown on the Plans
(7) Provide backer rod Material compatible with the sealer as shown on the Plans
(8) Remove and replace sealer at joints filled above the permissible level shown on the Plans at no additional cost to the Department

Handle and place joint sealer Material as recommended by the manufacturer and in accordance with the following requirements:

N.3.a Hot-Poured Sealers

Heat hot-poured sealers in a double-boiler type kettle or melter. Fill the space between inner and outer shells with oil or other Material as allowed by the manufacturer. Provide heating Equipment with automatic temperature control, mechanical agitation, and recirculating pump. Use heating Equipment as recommended by the manufacturer of the sealer Material. Do not melt quantities of sealer Material greater than the quantity used within the same day. After heating the sealer Material to the application temperature, maintain the Material temperature until placement. Place the sealer Material within 4 hours after the initial heating to the application temperature.

Apply sealant to the pavement at ambient pavement temperatures greater than 39°F.

N.3.b Silicone Sealers

Install silicone sealers as recommended by the manufacturer.

N.3.c Preformed Sealers

Provide preformed seals in one continuous length for each joint, except the Contractor may use butt splices in transverse joints at longitudinal joints.

Do not stretch the preformed sealer Material in the installation process by greater than 5 percent of the joint length.

O Opening Pavement to Traffic

Do not open a new pavement slab to general public traffic or operate paving or other heavy Equipment on it for 7 Calendar Days, or until the concrete has reached a minimum flexural strength meeting the requirements of Table 2301.3-7, or minimum compressive strength of 3,000 pounds per square inch; whichever occurs first.

If the pavement joints are widened, seal the joints before operating paving or other heavy Equipment and general public traffic on the pavement.

Cast the field control specimens in accordance with 2462.3G.4, “Test Methods and Specimens.” Cure the field control specimens in the same manner and under the same conditions as the pavement represented. The Engineer will test the field control specimens in accordance with 2462.3G.4, “Test Methods and Specimens.”

Table 2301.3-7
Minimum Strength Requirements for Opening Pavements to Construction and to General Public Traffic

Slab Thickness (inch)	Flexural Strength (pounds per square inch)
≤ 7.0	500
7.5	480
8.0	460
8.5	440
9.0	390
≥ 9.5	350

Perform operations on new pavement as approved by the Engineer and in accordance with the following:

(1) When moving on and off the pavement, construct a ramp to prevent damage to the pavement slab.
(2) Protect the concrete pavement surface and joints from damage due to heavy loads or Equipment in accordance with 1513, “Restrictions on Movement and Storage of Heavy Loads and Equipment.” Sweep the pavement surface free of debris before placing the protective Material or tracked paving Equipment onto the slab.
(3) Operate Equipment on a slab without causing damage. If damage results, suspend operations and take corrective action as approved by the Engineer. Do not operate the Equipment wheels or tracks within 4 inches of the slab edge.
(4) When hauling Aggregate and other Materials across newly constructed joints, keep the pavement surface free of debris by sweeping or other method as approved by the Engineer to prevent spalling of the pavement joints.

O.1 Early Opening of Pavement to Traffic

For early use of the pavement as required by the Engineer, construct a section of pavement of High-early strength concrete in accordance with Table 2301.2-4 at important Road crossings, Intersections, driveway entrances, or other locations as shown on the Plans or directed by the Engineer. Take precautions to satisfactorily finish, cure, and protect High-early strength concrete pavements.

P Pavement Smoothness – IRI (International Roughness Index)

Provide concrete pavement Smoothness in accordance with 2399, “Pavement Surface Smoothness.” For any pavement sections not subjected to 2399, “Pavement Surface Smoothness,” the Engineer will use a 10 foot straightedge to evaluate the hardened concrete pavement in accordance with 2301.3Q, “Workmanship and Quality.”

Q Workmanship and Quality

The Engineer may use the 10 foot straightedge as necessary to determine any defects in the hardened concrete.

When measuring the hardened concrete using the straightedge, the Engineer will:

(1) Measure the hardened concrete for surface deviations greater than 1/4 inch in 10 feet.

(2) Evaluate transverse joints by centering the straightedge longitudinally across the transverse joint.
(3) Not lay the straightedge across a lane break with differing cross slopes.

Q.1 Random or Uncontrolled Cracking

Repair or replace pavement with random or uncontrolled cracks as directed by the Engineer. If repairing the pavement as directed by the Engineer, use a dowel bar load transfer technique in accordance with the Concrete pavement rehabilitation details. Submit the intended repair technique to the Engineer for approval. Perform pavement repairs at no additional cost to the Department. If the repair fails, replace the pavement at no additional cost to the Department. The Engineer will accept repairs in accordance with 1516, "Acceptance."

Q.2 Pavement Smoothness after Corrective Work

In any location where the Contractor must remove and replace concrete full depth pavement due to workmanship, the Engineer will require reprofiling in accordance with 2399, "Pavement Surface Smoothness."

2301.4 METHOD OF MEASUREMENT

A Dowel Bars

The Engineer will measure dowel bars by the actual number of individual dowels placed. The Engineer will not measure dowels included in the Contract linear foot price for Dowelled expansion joints, design ___.

B Dowelled Expansion Joints

The Engineer will separately measure dowelled expansion joints of each design designation as shown on the Plans by length along the joint line.

C Integrant Curb

The Engineer will separately measure integrant curb of each design by length.

D Concrete Pavement and Concrete Pavement High-early

If the Contract includes the Contract Item Concrete Pavement or Concrete Pavement High-early, the Engineer will measure in accordance with the following:

(1) Measure the Concrete pavement placed to a uniform cross-section thickness by the surface area of the pavement as constructed, including integrant curb
(2) Include measurements for Concrete pavement without regard to grade, strength, type of concrete, width, or thickness of the pavement in a single measurement, except if the Plans include a Contract Item for High-early strength concrete

E Place Concrete Pavement

If the Contract includes the Contract Item Place Concrete Pavement, the Engineer will measure Concrete pavement placed by area based on specified dimensions, including integrant curb. This measurement will represent the surface area of the pavement as constructed.

F Structural Concrete and Structural Concrete High-early

If the Contract includes the Contract Item Structural Concrete or Structural Concrete High-early, the Engineer will measure the volume in accordance with the following:

(1) Measure the volume of Structural Concrete placed to a variable cross-section thickness using the average end-area method.
(2) Verify the volume measurements from the computerized batch ticket printouts from the plant, as verified by 2301.3C.8, "Concrete Ingredient Summaries," and the consideration of any waste as agreed with the Engineer.

(3) Include the volume of specified concrete pavements into a single item without regard to grade, strength, width, or thickness of the concrete pavement, except if the Plans include a Contract Item for High-early strength concrete.

G Supplemental Pavement Reinforcement

The Engineer will measure supplemental pavement reinforcement over Culverts, storm sewers, and water mains, by weight.

H Reinforcement Bars

The Engineer will not separately measure keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars.

2301.5 BASIS OF PAYMENT

The Engineer may pay for Concrete Pavement meeting the requirements and tolerances in accordance with this section at the Contract Unit Price. Pavement that fails to meet the minimum requirements when placed and tested in the prescribed manner is considered defective. The Engineer may reject or adjust the payment for defective concrete pavement in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

The Engineer will determine the limits of each individual defective pavement area. If applying a monetary deduction for defective payment, the Engineer will measure the area to the nearest whole square yard, except the Engineer will consider areas less than 1 square yard as 1 square yard. The Engineer will determine the condition of each individual defective area of pavement based on the calculation of greatest deficiency within the area.

A Dowel Bars

The Contract each price for dowel bars includes the cost of constructing the joints complete as shown on the Plans, including the costs of providing and placing dowel bars and dowel bar assemblies.

B Dowelled Expansion Joints

The Contract linear foot price for Dowelled expansion joints, design ___ includes the cost of constructing the joints complete in-place as shown on the Plans, including the costs of providing and placing dowel bar assemblies, filler, and sealer Materials.

C Integrant Curb

The Contract linear foot price for Integrant Curb, Design ___ includes the cost of forming and finishing the curb and protecting and curing the concrete.

D Concrete Pavement and Concrete Pavement High-Early

Unless the Plans include a separate Contract Item, the Engineer will consider the Contract square yard price for Concrete Pavement to include the cost of constructing the pavement, including the cost of batch Materials and mixing operations; plant-lab office; producing the concrete; fine grading; forming, including headers; providing and installing keyway and keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars; delivering; depositing; placing; spreading; screeding; vibration monitoring; finishing; texturing; curing; protecting; sawing; sealing; probing; scanning; and coring and filling the core holes.

If the Plans include a separate Contract Item for Concrete pavement High-early or if the Contractor requests High-early and the Engineer approves, the Department will not provide extra compensation for the production of High-early strength concrete. The Contract square yard price for Concrete Pavement High-early includes the cost of constructing the pavement, including the cost of batch Materials and mixing operations; plant-lab office; producing the concrete; fine grading; forming, including headers; providing and installing keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars; delivering; depositing; placing; spreading; screeding; vibration monitoring; finishing; texturing; curing; protecting; sawing; sealing; probing; scanning; and coring and filling of core holes.

If the Plans do not include a separate Contract Item for Concrete pavement High-early and the Engineer orders High-early concrete, the Department will pay for the additional cement at a rate of the invoice cost plus 15 percent.

E Place Concrete Pavement

Unless the Plans include a separate Contract Item, the Engineer will consider the Contract square yard price for Place Concrete Pavement to include the cost of constructing the pavement, including fine grading; forming, including headers; providing and installing keyway and keyway bars, tie bars, taper steel, stopper bars, and other reinforcement bars; placing; spreading; screeding; vibration monitoring; finishing; texturing; curing; protecting; sawing; sealing; probing; scanning; and coring and filling of core holes.

F Structural Concrete and Structural High-early

The Contract cubic yard price for Structural Concrete and Structural Concrete High-early includes the cost of producing, delivering, and depositing the concrete, including the cost of the batch Materials, mixing operations, and the plant-lab office. If the Plans include a separate Contract Item for Structural Concrete High-early or if the Contractor requests High-early and the Engineer approves, the Department will not provide extra compensation for the production of High-early strength concrete.

Due to variations in the asphalt or asphalt bond breaker Layer, the Contractor may request additional volume up to 102 percent of the Engineer's field calculated final volume of Structural Concrete, Structural Concrete High-early¸ or both for the entire Project. If the Engineer finds the Contractor's request for the additional final volume valid, the Engineer will pay for the additional volume up to 102 percent of the calculated quantity for the entire Project.

If the Plans include a separate Contract Item for Structural Concrete High-early or if the Contractor requests High-early and the Engineer approves, the Department will not provide extra compensation for the production of High-early strength concrete.

If the Plans do not include a separate Contract Item for Structural Concrete High-early and the Engineer orders High-early concrete, the Department will pay for additional cement at a rate of the invoice cost plus 15 percent.

G Supplemental Pavement Reinforcement

The Contract pound price for Supplemental Pavement Reinforcement includes the cost of providing and placing the metal reinforcement, including tie wires, supporting devices, and splicing.

H Type 8 Geotextile

The Department will pay for furnished and installed Type 8 geotextile in accordance with 2108.5, "Geosynthetic Construction Materials, Basis of Payment."

I Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Concrete Pavement. The amounts of these adjustments are deemed reasonable.

I.1 Optimized Aggregate Gradation Incentive

If the Contract includes 3,500 cubic yards or greater of paving concrete, the Department must apply an Incentive for Coarse Aggregate Quality on a per lot basis for any paving concrete provided by the Primary Concrete Plant in accordance with Table 2301.5-1.

Table 2301.5-1
Optimized Aggregate Gradation Incentive

Incentive per cubic yard*
$2.00 per cubic yard
*Apply Incentive for Concrete Pavement based on the theoretical volume of concrete used by multiplying the measured square yard of concrete by the thickness shown on the Plans. Apply Incentive for Structural Concrete based on the daily cubic yards batched of Structural Concrete as verified by the computerized batch ticket printouts from the plant, with consideration of any waste.

I.2 W/C Ratio Incentive/Disincentive

If the Contract includes 3,500 cubic yards or greater of paving concrete, the Department must apply an Incentive/Disincentive for W/C Ratio on a per lot basis for paving concrete (except High-early concrete) provided by the Primary Concrete Plant and hauled in dump trucks, agitator trucks, or both in accordance with Table 2301.5-2.

Table 2301.5-2
W/C Ratio Incentive/Disincentive

When using cement only or fly ash		**When using slag or ternary**	
W/C Ratio Lot Result	**Incentive/Disincentive per cubic yard***	**W/C Ratio Lot Result**	**Incentive/Disincentive per cubic yard***
≤ 0.37	+$3.00	≤ 0.39	+$3.00
0.38	+$1.75	0.40	+$1.75
0.39	+$0.50	0.41	+$0.50
0.40	$0.00	0.42	$0.00
0.41	−$0.50	0.43	−$0.50
0.42	−$1.75	0.44	−$1.75
≥ 0.43	The Engineer, in conjunction with the Concrete Engineer, will determine the concrete suitability for the intended use in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” This may include testing on the hardened concrete as required by the Engineer, in conjunction with the Concrete Engineer.	≥ 0.45	The Engineer, in conjunction with the Concrete Engineer, will determine the concrete suitability for the intended use in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” This may include testing on the hardened concrete as required by the Engineer, in conjunction with the Concrete Engineer.
*Apply Incentive/Disincentive for Concrete Pavement based on the theoretical volume of concrete used by multiplying the measured square yard of concrete by the thickness shown on the Plans. Apply Incentive/Disincentive for Structural Concrete based on the daily cubic yards batched of Structural Concrete as verified by the computerized batch ticket printouts from the plant, with consideration of any waste.			

I.3 Coarse Aggregate Quality Incentive/Disincentive

Coarse Aggregate Incentive/Disincentive does not apply to Class R Aggregates.

If the Contract includes 3,500 cubic yards or greater of paving concrete, the Department must apply an Incentive/Disincentive for Coarse Aggregate Quality for any paving concrete provided by the Primary Concrete Plant in accordance with Table 2301.5-3.

If the concrete mixture contains at least three fractions of coarse Aggregate, the Department may consider only the two containing the highest percentage by weight as eligible for a Coarse Aggregate Incentive/Disincentive.

Table 2301.5-3
Coarse Aggregate Quality Incentive/Disincentive

Aggregate Class	QI for Fraction, percent	Incentive/Disincentive per cubic yard*
Class A (including quartzite and gneiss)	—	$1.00
Class B (based on percent absorption)	< 1.00	$1.00
	1.01 – 1.45	$0.50
	1.46 – 1.76	$0.00
	1.77 – 1.85	–$1.00
	> 1.86	As recommended by the Concrete Engineer, with coordination of the Engineer
Class C (based on percent Carbonate)	< 15.0	$1.00
	15.1 – 24.0	$0.50
	24.1 – 31.0	$0.00
	31.1 – 35.0	–$1.00
	> 35.1	As recommended by the Concrete Engineer, with coordination of the Engineer
*Apply Incentive/Disincentive for Concrete Pavement based on the theoretical volume of concrete used by multiplying the measured square yard of concrete by the thickness shown on the Plans. Apply Incentive/Disincentive for Structural Concrete based on the daily cubic yards batched of Structural Concrete as verified by the computerized batch ticket printouts from the plant, with consideration of any waste.		

I.4 Air Content before Consolidation

If the Contractor places Type 3 concrete not meeting the air content requirements into the Work, the Department may apply monetary deductions to nonconforming concrete.

For the quantity of non-conforming concrete not meeting the required air content, the Engineer may make determinations regarding the disposition, payment, or removal in accordance with Table 2301.5-4.

Table 2301.5-4
Grade A Paving Concrete (Target Air Content 7.0 percent)

Air Content Before Consolidation, percent	Monetary Deduction
> 9.0	The Engineer, in conjunction with the Concrete Engineer, will determine the concrete suitability for the intended use in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”
5.5 – 9.0	No deduction for Materials placed as approved by the Engineer.
> 5.0 – < 5.5	$25.00 per cubic yard or 25 percent of the Contractor-provided invoice for quantity represented by the Materials placed.
> 4.0 – ≤ 5.0	The Engineer, in conjunction with the Concrete Engineer, will determine the concrete suitability for the intended use in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” This may include testing on the hardened concrete as required by the Engineer, in conjunction with the Concrete Engineer.
≤ 4.0	Remove and replace concrete in accordance with 1503, “Conformity with Contract Documents” and 1512, “Unacceptable and Unauthorized Work” as directed by the Engineer. This may include testing on the hardened concrete as required by the Engineer, in conjunction with the Concrete Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in place, the Engineer will not pay for the concrete and if the Engineer determines the surface is exposed to salt-brine freeze-thaw cycling, coat with an epoxy penetrant sealer from the *Approved/Qualified Products List*.

I.5 Pavement Thickness

I.5.a Deficient Core Thickness

For the purpose of the Work specified in section 2301.5I.5, “Pavement Thickness,” the Department defines defective pavement area as the entire area surrounding the deficient core within the entire width of the Traffic Lane and between acceptable cores.

I.5.a(1) Defective Pavement Area between 1/2 inch and 1 inch

For cores showing a pavement thickness greater than the Plan thickness minus 1/2 inch to 1 inch, the Contractor may choose one of the following:

(1) Remove and replace the defective pavement area at no additional cost to the Department
(2) Leave the pavement in place with a monetary deduction of $20.00 per square yard for the defective pavement area, as approved by the Engineer

I.5.a(2) Defective Pavement Area > 1 inch

For cores showing a pavement thickness greater than 1 inch below the Plan thickness, the Engineer, in conjunction with the Concrete Engineer, will determine whether the Contractor will do one of the following:

(1) Remove and replace the defective pavement area at no additional cost to the Department

(2) Leave the pavement in place at no cost to the Department and apply a monetary deduction of $20.00 per square yard for the defective pavement area in accordance with 1503, “Conformity with Contract Documents”

I.5.b Final Average Thickness

If any of the cores or scans do not meet the design Plan thickness requirements of the Project, the Engineer will determine the final average core thickness for each Plan thickness, except for the following:

(1) If exploratory cores are taken to identify the defective pavement area, substitute the two outside exploratory cores that are within Plan thickness minus 1/2 inch for the deficient core.
(2) If the length of core or scan exceeds the Plan thickness plus 0.30 inch, the Engineer will limit the core or scan length to the plan thickness plus 0.30 inch.
(3) If the final average thickness for each Plan thickness is deficient by more than the Plan thickness minus 0.10 inch, the Department may apply the monetary deduction to the Plan thickness, excluding areas of defective pavement in accordance with Table 2301.5-5.

Table 2301.5-5
Monetary Deduction for Final Average Thickness (Each Plan Thickness)

Thickness Deficiency Exceeding Permissible Deviations (inch)	Monetary Deduction per square yard of payment
0.00 – ≤ 0.10	None (tolerance)
0.11 – ≤ 0.20	$0.20
0.21 – ≤ 0.30	$0.40
0.31 – ≤ 0.40	$0.70
0.41 – ≤ 0.50	$1.00
0.51 – ≤ 1.00	$20.00

I.6 Concrete Curing and Protection

Failure to comply with 2301.3M, “Concrete Curing and Protection,“ may result in the Engineer, in conjunction with the Concrete Engineer, applying a monetary deduction in accordance with 1503, “Conformity with Contract Documents.”

When there is not a separate Contract Unit Price for Structural concrete, the Engineer may apply a monetary deduction of $30.00 per cubic yard or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

I.7 Workmanship and Quality

The Engineer will require corrective work on vertical surface deviations greater than 1/4 inch within the span of the straightedge in any direction.

If the Engineer and Contractor mutually agree to not perform corrective Work, the Engineer may assess a monetary deduction of $1,500.00 per event per lane. For corrected variations, the Engineer may accept deviations less than or equal to 1/4 inch within the span of a 10 foot straightedge in any direction.

J Schedule

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

Item No.	Item	Unit
2301.502	Dowel Bar	Each
2301.503	Dowelled Expansion Joints, Design ___	linear foot
2301.503	Integrant Curb Design ___	linear foot
2301.504	Concrete Pavement ___ "	square yard
2301.504	Concrete Pavement ___ " High-Early	square yard
2301.504	Place Concrete Pavement ___"	square yard
2301.507	Structural Concrete	cubic yard
2301.507	Structural Concrete High-Early	cubic yard
2301.508	Supplemental Pavement Reinforcement	pound

2302 CONCRETE PAVEMENT REHABILITATION

2302.1 DESCRIPTION

This Work shall consist of performing concrete pavement repairs, load transfer restoration, and joint/crack sawing and sealing. Perform all concrete pavement rehabilitation in accordance with the Concrete Pavement Rehabilitation (CPR) standard details as shown in the Contract.

2302.2 MATERIALS

A Structural Concrete 2461

A.1 Partial Depth Repairs, Type B, Mix No. 3U18

A.1.a Pre-bagged Grade 3U18 Concrete Patch Mix

Provide a dry, bagged Department Grade 3U18 concrete patch mix, in accordance with 3105, "Bagged Portland Cement Concrete Patching Mix 3U18 and 3U58M."

A.1.b Field-Proportioned Grade 3U18 Concrete Patch Mix

Provide Grade 3U18 concrete mix by mass in accordance with Table 2302.2-1.

Table 2302.2-1
Mix Proportions

Material	Weight, pounds
Type 1 cement	100
Coarse Aggregate, #89	159
Fine Aggregate	162

A.1.c Coarse Aggregate Gradation Requirements, #89 or CA-80

Provide either an #89 or CA-80 Gradation in accordance with Table 3137.2-4 for use in Grade 3U18 concrete patch mix or Dowel bar retrofit repairs. Provide coarse Aggregate meeting the quality requirements of 3137.2D.3, "Coarse Aggregate for Concrete Pavement."

A.2 Type C Repairs, Mix No. 3R52 and 3RHE52 2461

B Reinforcement Bars 3301

C Dowel Bars Used in Dowel Bar Baskets 3302

C.1 Dowel Bars Used in Drill and Grout or Dowel Bar Retrofits Applications............ 3302.2A

D Curing Materials

H Dowel Bar Retrofit (DBR) Repair Materials

H.1 Approved Non-Shrink Rapid Set Concrete for Dowel Bar Retrofit Repairs

Provide a packaged, dry, non-shrink, rapid-hardening cementitious Material for Dowel bar retrofits repairs from the *Approved/Qualified Products List*.

The Engineer will allow on site addition (extension) of coarse Aggregate in accordance with the mix design shown on the *Approved/Qualified Products List*.

H.2 DBR Project Submittal Requirements

In lieu of providing an *Approved/Qualified Products List* DBR backfill product, provide the Concrete Engineer the reference Material and all test results outlined in the DBR qualification process found at MnDOT's Packaged, dry, non-shrink, rapid-hardening cementitious material for dowel bar retrofit repairs website.

The Engineer, in conjunction with the Concrete Engineer, will determine final acceptance of the DBR repair backfill Material based on satisfactory field placement and performance, in accordance with 2302.3G.4, "Test Section" and 2302.3H, "Repair Evaluation Period."

H.3 End Caps

Provide tight fitting, nonmetallic, non-organic end caps that will allow for a 1/4 inch expansion movement of the dowel bar at each end.

H.4 Compressible Foam Board

Provide either a Type D-1 or D-2 preformed foam joint filler, in accordance with 3702, "Preformed Joint Filler." Provide foam joint filler that is at least 3/8 inch thick and is a minimum of 1/8 inch thicker than the joint or crack to ensure no leakage of patching Material into the crack. Cut foam preformed joint filler to fit the full width and depth of the saw slot, as shown in the Dowel bar retrofit detail. The Engineer will not permit multiple pieces to obtain the proper height of the saw slot.

H.5 Dowel Bar Support Chairs

Provide two, nonmetallic support chairs that are either epoxy coated steel in accordance with *ASTM A884/A884M, Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement*, or fabricated of commercial quality nonmetallic, non-organic Material to support each dowel bar. The chairs when placed shall press securely against the slot face to firmly hold the dowels in the proper position while the backfill Material is placed and consolidated.

H.6 Caulking Filler

Provide commercial caulk that is designed as a crack sealant that is compatible with the proposed patching Material. Use the caulking filler for sealing the existing joint or crack at the bottom and sides of the slot as shown in the Dowel bar retrofit detail. Do not extend or over band the caulk filler beyond the limits of the crack by greater than 1/2 inch.

I Concrete Admixtures

Provide admixtures from the *Approved/Qualified Products List* for concrete grades shown in Table 2461.2-6 and Table 2461.2-7.

2302.3 CONSTRUCTION REQUIREMENTS

A Concrete Mix Design Requirements

A.1 3U18 Concrete Mixture Requirements for Partial Depth Repairs

Mix all dry, pre-bagged grade 3U18 concrete patch mix onsite, in a paddle type mixer for at least 5 minutes.

The Engineer may also allow batching by volume in a calibrated mobile type mixer to produce grade 3U18 concrete. Calibrate the mobile mixer to the weights shown in Table 2302.2-1. Proportion the cement, coarse Aggregate, and fine Aggregate by volume (± 2.0 percent) in accordance with 2404.3E.1, "Mixer Requirements" and 2461.3D.2, "Batching by Volume."

Adjust water additions to achieve a maximum slump of 1 inch 5 minutes after batching concrete mix.

Maintain the air content of 3U18 at the specified target of 6.5 percent (+2.0 percent and −1.5 percent) of the measured volume of the plastic concrete in accordance with 1503, "Conformity with Contract Documents."

Make any adjustments immediately to maintain the desired air content.

Do not accelerate concrete strength gain to facilitate early strength of pavement repairs solely for construction traffic unless approved by the Engineer.

If the Engineer approves the use of accelerating (Type C or E) admixtures, take extra precautions as necessary to ensure satisfactory finishing, curing, and protection of the concrete repairs. The Contractor assumes full responsibility for the performance of the concrete. The Engineer will determine final acceptance of the Type B repair concrete based on satisfactory field placement and performance, in accordance with 2302.3H, "Repair Evaluation Period."

Refer to Table 2302.3-1 to determine the allowable mix adjustments to Grade 3U18 concrete. When anticipated time to opening for construction Equipment or general traffic is less than 7 Calendar Days, and the ambient temperatures are anticipated to remain at or above 60°F during the curing time, provide approved admixture as outlined in Table 2302.3-2. The mix design will include the admixtures solution as part of the total recommended mixing water.

Table 2302.3-1
Mix 3U18 Opening Times

Anticipated Minimum Time to Opening *	Concrete Mix Grade	Admixture Dosage & Type (Based on manufacturer's recommended dosage rate)	Mix Design Responsibility	Testing and Strength Required for Opening
≥ 7 Calendar Days	3U18 ǁ	None Required	2302	None *
72 hours to 7 Calendar Days	3U18 ǁ	Type A ‡	2302	None *
36 hours to < 72 hours	3U18 ǁ	Type A ‡	2302	Field Control Cylinders as per 2302.3C.4, "Opening to Construction Equipment and Traffic" # **
12 hours to < 36 hours	3U18 ǁ †	As Needed §	2302	Field Control Cylinders as per 2302.3C.4, "Opening to Construction Equipment and Traffic" # **

* If at any time the ambient temperature falls below 60°F during the curing time, use field control specimens to determine opening times in accordance with 2302.3C.4, "Opening to Construction Equipment and Traffic."
ǁ The maximum slump for 3U18 mixes measured after 5 minutes is 1 inch.
† Accelerating admixtures are not allowed when the ambient air temperature exceeds 80°F without the approval of the Concrete Engineer.
‡ Use manufacturer's recommended dosage rate to achieve 3000 pounds per square inch minimum compressive strength or 500 pounds per square inch flexural strength at the time of opening.
# The Engineer may reduce the number of control specimens required based on previous control specimen strengths gains and site conditions.
§ Use a Type A, C, or E admixture in accordance with 2302.3A.1, "3U18 Concrete Mixture Requirements for Partial Depth Repairs," and the manufacturer's recommended dosage rate to achieve 3000 pounds per square inch minimum compressive strength or 500 pounds per square inch flexural strength at the time of opening.
** Do not allow construction vehicles or general traffic on Type B repairs unless a minimum of 12 hours have elapsed and control cylinders achieve a minimum compressive strength of 3000 pounds per square inch or 500 pounds per square inch flexural strength.

A.2 3R52 or 3RHE52 Concrete Mixture Requirements for Type C Repairs

Provide a Contractor designed concrete in accordance with 2461, "Structural Concrete," the Plan, and Concrete pavement rehabilitation (CPR) standard details.

Design either a concrete grade 3R52 or 3RHE52 for use in Type C Repairs in accordance with specification 2461 "Structural Concrete."

Refer to Table 2302.3-2 to determine the criteria for opening 3R52 and 3RHE52 concrete to traffic.

Do not accelerate concrete strength gain to facilitate early strength of pavement repairs solely for construction traffic unless approved by the Engineer.

If the Engineer approves the use of accelerating (Type C or E) admixtures, take extra precautions as necessary to ensure satisfactory finishing, curing, and protection of the concrete repairs. The Contractor assumes full responsibility for the performance of the concrete. The

Engineer will determine final acceptance of the Type C repair concrete based on satisfactory field placement and performance, in accordance with 2302.3H. "Repair Evaluation Period."

Table 2302.3-2
Mix 3R52 and 3RHE52 Opening Requirements

Anticipated Minimum Time to Opening *	Concrete Mix Grade	Admixture Dosage & Type (Based on manufacturer's recommended dosage rate)	Mix Design Responsibility	Testing and Strength Required for Opening
≥ 7 Calendar Days	3R52	2461, Structural Concrete"* ǁ	Contractor	None
< 7 Calendar Days to ≥ 12 hours	3R52 3RHE52	2461, "Structural Concrete"* ǁ	Contractor	Field Control Cylinders as per 2302.3C.4, "Opening to Construction Equipment and Traffic" † ‡

* Accelerating admixtures are not allowed when the ambient air temperature exceeds 80°F without the approval of the Concrete Engineer.
ǁ Use manufacturer's recommended dosage rate to achieve 3000 pounds per square inch minimum compressive strength or 500 pounds per square inch flexural strength at the time of opening.
† The Contractor may request to the Engineer a reduction in the number of field control specimens required based on the results of the field control specimen strengths and site conditions.
‡ Do not allow construction vehicles or general traffic on Type C repairs unless a minimum of 12 hours has elapsed and field control cylinders achieve a minimum compressive strength of 3000 pounds per square inch or 500 pounds per square inch flexural strength.

B Placement Limitations

B.1 Type A Repairs

(1) Do not place joint sealant when the ambient temperature is below 40°F, nor when the joint faces show signs of frost or moisture.
(2) Do not perform Type A repairs until the concrete grinding operations are completed.
(3) If the pavement joints are widened, seal the joints before traffic is placed on the repairs.
(4) Do not place joint sealant outside of the manufacturer's temperature recommendations.

B.2 Type B Repairs

(1) Do not place concrete at ambient temperatures less than 50°F.
(2) Do not place concrete when in-place pavement temperatures are below 50°F.
(3) Do not place any concrete mixture after October 15th.
(4) Do not place epoxy resin adhesive or non-shrink grout for bonding reinforcement bars to in-place concrete outside of the manufacturer's temperature recommendations.
(5) Do not use accelerating admixtures (Types C and E) when the ambient air temperature exceeds 80°F without the approval of the Concrete Engineer.

B.3 Type C Repairs

(1) The Engineer will consider all drill and grout dowel bars installed and anchored to the in-place concrete pavement before performing the 2302.3F.5, “Dowel Bar Anchoring Test Section,” unacceptable in accordance with 1512, “Unacceptable and Unauthorized Work”

(2) Place concrete in accordance with 2461, “Structural Concrete,” and 2302.3F, “Type C Repairs.”

(3) Do not place any concrete mixture after October 15th, unless approved by Concrete Engineer, in conjunction with the Engineer, and an approved cold weather protection Plan is in place.

(4) Do not place epoxy resin adhesive or non-shrink grout for bonding reinforcement bars or dowel bars to in-place concrete outside of the manufacturer’s temperature recommendation.

B.4 Dowel Bar Retrofits

(1) Do not place pre-blended, non-shrink, rapid set concrete Material when the pavement temperatures are above 90°F.

(2) Maintain pre-blended, non-shrink, rapid set concrete Material temperature at or below 90°F.

B.5 Concrete Grinding

(1) Do not grind the concrete unless the opening times and minimum strengths established in either Table 2302.3-1, Table 2302.3-2 or, 2302.3C.4, “Opening to Construction Equipment and Traffic,” have been met.

(2) The Engineer will schedule a pre-grinding meeting at the Project Site. At the pre-grinding meeting, submit to the Engineer in writing the proposed slurry management Plan the grinding Contractor will utilize to remain in conformance with 1717, “Air, Land, and Water Pollution.” At the pre-grinding meeting, the Engineer and Contractor will review the site to identify the environmentally sensitive areas.

C General

Establish traffic control one day in advance of the beginning of the rehab operation for rehab surveys and locations.

C.1 Removals

Dispose of all removals outside the Right-of-way in accordance with 2104, “Removing Pavement and Miscellaneous Structures,” to the satisfaction of the Engineer.

Repair any damage to any in-place pavement, Roadway Structure, joints, Shoulders, or appurtenance caused by the Contractor’s operations as directed by the Engineer before final acceptance at no cost to the Department. Replace bituminous Shoulder pavement, as directed by the Engineer, is included in the appropriate Type B or Type C pay item found in 2302, “Concrete Pavement Rehabilitation.”

To prevent concrete pavement blow ups, saw full-depth relief cuts in the adjacent lanes and remove a transverse section 4 inches wide by full-width of the slab as the Contractor determines necessary to protect the existing concrete pavement. If the Contractor chooses not to saw a relief cut and damage is caused to the remaining concrete pavement, the Contractor shall make repairs as directed by the Engineer, at no cost to the Department. Before opening to traffic, backfill the void formed after concrete removal with Class 5 or other Material as approved by the Engineer at no cost to the Department. Maintain the backfill Material flush within a tolerance of +/- 1/2 inch with adjacent concrete.

C.2 Placing and Finishing Concrete

Use concrete placing and finishing procedures that do not result in rounding of the surface at any joints or headers.

Reestablish longitudinal and transverse joints and cracks according to Joint Repair (Type A1) detail.

Tool rounded edges adjacent to all inserts and forms.

Limit overcutting into adjacent lanes to the Nominal radius of the saw blade. At no cost to the Department, seal overcuts into adjacent lanes in accordance with the Joint Repair Type A1 detail.

Assure that concrete repairs do not protrude beyond the original cross-section of the pavement by more than 3/8 inch by forming or sawing the edges.

Provide broomed surface texturing for skid resistance to all repairs, including when concrete grinding is to take place.

C.3 Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1) For Type B Repairs, place the membrane curing compound conforming to 3754, “Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound,” or 3755, “Linseed Oil Membrane Curing Compound,” within 10 minutes of concrete placement or once the bleed water has dissipated unless otherwise directed by the Engineer in accordance with 2302.3C.3.a(1), “Membrane Curing Method.”

(2) For Type C Repairs, place the membrane curing compound conforming to 3754, “Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound,” or 3755, “Linseed Oil Membrane Curing Compound,” within 30 minutes of concrete placement or once the bleed water has dissipated unless otherwise directed by the Engineer in accordance with 2302.3C.3.a(1), “Membrane Curing Method.” Place the membrane-curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets unless otherwise specified in the Contract.

(3) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2302.3C.3.a(2), “Blanket Curing Method.”

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

If necessary to remove the coverings to saw joints or perform other required Work, remove the covering for the minimum time required to complete that Work.

C.3.a Curing Methods

C.3.a(1) Membrane Curing Method

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

The Engineer will only approve airless spraying machines equipped with a recirculating bypass system that provides for continuous agitation of the reservoir Material, separate filters for the hose and nozzle, and multiple or adjustable nozzle system that provides for variable spray patterns.

Apply the curing compound in accordance with the following:

(1) At a rate of 1 gallon per 150 square foot of surface area.
(2) Apply curing compound homogeneously to provide a uniform, solid, white, opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper). If using a Department-approved curing compound with a non-white base color, apply the compound to provide a uniform, solid, opaque consistency meeting the intent of the requirement in this section.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by re-spraying.
(4) If the Engineer determines that the initial or corrective spraying results in unsatisfactory curing, the Engineer may require the Contractor to use the blanket curing method at no additional cost to the Department.

C.3.a(2) Blanket Curing Method

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

C.3.b Protection Against Rain

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

C.3.c Protection Against Cold Weather for Full Depth (Type C) Repairs

If the National Weather Service forecast for the construction area predicts air temperatures of 36°F or less within the next 24 hours and the Contractor wishes to place concrete, submit a cold weather protection Plan.

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

C.3.c(1) Cold Weather Protection Plan

Submit a proposed time schedule and Plans for cold weather protection of concrete in writing to the Engineer for acceptance that provides provisions for adequately protecting the concrete during placement and curing. Include a method of monitoring the concrete temperatures. Ensure concrete pavement repair temperatures remain above 32°F for the entire cure time as defined in 2302.3C.4, “Opening to Construction Equipment and Traffic,” note (3). Do not place concrete until the Engineer accepts the Contractor's cold weather protection Plans.

C.4 Opening to Construction Equipment and Traffic

The Engineer will not allow the Contractor to open concrete pavement repairs to construction Equipment or vehicles, concrete grinding Equipment, cleanup Equipment, or public traffic unless one of the following requirements has occurred:

(1) When Department designed 3U18 concrete or Contractor designed 3R52 or 3RHE52 concrete attains a minimum age of 7 Calendar Days
(2) When Department designed 3U18 concrete attains a minimum age of 72 hours and the admixture type, dosage rate, and minimum ambient temperature requirements outlined in Table 2302.3-1 are met
(3) When Department designed 3U18 concrete or Contractor designed 3R52 or 3RHE52 concrete attains a minimum age of 12 hours and control strength specimens obtain minimum compressive strength of 3000 pounds per square inch, or minimum flexural strength of 500 pounds per square inch
(4) For dowel bar retrofits repairs, reach a minimum age of 4 hours and control strength specimens obtain minimum flexural strength of 500 pounds per square inch or minimum compressive strength of 3000 pounds per square inch
(5) For both (3) and (4) above, the Contractor will cast and cure the control specimens in accordance with 2461, “Structural Concrete.” The Engineer will test the control specimens in accordance with *ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*. If the Engineer is unable to test the control specimens the Contractor will test the control specimens in accordance with the following:

    (a) Supply and operate (in the presence of the Engineer) a calibrated mechanical or hydraulic concrete cylinder testing machine, in accordance with *ASTM C39*
    (b) Perform testing at a distance no greater than 30 miles from the control specimen fabrication site
    (c) At no additional cost to the Department

When opening times are less than 3 Calendar Days, provide the Engineer with a letter from the manufacturer stating the required minimum cure times of the Epoxy Resin Adhesive (ERA) or Non-Shrink Grout (NGS) used to anchor either the dowel bars or reinforcement bars to comply with the early opening times. Do not open to construction Equipment or traffic until the manufacturer’s recommended minimum cure times are met.

Once one of the above conditions has been met, sweep the portion of the closed Traffic Lane with a power pick-up broom before opening. Use water to control dust at the discretion of the Engineer.

D Type A Repairs

Type A repairs include: variable width joint crack repair/joint repair (Type A1) and variable width in-place joint or crack repair/joint repair (Type A2).

Saw and clean transverse and longitudinal joints or cracks as specified below, in preparations for sealing seal joints or cracks.

D.1 Removals

When performing variable width joint crack repair/joint repair (Type A1):

Remove the in-place joint sealer if applicable. The Contractor may remove the in-place joint sealer in conjunction with widening of the inplace joint or crack.

Widen in-place or newly constructed transverse or longitudinal joint or crack by saw cutting and to a depth shown on the Variable width joint crack repair/joint repair (Type A1) detail. Freshly saw both joint faces. Do not widen the in-place joint or crack greater than 1/4 inch from its existing width.

When performing the variable width in-place joint or crack repair/joint repair (Type A2):

Remove all of the existing joint seal Material from the in-place joint, insofar as possible, with ripping teeth, wire brush, sawing, or other reasonable Equipment to the satisfaction of the Engineer.

Do not use Equipment that will cause spalling of the pavement surface.

D.2 Preparation

Thoroughly clean all joints and cracks by water flushing immediately after sawing.

After joint has dried, sandblast then air blast.

Assure that the joints or cracks are clean, dry, and free of all incompressible Material before applying sealant.

D.3 Repair

Install a closed cell backer rod when joints or cracks are 1/4 inch or greater. Install backer rod of a diameter and to the depth shown on the Joint repair (Type A) details.

Use a Department approved hot pour joint sealer meeting the requirements of 3725, “Hot-Poured, Extra Low Modulus, Elastic Type Joint and Crack Sealer.”

Apply joint sealer in accordance with the manufacturer’s recommendations.

Fill joints or cracks to 1/16 inch below the pavement surface. Any overfilling of hot-pour joint sealer will require removal and replacement by the Contractor at no cost to the Department.

E Type B Repairs

Type B Repairs include: Partial depth repair (Type BA), Partial depth repair special (Type BE), and Joint and crack repair (Type B3).

Remove deteriorated concrete at designated (Type B) repair areas; reestablish joints and cracks; furnish, place, and cure 3U18 concrete to the original slope and grade; and saw and seal reestablished joints.

E.1 Removals

The Engineer will not allow jackhammers for partial depth concrete removals. Removal chipping hammers are limited to a maximum rated weight of 35 pounds.

Equip milling machines used for concrete removal with a device for stopping at preset depths to prevent damage to the dowel bars.

Remove the concrete surface and all deteriorated concrete in the designated repair areas to a minimum depth of 2 inches.

Do not damage the dowel bars during the removal process. Any damage is the responsibility of the Contractor at no cost to the Department.

Remove the concrete surface in the designated repair area by either of the following:

(1) Milling transversely or longitudinally. Chip-out secondary spalling resulting from the Contractor's removal operations at no cost to the Department.
(2) Delineate the repair area by saw cuts and chipping back the saw cuts to a 30 degree to 60 degree angle.

E.2 Preparation

If dowel bar or reinforcement bar cross-sectional loss due to corrosion is slight, place duct tape over the dowel bar, or another bond breaking Material approved by the Engineer. Cut or burn-off the bar if the dowel bars are misaligned, exhibit corrosion to a greater degree, or if the end of the dowel is exposed. If this involves more than three adjacent dowels, remove and replace the entire joint with a Full depth repair (Type CD).

Sandblast then air blast Type B repairs clean.

Drill and grout No. 4 epoxy coated reinforcement bars for Partial depth repair special (Type BE). Maintain a minimum of 1 inch concrete cover around bar. Install additional drill and grout No. 4 epoxy coated bars at 6 inches center-to-center while maintaining the minimum concrete cover.

The installation of the preformed joint filler is required before concrete placement in order to reestablish the joint or crack within the repair and to prevent the infiltration of the concrete into the crack or joint that runs through the repair. Allowing concrete to infiltrate into the joint or crack may cause a compression failure.

In some instances (mainly when concrete is removed under dowel bars), the preformed joint filler will not completely plug the joint or crack within the repair. If this circumstance is encountered, remove a section of the dowel bar to allow the placement of the preformed joint filler or place clean concrete sand to fill the void below the joint filler.

The practice of using sand in places where joint filler installation is impractical may result in a reduced repair life and is meant to be used on an occasional basis. Therefore, the Engineer should make an early determination of the extent of this type of fix and may want to use a Full depth repair (Type CD) in lieu of the Joint and crack repair (Type B3).

The Engineer may allow sawing for joint establishment when all of the following conditions exist:

(1) Precautions are taken to prevent infiltration of concrete into underlying joints
(2) Depth of the entire Type B repair remains above dowel bars
(3) In order to prevent compression spalls, saw cut the entire depth of the Type B repair
(4) Green sawing takes place in a timely manner, to prevent random cracks
(5) Green sawing does not produce excessive spalling

The Engineer will not allow sawing for joint establishment if Type B repair depth extends below the top of the dowel bars or Type B repair is used to repair a random crack.

E.2.a Application of Bonding Agent

The Contractor will choose a method for bonding the 3U18 mix to the in-place concrete in accordance with the following:

(1) Bonding Grout/Slurry Method

(a) Provide and place bonding grout to the prepared concrete repair surface consisting of 2 parts of Type I or Type I/II Portland cement and 1 part sand, mixed with sufficient water to form a slurry.
(b) Mix the grout mechanically and apply by brushing or scrubbing (with a stiff bristle broom) onto the in-place concrete surface. After applying the grout/slurry, immediately backfill repair with concrete.
(c) If the bonding grout dries or whitens before backfilling, discontinue the concrete backfill operation. Re-sandblast the repair before reapplying grout and concrete backfill.
(d) The life of the grout shall not exceed one hour.

(2) Water Bonding Method

(a) Apply clean potable water to the sandblasted concrete surface to achieve a saturated condition before 3U18 concrete backfilling. Apply multiple applications of potable water as necessary to achieve a saturated condition.
(b) If standing water is visible within the limits Type B repair, discontinue concrete backfill operations.
(c) In accordance with 2302.3E.3, “Repair,” an application of slurry/grout is still required at the repair surface.

E.3 Repair

Furnish 3U18 concrete, mix, place, surface finish, apply broom texture, apply grout slurry, cure, and saw and seal.

Provide a repaired surface tolerance that does not vary by more than 1/8 inch from the existing pavement surface as measured with a straightedge placed over the repair. Replace or grind the repair as necessary to correct deficiencies.

After radius edging inserts, final finishing, and providing broomed surface texture, apply a heavy application of bonding grout/slurry at the surface interface (around the perimeter) of the Type B repair and the in-place concrete pavement. Position the grout/slurry band so 1 inch is over the in-place pavement and 3 inches is located over the newly placed repair.

Apply the concrete cure in accordance with 2302.3C.3, “Curing Methods,” and protect the concrete repair from damage.

Saw and seal reestablished joints and cracks within Type B repairs in accordance with the variable width joint crack repair/joint repair (Type A1).

F Type C Repairs

Type C Repairs include: Full depth repair (Type CD-LV), Full depth repair (Type CD-HV), Pavement replacement (Type CX), Full depth repair (Type CA-LV), Spot full depth repair (Type C1-LV), and Utility trench full depth repair (Type C2).

Repairs with the designation LV are intended for use on non-state designated Roadways only. The Full depth repair (Type C1-LV, Type C2-LV, and CA-LV) are for use on Projects with a small quantity of repairs.

Saw cut concrete full depth and perform full-depth concrete removal; restore and compact the grade; install reinforcement bars, dowel bars, or both; and furnish, place, finish, cure concrete and saw, and seal joints.

F.1 Removals

Saw cut the concrete pavement full depth.

Remove in-place concrete pavement. Removal of the concrete pavement must take place within 48 hours of the full depth saw cutting, unless otherwise allowed by the Engineer.

Repair or replace any damage to the adjacent pavement that occurs during the removal process to the satisfaction of the Engineer and at no cost to the Department.

F.2 Preparation

When the Full depth repair is used in the transverse direction, furnish and install 18 inch by 1.25 inch diameter dowel bars. When the Full depth repair is used in the longitudinal direction, furnish and install 18 inch long, No. 8 epoxy coated reinforcement bars, in lieu of the dowel bars.

Provide dowel bars or reinforcement bars that are free of dirt, grease, oil, or other foreign Material.

Use drill bit(s) 1/8 inch or greater than the Nominal outside diameter of the dowel bar or epoxy coated reinforcing steel that are anchored to the in-place concrete pavement.

Provide a drill assembly or gang drill assemblies capable of drilling straight and true holes, to the required penetrating depth, drilling at mid-concrete pavement thickness, and to the tolerances shown below.

Install dowel bars in Full depth repair (Type CD-LV), Full depth repair (Type CD-HV), and if applicable, the Spot full depth repair (Type C1-LV) in accordance with the following tolerances:

(1) The final placement of the dowel bars is 9 inches into the face of the in-place concrete slab
(2) Parallel to the top of the pavement within ± 1/4 inch
(3) Parallel to the other dowel bars within ± 1/8 inch
(4) Parallel to the Roadway centerline ± 1/2 inch

Place dowel bar basket assemblies as outlined in the Pavement replacement (Type CX) and Full depth repair (Type CA-LV) details.

Use either the epoxy resin adhesive (ERA) or non-shrink grout (NSG) installation method to anchor the dowel bars and reinforcement bars into the concrete. Clean and prep the drilled holes in accordance with adhesive manufacturer’s recommendations.

Final approval of the methods used to anchor dowel bars or reinforcement bars is based on actual field performance as verified by random coring.

F.2.a Epoxy Resin Adhesive (ERA) Installation Method

From the *Approved/Qualified Products List* furnish an ERA Material with a stated application of anchoring dowel bars or reinforcement bars. Provide to the Engineer an installation data sheet from the manufacturer. The ERA will meet *AASHTO M 235,* “Standard Specification for Epoxy Resin Adhesives,” Type IV (Load Bearing Applications), Grade 3 (Non-sagging consistency), and of a Class (Temperature Range) to match the pavement temperature at the time of application. ERA Class (Temperature Range) designations are as follows:

(1) Class A, for use below 40°F
(2) Class B, for use between 40°F and 60°F
(3) Class C, for use above 60°F the highest allowable temperature to be defined by the manufacturer of the ERA

When pavement temperatures are below 40°F use Class A, when pavement temperatures are between 40°F and 60°F use either Class A or B, when pavement temperatures are above 60°F use Class A, B or C.

ERA injection can be by either a mechanical caulking apparatus or a pneumatic injection system and have a nozzle capable of reaching and filling the back of the drill hole. In accordance with the manufacturer's recommendations, fill drill hole with adhesive and insert dowel or reinforcement bars.

F.2.b Non-Shrink Grout (NSG) Installation Method

From the *Approved/Qualified Products List* furnish a NSG Material with a stated application of anchoring horizontal dowel bars or reinforcement bars. Provide to the Engineer an installation data sheet from the manufacturer of NSG Material.

Provide either self-contained grout capsule or pre-bagged NSG utilizing an injection system capable of reaching and filling the back of the drill hole.

F.3 Before Concrete Placement

When placing concrete adjacent to in-place concrete pavement joints, protect ends of transverse joints to the satisfaction of the Engineer to prevent concrete mortar from infiltrating into the existing joints, resulting in compression spalls.

Do not remove any preformed joint filler used in the re-establishment of joints in Type C repairs, except by sawing or as allowed by the Engineer.

F.4 Repair

Furnish, place, finish, and cure concrete grades 3R52 or 3RHE52 for Type C repairs.

In accordance with Full depth repair details Types CD-HV, CD-LV, and CA-LV, furnish, and place transverse No. 4 epoxy coated reinforcing steel.

In accordance with the Full depth repair detail Type C2-LV, furnish both transverse and longitudinal reinforcing steel.

In accordance with Pavement replacement (Type CX) repair detail, drill and grout No. 4 by 18 inches long epoxy coated reinforcing (tie) steel into the adjacent lane at a spacing of 30 inches.

The Engineer will require corrective Work on vertical surface deviations greater than 1/4 inch within the span of the 10 foot straightedge in any direction. For corrected variations, the Engineer will accept deviations less than or equal to 1/4 inch within the span of a 10 feet straightedge in any direction.

Restore contraction joints by green sawing to a depth of 1/3 of the pavement thickness.

In accordance with Joint repair (Type A1) detail, prepare and seal saw cuts and reestablished cracks.

F.5 Dowel Bar Anchoring Test Section

Provide a dowel bar anchoring test section consisting of a complete Full depth repair (Type CD-HV or CD-LD) at a site directed by the Engineer at least 1 Calendar Day before startup of major Full depth repair (Type CD-HV or CD-LV) operations. Perform the dowel bar anchoring test section as follows:

(1) Saw cut and remove in-place pavement to the dimensions shown on the Full depth repair (Type CD-HV or CD-LV) detail.
(2) In the test section drill and install either 6 or 11 dowels in accordance with appropriate Full depth repair (Type CD-HV or CD-LV).
(3) Use either a Department approved ERA or NSG as an adhesive to secure the dowel bars to the in-place concrete pavement.
(4) Cure the dowel bar anchoring adhesive at least 4 hours before coring.
(5) Do not place concrete in the dowel bar test section.
(6) The Engineer will identify and mark 3 core locations on a single side of the Full depth repair (Type CD-HV or CD-LV).
(7) Take three 4-inch diameter full depth cores centered on the dowel and 1 inch from the sawed vertical face.

F.5.a Evaluation of Dowel Bar Anchoring Test Section

The Engineer in conjunction with the Concrete Engineer will determine if the anchoring of the dowels is acceptable. The Concrete Engineer considers the anchoring method acceptable if no air voids are greater than 1/4 inch in any direction. Cores will become the property of the Engineer.

If the Engineer determines the anchoring of the dowels is acceptable, the Engineer will notify the Contractor to begin production operations. The Engineer’s continued acceptance is based on satisfactory placement and performance.

If the Engineer determines the anchoring of the dowels is not acceptable, remove the first test section and install another test section at the Contractor’s expense. The Engineer will not extend the Contract Time for the additional test section.

Upon acceptance of the dowel bar anchoring test section, perform the following:

(1) Place a full depth saw cut offset 1 foot from the vertical face of the test section.
(2) Completely remove the cored side of the dowel bar test section.
(3) Drill and anchor a new set of dowels as shown on the Full depth repair (Type CD) detail.
(4) The Engineer will pay for the Work in this subsection at the unit bid price of Full depth repair (Type CD) and Pavement replacement (Type CX).
(5) The Working Days for the test section are built into the total Contract Time.

F.6 Dowel Bar Anchoring Assurance

Take additional cores to confirm consistent dowel bar or reinforcing steel anchoring. For each 1500 linear feet of Full depth repair (Type CD), the Engineer will randomly choose 2 separate repairs and mark dowel bars for an assurance core. For each 6000 square feet of Full depth repair (Type C1), the Engineer will randomly choose 2 separate repairs and mark reinforcing steel for an assurance core. The Engineer will review the cores to determine if the anchoring operations remain acceptable. If the dowel bars or reinforcing bars show air voids greater than that specified in 2302.3F.5.a, “Evaluation of Dowel Bar Anchoring Test Section,” take additional cores as directed by the Engineer to determine the severity.

The Engineer will suspend full depth repair operations if dowel bars are anchored improperly. Operations will not resume until the Contractor has demonstrated to the Engineer that the problem which caused the air voids is corrected.

If the cores show proper anchoring, back fill core holes with 3U18 concrete.

When the dowel bar anchoring assurance coring operations show satisfactory placement and performance, the Engineer, in conjunction with the Concrete Engineer, may decrease the frequency to 2 assurance cores for every 3000 lineal feet of full depth repair (Type CD-HV or CD-LV).

G Dowel Bar Retrofit

Retrofit dowel bars in mainline joints and/or mid-panel cracks as shown on the Plans. Perform dowel bar retrofits only after all other repairs are completed on the joint or crack.

G.1 Removal

Schedule operations so that concrete removed during any Work shift is replaced with dowel bars and backfill Material before the time the lane is re-opened to traffic.

Employ saws equipped with gang mounted diamond blades capable of cutting the required amount of slots in each wheel path simultaneously. Vacuum up and remove water and saw residue from the pavement surface. Skewed joints or cracks may require slots longer than that specified in the details. The Engineer will not provide compensation for the additional sawing or any component of the dowel bar retrofit beyond the limits shown on the dowel bar retrofit detail required to ensure at least 7 inches of dowel bar is placed on each side of the joint or crack. Limit traffic to 5 Calendar Days on sawn slots before completing the retrofit operation. For smaller Projects (100 bars or less), the Engineer may allow walk-behind saws instead of slot saws as long as a template is used to ensure the slot locations are within the tolerances specified on the dowel bar retrofit detail and below.

Make two saw cuts in the pavement to outline the longitudinal sides of each dowel bar slot. Saw the slots to the depth and length that allows placing the dowel at mid-depth in the pavement slab. Place the slot saw cuts:

(1) Parallel to the top of the pavement within ± 1/4 inch
(2) Parallel to the other slots within ± 1/8 inch
(3) Parallel to the Roadway centerline ± 1/2 inch

Note: Always measure dowel bar offsets from the Roadway centerline.

Remove the concrete between the parallel saw cuts with a chipping hammer. Do not punch through the bottom of the slot or dislodge the pavement that is to remain in place. During concrete removal operations, use a small brush hammer as necessary to produce a flat, level surface within the slot for placing the bar in the proper location. Dispose of the removal debris on a daily basis, unless otherwise approved by the Engineer.

G.2 Preparation

G.2.a Slot Cleaning and Preparation

Sufficiently clean the bottom of the slots with a chipping or brush hammer to allow the dowel bar assembly to sit parallel to the pavement surface.

If needed, dry the slot before sandblasting with a high pressure air blasting heat lance.

Sandblast the vertical sides and bottom of the slot after the concrete removal operations to completely remove loose debris and saw residue. Continue to sandblast until the sawing residue is removed and the vertical sawed faces are rough to the touch. The Contractor may recommend alternative methods of roughening for approval by the Engineer. The Engineer will require additional sandblasting if the slots become wet from any source after initial sand and air blasting other than 2302.3F.3, “Before Concrete Placement.”

Immediately before beginning sealing of the joint or crack inside the slot, further clean exposed surfaces and cracks with a “moisture and oil free” high pressure air blasting of 150 pounds per square inch minimum.

Protect traffic from sand and air blasting in a manner approved by the Engineer.

G.2.b Sealing Joints and Cracks in Slot

After sand and air blasting the slot, seal the bottom and sides of the crack with caulking Material to keep the patching Material from leaking into the joint or crack. Cure caulking Material for a minimum of 2 hours or until tack free or according to the manufacturer's recommendations, whichever is longer, before placing the approved rapid set, non-shrink concrete. The caulking filler shall not extend 1/2 inch beyond each side of the existing joint or crack. The Contractor may complete sealing of the cracks in conjunction with furnishing and installing the dowel assembly.

G.2.c Installation of Preformed Joint Filler

Furnish preformed joint filler in accordance with 2302.3G, “Dowel Bar Retrofit,” and the following:

(1) Provide a round hole in the preformed joint filler the same Nominal diameter as the specified dowel bar. Use a slightly larger hole when necessary to accommodate a skewed joint or crack.
(2) Slots cut into the preformed joint filler to accommodate the dowel bar are not allowed.
(3) Locate the hole to provide enough preformed joint filler below the dowel to extend to the bottom of the slot.
(4) The preformed joint filler is required to remain centered over the joint or crack and tight to the bottom and edges of the slot during placement of the concrete. If the preformed joint filler shifts during construction operations or if a crack forms adjacent to the preformed joint filler, the Engineer will require removal and replacement of the dowel bar retrofit at the Contractor’s expense.

G.2.d Installation of Dowel Assembly into Slot

Supply dowel bar chairs that provide a minimum of 1/2 inch clearance between the bottom of the dowel and the bottom of the slot and with sufficient rigidity to hold the dowel bar in place during concrete placement and vibratory consolidation.

Apply form release agent as a bond breaker on dowel bars before their placement in the slots.

Install dowel assembly that has the bond breaker applied and is fitted with the compressible foam core board Material, the support chairs, and the 1/4 inch expansion caps on both ends into the slot in accordance with the following:

(1) Parallel to the top of the pavement within ± 1/4 inch
(2) Parallel to the other slots within ± 1/8 inch
(3) Parallel to the Roadway centerline ± 1/2 inch, measure dowel bar offsets from the Roadway centerline
(4) Minimum of 1/2 inch clearance between the bottom of the dowel and the bottom of the slot

G.3 Repair

Thoroughly moisten (with potable water) surfaces of the slot immediately before filling with backfill Material. The Engineer will not allow standing water in the slot.

Fill each prepared slot with an approved rapid set, non-shrink concrete for dowel bar retrofit repairs. Ensure the compressible foam core board remains upright over the existing joint or crack during the backfill operation. Vibrate the rapid set, non-shrink concrete with a small 1 inch diameter hand-held vibrator capable of thoroughly consolidating the concrete around the dowel bar and support chairs and without segregation.

Finish the concrete flush to within a tolerance of 1/16 inch above the adjacent concrete surface. When concrete grinding is part of the Contract, leave the surface of the backfill Material 1/4 inch above the adjacent concrete surface.

Immediately after final finishing, coat concrete with a membrane curing compound in accordance with 2302.3B.3, “Type C Repairs.”

G.4 Test Section

Provide a test section consisting of complete dowel bar retrofit at a site directed by the Engineer at least 3 Calendar Days before startup of major operations as follows:

(1) Install 24 retrofit dowels in the test section.
(2) The Engineer will identify and mark 3 locations for coring.
(3) Take three 4-inch diameter full depth cores through the dowel bar retrofits at least 4 hours after completion of the test section.

G.4.a Evaluation of Dowel Bar Retrofit Test Section

The Engineer will determine if the retrofitting operation is acceptable.

If the Engineer determines the retrofitting operation is acceptable, the Engineer will notify the Contractor to begin production operations. The Engineer’s continued acceptance is based on satisfactory placement and performance.

If the Engineer determines the retrofitting operation is not acceptable, remove the first test section and install another test section at the Contractor’s expense. The Engineer will not extend the Contract Time for the additional test section.

Upon acceptance of the dowel bar retrofit test section, perform the following:

(1) Completely remove and replace the dowel installation where the core samples were taken.
(2) The Department will pay for the Work in this subsection at the unit bid price for Dowel bar retrofit.

(3) The Working Days for the test section are built into the total Contract Time.

G.5 Retrofit Dowel Bar Placement Alignment Assurance

Take additional cores to confirm consistent dowel bar placement and proper consolidation for each 600 bars placed. The Engineer will randomly mark 2 retrofit locations for assurance coring. The Engineer will review the cores to determine if the retrofitting operation is acceptable. If the dowels are located incorrectly or air voids exist around the dowel bars, take additional cores, as directed by the Engineer, to determine the severity.

The Engineer will suspend dowel retrofitting operations if dowels are installed improperly. Dowel retrofitting operations will not resume until the Contractor has demonstrated to the Engineer that the problem which caused the improper dowel positions or air voids is corrected. Replace any individual Dowel bar retrofit not functioning or damaged at the expense of the Contractor.

The Engineer will not allow water from the coring operation to flow across lanes occupied by public traffic or flow into closed drainage facilities.

After removal of the cores, completely remove and replace the dowel installation where the core samples were taken.

When the dowel bar retrofit assurance coring operations show satisfactory placement and performance, the Engineer, in conjunction with the Concrete Engineer, may decrease the frequency of assurance cores to every 1200 bars placed or more.

H Repair Evaluation Period

The repair evaluation period lasts 30 Calendar Days. The repair evaluation period begins after all Type B, Type C, Dowel bar retrofits repair and Concrete grinding (when required) are completed in a single Traffic Lane. The continuity of a single Traffic Lane is not broken by either staging or Project exceptions unless otherwise authorized by the Engineer.

The Department will review concrete pavement repairs and the diamond ground finished surface for failures during the repair evaluation period. Remove and replace failures that appear within the review evaluation period in accordance with 1512, "Unacceptable and Unauthorized Work."

Failures include (but are not limited to) the loss of bonding to the in-place concrete or crack apparent in the repair other than the desired crack in the newly constructed joint or re-established crack, and damage caused by the Contractor's operations.

The repair evaluation period starts over for repaired failures.

Provide traffic control for inspection of repairs within the repair evaluation period, for removal and replacement of failed repairs, and for re-evaluation of the repaired failures.

2302.4 METHOD OF MEASUREMENT

The Engineer will not measure extra width to accommodate the Contractor's Equipment. Any extra width to accommodate the Contractor's Equipment is at the Contractor's expense.

A Variable Width Joint or Crack Repair / Joint Repair (Type A1)

The Engineer will measure Joint repair (Type A1) by the lineal length. The Engineer will not take separate measurements for varying widths. The Engineer will not measure and pay the restoration of joints and cracks through or alongside any Type B, Type C, or Dowel bar retrofit repairs under this Contract Item.

B Variable Width In Place Joint or Crack Repair / Joint Repair (Type A2)

The Engineer will measure Joint (Type A2) by the lineal length. The Engineer will not take separate measurements for varying widths.

C Partial Depth Repair (Type BA)

The Engineer will measure Partial depth repair (Type BA) by the actual area of the repair. Take the measurements for the area calculations at the pavement surface; include the 30 to 60 degree tapers in the measurements for the area calculations.

D Joint and Crack repair (Type B3)

The Engineer will measure Joint and crack repair (Type B3) by the lineal length. The Engineer will take additional measurements for payment under this or other Type B repairs only when the following requirement are met:

(1) In isolated areas the typical width of the repair is exceeded and the measured quantity is equal to or greater than 1 square foot. This is not a cumulative quantity within a single Type B3 repair.
(2) A full width pass with the mill is taken on both sides of the joint or crack as directed by the Engineer.
(3) The Type B3 repair is placed on only one side of the joint or crack, and the opposite side of the joint or crack requires an additional repair when directed by the Engineer, regardless of the size of the repair preformed.

E Partial Depth Repair Special (Type BE)

The Engineer will measure Partial depth repair special (Type BE) by the area of the repair. Take the measurements for the Type BE area calculation at mid-depth of the concrete pavement. The Engineer will take measurements for the Type BE only when the following requirements are met:

(1) When the in-place concrete pavement is removed full depth and when the grade below the concrete pavement is visible
(2) When reinforcement bars are furnished and installed as shown in Partial depth repair special (Type BE) detail and at least one reinforcement bar is installed per unit of measure.

When the above requirements are not met, the Engineer will only take measurements for payment on the Partial depth repair (Type BA) or Joint and crack repair (Type B3) regardless of the depth of the repair. The Engineer will provide measurement for payment for overlapping Type BA and Type B3 repairs for the most expensive repair only.

F Full Depth Repair (Type CD-HV and Type CD-LV)

The Engineer will measure Full depth repair (Type CD-HV and Type CD-LV) by the linear width. Take a single linear measurement of the repair at a right angle from the standard dimension of 4 feet as shown on the Full depth repair (Type CD-HV and Type CD-LV) detail. Unless the repair is placed at a skew to the Roadway centerline, then take the single linear measurement along the skewed saw cut.

G Pavement Replacement (Type CX)

The Engineer will measure Pavement replacement (Type CX) by the area of the repair. When the standard dimension of 4.0 feet as outlined on the Full depth repair (Type CD) or Full depth repair (Type CA-LV) detail is exceeded, measure the area that is outside the 4.0 feet dimension as Pavement replacement (Type CX).

H Spot Full Depth Repair (Type C1-LV)

The Engineer will measure Spot full depth repair (Type C1-LV) by area of the repair.

I Utility Trench Full Depth Repair (Type C2-LV)

The Engineer will measure Utility trench full depth repair (Type C2-LV) by area of the repair.

J Full Depth Repair (Type CA-LV)

The Engineer will measure Full depth repair (Type CA-LV) by the linear width. Take a single linear measurement of the repair at a right angle from the standard dimension of 4 feet as shown on the Full Depth Repair (Type CA-LV) detail. Unless the repair is placed at a skew to the Roadway centerline, then take the single lineal measurement along the skewed saw cut.

K Dowel Bars

The Engineer will measure Dowel bars per each individual Dowel bar, as supplied in dowel bar basket assemblies for Pavement replacement (Type CX) repairs.

L Drill and Grout Reinforcement Bars

The Engineer will measure Drill and grout reinforcement bars per each reinforcement bar, as furnished and installed as tie bars for Pavement replacement (Type CX) of 75 feet or greater in length.

M Dowel Bar Retrofit

The Engineer will measure Dowel bar retrofit per each individual dowel bar successfully installed.

N Supplemental Reinforcement Bars (Epoxy Coated)

The Engineer will measure Supplemental reinforcement bars (epoxy coated) by mass.

2302.5 BASIS OF PAYMENT

The payment for concrete pavement rehabilitation Pay Items is compensation in full for costs of Materials, Equipment, and labor required to complete the Work as specified in the repair detail, to the satisfaction of the Engineer.

A Variable Width Joint or Crack Repair / Joint Repair (Type A1)

The Department will pay for Variable width joint or crack repair / joint repair (Type A1) at the Contract Unit Price as full compensation for costs of removing and disposing of the in-place joint sealer, saw cutting both faces of the joint or crack to the proper depth and width, cleaning, sandblasting, furnishing and installing backer rod of the proper size and to the proper depth, furnishing and installing (hot poured) joint and crack sealer, cleanup, and any other Materials, labor, or Equipment necessary to complete the Work as specified.

B Variable Width In Place Joint or Crack Repair / Joint Repair (Type A2)

The Department will pay for Variable width in-place joint or crack repair / joint repair (Type A2) at the Contract Unit Price as full compensation for costs including but not limited to: removing and disposing of the in-place joint sealer; cleaning, sandblasting, furnishing and installing backer rod of the proper size and to the proper depth; furnishing and installing (hot poured) joint and crack sealer; cleanup, and any other Materials, labor, or Equipment necessary to complete the Work as specified.

C Partial Depth Repair (Type BA)

The Department will pay for Partial depth repair (Type BA) at the Contract Unit Price as full compensation for costs including but not limited to: removing and disposing of the in-place concrete pavement as marked by the Engineer, tapering the edges of the repair back at 30 to 60 degrees, cleaning, sandblasting and air blasting, furnishing and installing bonding grout, furnishing and installing preformed joint filler to reestablish the joint or crack within or along the repair, furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, placing cement and sand slurry around the edges, curing and protecting the concrete, sawing and sealing reestablished joints and cracks in accordance with the Joint repair (Type A1) detail, cleanup, and any other Materials, labor, or Equipment necessary to complete the Work as specified.

D Joint and Crack Repair (Type B3)

The Department will pay for Joint and crack repair (Type B3) at the Contract Unit Price as full compensation for costs including but not limited to: removing and disposing of the in-place concrete pavement as marked by the Engineer, tapering the edges of the repair back at 30 to 60 degrees, cleaning, sandblasting, furnishing and installing preformed joint filler to reestablish the joint or crack within or along the repair, furnishing and installing bonding grout, furnishing and placing concrete within the repair, vibrating, screeding, finishing, applying surface texture, placing cement and sand slurry around the edges, curing and protecting the concrete, sawing and sealing reestablished joints and cracks in accordance with the Joint repair (Type A1) detail, cleanup, and any other Materials, labor, or Equipment necessary to complete the Work as specified.

E Partial Depth Repair Special (Type BE)

The Department will pay for Partial depth repair special (Type BE) at the Contract Unit Price as full compensation for costs including but not limited to: removing and disposing of the in-place concrete pavement, cleaning, sandblasting and air blasting, furnishing and grouting reinforcement bars (epoxy coated), furnishing and installing bonding grout, furnishing and installing preformed joint filler to reestablish the joint or crack within or along the repair, furnishing and placing concrete within the repair, and vibrating. The Department will pay in conjunction with the Partial depth repair (Type BA) or Joint and crack repair (Type B3).

If after removal the Engineer changes the initial Partial depth repair (Type BA) or Joint and crack repair (Type B3) to a Full depth repair (Type CD-HV or CD-LV), the Department will pay the Contractor at a measured quantity of 40 percent of the Type B repair Contract Item plus the full cost for the Type C repair.

F Full Depth Repair (Type CD-HV and Type CD-HV)

The Department will pay for Full depth repair (Type CD-HV and Type CD-LV) at the Contract Unit Price as full compensation for costs including but not limited to: saw cutting the pavement full depth; removal and disposal of the in-place pavement; restoring and compacting the base; furnishing and installing preformed joint filler; furnishing, drilling, and anchoring dowel bars; coring both the dowel bar anchoring test section and the random assurance cores; backfilling the assurance core holes with 3U18 concrete; furnishing and placing concrete within the repair; vibrating, screeding, finishing, applying surface texture, curing, and protecting the concrete; sawing and sealing reestablished joints, cracks and saw cuts in accordance with the Joint repair (Type A1) detail; cleanup; and any other Materials, labor, or Equipment necessary to complete the Work as specified.

G Pavement Replacement (Type CX)

The Department will pay for Pavement replacement (Type CX) at the Contract Unit Price as full compensation for costs including but not limited to: saw cutting the pavement full depth; removing and disposal of the in-place pavement; restoring and compacting the base; furnishing and installing preformed joint filler; furnishing and placing concrete within the repair; vibrating, screeding, finishing, applying surface texture, curing, and protecting the concrete; sawing; sealing reestablished crack, joints, and saw cuts in accordance with the Joint repair (Type A1) detail; cleanup; and any other Materials, labor, or Equipment necessary to complete the Work as specified. The Department will pay for Pavement replacement (Type CX) in conjunction with the Full depth repair (Type CD-HV) or the Full depth repair (Type CA-LV).

H Spot Full Depth Repair (Type C1-LV)

The Department will pay for Spot full depth repair (Type C1-LV) at the Contract Unit Price as full compensation for costs including but not limited to: saw cutting the pavement full depth; removal and disposal of the in-place pavement; restoring and compacting the base; furnishing and installing preformed joint filler; furnishing, drilling, and grouting dowel bars, epoxy coated reinforcement bars, or both; random assurance cores; backfilling the assurance core holes with 3U18 concrete; furnishing and placing concrete within the repair; vibrating, screeding, finishing, applying surface texture, curing, and protecting the concrete; sawing, sealing reestablished joints, cracks, and saw cuts in accordance with the Joint repair (Type A1) detail; cleanup; and any other Materials, labor, or Equipment necessary to complete the Work as specified.

I Utility Trench Full Depth Repair (Type C2-LV)

The Department will pay for Utility trench full depth repair (Type C2-LV) at the Contract Unit Price as full compensation for costs including but not limited to: saw cutting the pavement full depth; removal and disposal of the in-place pavement; restoring and compacting the base; furnishing and installing preformed joint filler; furnishing, drilling, and grouting epoxy coated reinforcement bars; furnishing and placing concrete within the repair; vibrating, screeding, finishing, applying surface texture, curing, and protecting the concrete; sawing; sealing reestablished joints, cracks, and saw cuts in accordance with the Joint repair (Type A1) detail; cleanup; and any other Materials, labor, or Equipment necessary to complete the Work as specified.

J Full Depth Repair (Type CA-LV)

The Department will pay for Full depth repair (Type CA-LV) at the Contract Unit Price as full compensation for costs including but not limited to: saw cutting the pavement full depth; removal and disposal of the in-place pavement; restoring and compacting the base; furnishing and installing preformed joint filler and dowel bar baskets assemblies; drilling and grouting reinforcement bars; furnishing and placing concrete within the repair; vibrating, screeding, finishing, applying surface texture, curing, and protecting the concrete; sawing; sealing reestablished joints, cracks, and saw cuts in accordance with the Joint repair (Type A1) detail; cleanup; and any other Materials, labor, or Equipment necessary to complete the Work as specified.

K Drill and Grout Reinforcement Bars

The Department will pay for Drill and grout reinforcement bars at the Contract Unit Price as full compensation for costs including but not limited to: drilling concrete, furnishing reinforcement bars (epoxy coated), and installing reinforcement bars with an approved grout or epoxy bonding agent.

L Dowel Bar Retrofit

The Department will pay for Dowel bar retrofit at the Contract Unit Price as full compensation for costs including but not limited to: sawing the slot; removal of the concrete within the slot; removing and vacuuming debris; sandblasting and air blasting; dowel bar retrofit test section and assurance testing including coring and removals; sealing the crack inside of the slot, the dowel bar, and expansion caps; chairs; release agent; preformed joint filler or cardboard Material; furnishing and placing non-shrink, rapid setting concrete mixture; finishing, curing, and protecting the concrete; sawing; sealing reestablished joints and cracks in accordance with the Joint repair (Type A1) detail; cleanup; and any other Materials, labor, or Equipment necessary to complete the Work as specified.

M Supplemental Reinforcement Bars (Epoxy Coated)

The Department will pay for Supplemental reinforcement bars (epoxy coated) at the Contract Unit Price as full compensation for costs including but not limited to, furnishing and installing epoxy coated reinforcement bars as specified.

N Dowel Bars

The Department will pay for Dowel bars at the Contract Unit Price as full compensation for costs including but not limited to, furnishing and installing dowel bars in dowel bar basket assemblies.

O Monetary Adjustment

The Department must apply Incentives and Disincentives and may apply monetary deductions for Concrete Pavement Rehabilitation. The amounts of these adjustments are deemed reasonable.

O.1 Concrete Curing and Protection

Failure to comply with the 2302.3C.3, “Concrete Curing and Protection,” will result in the Engineer, in conjunction with the Concrete Engineer, applying a monetary deduction in accordance with 1503, “Conformity with Contract Documents” and 1512 “Unacceptable and Unauthorized Work.”

For Type B Repairs, the Department will apply a monetary deduction of 100 percent of the unit bid price for the concrete in question.

For Type C Repairs, the Department will apply a monetary deduction of $100.00 per cubic yard or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

The Contractor may remove and replace the Type B or Type C Repairs at their own expense in lieu of the monetary deduction.

P Schedule

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

Item No.	Item	Unit
2302.502	Dowel Bars	each
2302.502	Drill and Grout Reinforcement Bar (Epoxy Coated)	each
2302.502	Dowel Bar Retrofit	each
2302.502	Joint Repair (Type A1)	each
2302.502	Joint Repair (Type A2)	each
2302.503	Joint and Crack Repair (Type B3)	linear foot
2302.503	Full Depth Repair (Type CA-LV)	linear foot
2302.503	Full Depth Repair (Type CD-LV)	linear foot
2302.503	Full Depth Repair (Type CD-HV)	linear foot
2302.504	Pavement Replacement (Type CX)	square yard
2302.504	Utility Trench Full Depth Repair (Type C2-LV)	square yard
2302.508	Supplemental Reinforcement Bars (Epoxy Coated)	pound
2302.518	Partial Depth Repair (Type BA)	square foot
2302.518	Partial Depth Repair Special (Type BE)	square foot
2302.518	Spot Full Depth Repair (Type C1-LV)	square foot

2353 ULTRATHIN BONDED WEARING COURSE

2353.1 DESCRIPTION

This Work is the construction of an ultrathin bonded wearing course (UTBWC) on a prepared pavement. An ultrathin bonded wearing course is the application of a polymer modified emulsion membrane followed immediately with an ultrathin wearing course mixture.

2353.2 MATERIALS

A Bituminous Materials

A.1 Polymer Modified Emulsion Membrane 3151.2G

A.2 Asphalt Binder 3151

Use a performance graded binder, PG 58V-34

B **Aggregate** **3139.2C**

B.1 Mineral Filler .... ***AASHTO M 17***

C Mix Design

Contractor shall design the UTBWC mixture to meet the requirements of this section.

For optimum binder content the mixture shall meet the requirements in Table 2353.2-1.

Each design shall include the additional design trial points that bracket the optimum AC content and with at least one point at 0.4 above and below the optimum AC content. Draindown testing and adjusted asphalt film thickness (Adj. AFT) determinations are required on these trial points.

D Mix Design Submittal

Submit a proposed job mix formula (JMF) in writing to the Department Bituminous Engineer for review as specified meeting the requirements in Table 3139.2-9 and Table 2353.2-1 and include the following:

(1) Source, pit identification, and description of the Materials used
(2) The proportion and gradation of each Material in the JMF
(3) The composite gradation of the design blend
(4) Bulk and apparent specific gravities and water absorption (by percent weight of dry Aggregate) of both coarse and fine Aggregate, for each product used in the mixture (including RAP/RAS). Use *Laboratory Manual* Method 1204 and 1205. The tolerance allowed between the Contractor's and the Department's specific gravities are Gsb (individual) = 0.040 (+4 and -4) and Gsb (combined) = 0.020
(5) Test results and worksheets for all properties required in Table 2353.2-1 and Table 3139.2-7 to Table 3139.2-9
(6) Testing results and worksheets for the additional design points that bracket the optimum AC point

Table 2353.2-1
UTBWC Mixture Requirements

Test	Criteria	Test Reference
Asphalt Content	4.8-6.0	*Laboratory Manual* Methods 1853 or 1852
Adj. AFT (Calculated)	10.5 micrometer minimum	*Laboratory Manual* Method 1854
Draindown Test	0.10 percent maximum	*AASHTO T 305*
Lottman (TSR)	80 percent minimum, 7-8 percent voids	*Laboratory Manual* Method 1813

D.1 Job Mix Formula Properties

Base gradation, asphalt binder content, and adjusted AFT on the current Department reviewed mixture design report. The JMF limits are the target plus or minus the limits in accordance with Table 2353.2-2. Use JMF limits as the criteria for acceptance of Materials based on individual sample testing. Stop production if the test results vary from the JMF by more than the limits in Table 2353.2-2. Identify the cause and document in detail the corrective action. The JMF may only be adjusted if the revised JMF meets the mixture requirements in Table 2353.2-1 and Table 3139.2-9. Do not resume paving until brought back into Specification limits.

Table 2353.2-2
UTBWC JMF Limits

Gradation	Broad Band Limits
Asphalt Content	±0.4*
Adj. AFT	-0.5*
*Note: The above limits shall not exceed the UTBWC mixture requirements in Table 2353.2-1	

D.2 JMF Adjustments

The Contractor may make a request to the Bituminous or District Materials Engineer for a JMF adjustment if the QC test results indicate a necessary change to the design. A Certified Level II Bituminous QM Mix Designer will review the requested change for the Department. If the request meets the requirements in Table 3139.2-9 and Table 2353.2-1 a revised Mixture Design Report will be issued.

2353.3 CONSTRUCTION REQUIREMENTS

A Weather Restrictions

The pavement surface temperature and ambient air temperature shall be at least 50°F. A damp pavement surface is acceptable, if it is free of standing water and favorable weather conditions are expected.

B Surface Preparation

Complete the following Incidental Work before the paving operations. Remove thermoplastic and tape traffic markings greater than 0.2 inches thick. Protect with plastic or building felt manhole covers, drains, grates, catch basins, and other utility Structures. Clean the pavement surface.

C Equipment

Use a paver designed and built for the purpose of applying the ultrathin bonded wearing course. The paving machine shall incorporate a receiving hopper, feed conveyor, a storage tank for polymer modified emulsion membrane, polymer modified emulsion membrane spray bar and a variable width, and heated vibratory or tamper bar screed. The screed shall have the ability to crown the pavement at the center both positively and negatively and have vertically adjustable extensions to accommodate the desired pavement profile.

D Paving

Mixture must be produced by a certified plant.

Apply the polymer modified emulsion membrane and the ultrathin bonded wearing course in one pass. Spray the polymer modified emulsion membrane so it is not driven on immediately before the application of the UTBWC. Use a metered mechanical pressure spray bar at a temperature of 120 – 180°F. Accurately and continuously monitor the rate of spray and provide a uniform application across the entire pavement width. Use a spray rate in the range of 0.20 gallons per square yard ± 0.07 gallons per square yard. Make adjustments based upon the existing pavement surface conditions and recommendations of the polymer modified emulsion membrane supplier. Apply the UTBWC at a temperature of 290-330°F as measured in front of the screed. No wheel or other part of the paving machine shall come in contact with the polymer modified emulsion membrane before the UTBWC is applied. Use a heated vibratory or tamper bar screed. Open the new pavement to traffic after the rolling operation is complete and the Material has cooled below 158°F.

E Thickness

The minimum finished wearing course thickness is 5/8 inch with a maximum 1/2 inch vertical edge at the adjacent Shoulder pavement edge.

F Rolling

Roll the wearing course a minimum of two passes, before the Material temperature has fallen below 185°F.

Use steel double drum asphalt rollers with a minimum weight of 11 tons. Do not allow the roller(s) to remain stationary on the freshly placed UTBWC. Roll in static mode only immediately following the placement of the UTBWC in order to seat the mix.

G Pavement Smoothness

After placement, the ultrathin bonded wearing surface shall show no variation greater than 1/8 inch from the edge of a 10 foot straightedge laid parallel to or at right angles to the centerline.

Evaluation of pavement surface Smoothness, per 2399, “Pavement Surface Smoothness,” is required only when UTBWC is placed over a new Lift(s) of asphalt. When 2399, “Pavement Surface Smoothness,” is required make the following modification.

Replace section 2399.3C.2, “Areas of Localized Roughness,” with the following:

ALR will be evaluated only on the asphalt pavement placed prior to the placement of the UTBWC. Identify ALR using the ProVAL “Smoothness Assurance” module, calculating MRI with a continuous short interval of 25 feet, with a 250 millimeter filter applied. Smoothness will not be evaluated on the asphalt pavement under the UTBWC.

H Quality Control

The Contractor is responsible for Quality Control (QC) sampling and testing as per the *Schedule of Materials Control*.

I Polymer Modified Emulsion Membrane

Verify the application rate of the polymer modified emulsion membrane by dividing the volume of polymer modified emulsion membrane used by the area of paving for that day.

J Quality Assurance

The Engineer is responsible for Quality Assurance (QA) sampling according to *Schedule of Materials Control*. The QA sample is the Department’s companion sample to the Contractor’s QC sample and tested as required.

J.1 Verification Sampling and Testing

The Department will test at a minimum 1 verification sample per day to assure compliance of the Contractor's QC program. The Department will decide daily, which QC/QA companion samples are to be submitted and tested as the verification sample. The verification sample can be any one or all of the QC/QA split samples.

In addition, the Engineer may obtain additional verification samples at any time and location during production to determine quality levels of the mixture. When additional verification samples are taken, the Department will provide the Contractor a verification companion. The Contractor is required to test and use this verification companion sample as part of the QC program. Use the verification companion sample to replace the next scheduled QC sample.

Compare the verification companion sample to the verification sample for compliance with allowable tolerances in Table 2353.3-1. The Department’s verification test results will be available to the Contractor within two Working Days from the time the sample is delivered to the district laboratory.

If the tolerances between the Contractor's verification companion sample and the Department's verification sample do not meet the requirements of Table 2353.3-1, the Department will retest the Material. If the retests fail to meet tolerances, the Department will substitute the Department's verification test results for the Contractor's results in the QC program and use those results for acceptance. The Department will only substitute the out-of-tolerance parameters.

The Department will test the previously collected QA samples until they meet the tolerances or until the Department has tested all of the remaining samples. After testing the samples, the Department will test QA samples subsequent to the verification sample until tolerances are met.

If the adjusted AFT calculation does not meet the tolerance in Table 2353.3-1, equalize the Departments adjusted AFT result by increasing the original Department value by 0.5 microns. The increased Department adjusted AFT will be the basis for acceptance.

The Department will base acceptance on QC data with substitution of Department test results for those parameters that are out of tolerance. Cease mixture production and placement if reestablished test results do not meet tolerances within 48 hours. Resume production and placement only after meeting the tolerances.

Table 2353.3-1
Allowable Differences between Contractor and Department Test Results

Test	Item	Allowable Difference
Asphalt Binder	Chemical Extraction Incinerator Oven	0.4 0.3
Mixture maximum gravity (Gmm)	Rice Test	0.019
Adjusted AFT (Calculated)	-	1.2
Gradation	Percent Passing	
	3/8 inch	6 percent
	No. 4	5 percent
	No. 8 No. 16 No. 30	4 percent
	No. 50	3 percent
	No. 100	2 percent
	No. 200	1.2 percent

2353.4 METHOD OF MEASUREMENT

Measure the Ultrathin Bonded Wearing Course by area of pavement surfaced.

2353.5 BASIS OF PAYMENT

Payment for the accepted quantity of Ultrathin Bonded Wearing Course at the Contract Unit Price of measure will be compensation in full for all costs of furnishing and applying all Materials required in this section. The Unit Price includes all labor, Materials, and Equipment necessary to complete the Work.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Ultrathin Bonded Wearing Course. The amounts of these adjustments are deemed reasonable.

Replace the first paragraph in section 2399.3D.1, "Smoothness," with the following:

Evaluate Smoothness after the UTBWC is placed using the following tables:

(1) Table 2399.5-1 for bituminous pavements
(2) Table 2399.5-3 for percent improvement projects

ALR will not be evaluated on the UTBWC.

Replace the second and third paragraphs in 2399.3E, “Corrective Work,” with the following:

Perform any corrective Work for ALR on the asphalt pavement placed before the UTBWC is paved. No corrective Work is allowed on the UTBWC.

A.1 Pavement Smoothness

Any Smoothness value on the UTBWC indicating corrective Work may be assessed a monetary deduction of $400.00 per 0.1 mile segment.

A.2 Failures

The Department will base Material acceptance on individual test results and those exceeding the JMF limits as failing.

The Department will apply monetary deductions for failing tests in accordance to Table 2353.5-1. The Department will calculate the quantity of unacceptable Material on the tonnage placed from the sample point of the failing test to the sample point when the testing result is back within the JMF. If the failure occurs at the first test after the start of daily production, the Department will include tonnage from the start of production that day with the tonnage subjected to reduced payment.

If an individual failing test for percent asphalt binder content, adjusted AFT, or gradation exceeds the limits in Table 2353.2-1, or Table 3139.2-9 then the mix will be subject to an assessment according to Table 2353.5-1.

Table 2353.5-1
UTBWC Monetary Deduction Schedule

Item	Percent *
Asphalt Content, percent	20
Adjusted AFT ≥ 10.5	0
Adjusted AFT 10.4 to 10.0	10
Adjusted AFT 9.9 to 9.1	25
Adjusted AFT ≤ 9.0	R & R ‖
Gradation	5
* Highest monetary deduction applies when there are multiple deductions on a single test. ‖ Remove and replace at no expense to Department.	

The Department will reduce payment if the mat thickness is less than 5/8 inch, or greater than 1 inch, or the pavement edge is greater than 1/2 inch. Any mixture placed outside of this requirement will be assessed a 50 percent pay reduction or removed and replaced, as determined by the Engineer, full width, by station.

B Schedule

The Department will pay for the Ultrathin bonded wearing course on the basis of the following schedule:

Item No.	Item	Unit
2353.504	Ultrathin Bonded Wearing Course	Square yard

2354 MICRO-SURFACING

2354.1 DESCRIPTION

This Work consists of constructing micro-surfacing on a prepared pavement.

Micro-surfacing is a mixture of polymer modified asphalt emulsion, well-graded crushed mineral Aggregate, mineral filler, water, and other additives.

2354.2 MATERIALS

A Bituminous Material

A.1 Micro-surfacing Emulsified Asphalt: Polymer modified CQS-1hP for rut filling or CQS-1P for non-rut filling applications 3151.2H

A.2 Bituminous Emulsion for Fog Seal 3151.2D.1.b

B Aggregate 3139.2D

If no Aggregate is specified use Class A per 3139, “Graded Aggregate for Bituminous Mixtures” and Type 2 per 3139.2D, “Micro-Surfacing.”

C Mineral Filler

C.1 Portland cement, Type I 3101

C.2 Hydrated lime 3106

D Water 3906

E Mixture Requirements

E.1 Mix Design

Fourteen Business Days before beginning production, submit to the Engineer a complete mix design and a 150 pound Aggregate sample. List the source of Materials used for the mix design. Show that the individual proportions of each of the Materials, when combined, meet the mix design requirements of Table 2354.2-1. Testing procedures may be obtained from the International Slurry Surfacing Association (ISSA).

Table 2354.2-1
Mix Design Test Requirements

Test	Description	Specification
ISSA TB-114	Wet stripping	≥ 90
ISSA TB-100	Wet track abrasion loss, 1 hour soak	≤ 1.8 ounce/square feet
ISSA TB-100	Wet track abrasion loss, 6 Calendar Day soak	≤ 2.6 ounce/square feet *
ISSA TB-144	Saturated abrasion compatibility	≤ 3 g loss
ISSA TB-113	Mix time at 77°F	Controllable to ≥120 s
ISSA TB-113	Mix time at 100°F	Controllable to ≥35 s
* The requirement is for CQS-1hP only, report only for CQS-1P and other emulsions.		

Provide a Job Mix Formula (JMF) containing from 5.5 percent to 10.5 percent of residual asphalt by dry weight of Aggregate and 0.25 percent to 3.0 percent mineral filler by dry weight of Aggregate.

Submit a new mix design to the Engineer, if Aggregate source, Aggregate blend, or asphalt emulsion sources are changed.

E.2 Mix Design Format

Submit the final mix design that includes the following information:

(1) Source of each individual Material

(2) Aggregate:

(a) Gradation
(b) Sand equivalent
(c) Abrasion resistance
(d) Soundness

(3) Field simulation tests:

(a) Wet stripping test
(b) Wet track abrasion loss (1 hour & 6 Calendar Days)
(c) Saturated abrasion compatibility
(d) Trial mix time at 77°F and 100°F

(4) Interpretation of results and the determination of a JMF:

(a) Minimum and maximum percentage of mineral filler
(b) Minimum and maximum percentage of water, including Aggregate moisture
(c) Percentage of mix set additive (if necessary)
(d) Percentage of modified emulsion
(e) Residual asphalt content of modified emulsion
(f) Percentage of residual asphalt

(5) Signature and date

2354.3 CONSTRUCTION REQUIREMENTS

A Equipment

A.1 Mixing Machine

Provide a continuous micro-surfacing lay down machine. Provide a positive connection conveyer belt Aggregate delivery system and an inter-connected positive displacement, water-jacketed gear pump to accurately proportion Aggregate and asphalt emulsion. Locate the mineral filler feed to ensure that the proper amount of mineral filler drops on the Aggregate before discharging into the pugmill. Provide a pugmill meeting the following characteristics:

(1) Capable of providing a continuous flow
(2) Twin shaft
(3) Multi-blade
(4) At least 4 feet long
(5) Blade size and side clearance meeting the Equipment manufacturer's recommendations

Introduce the asphalt emulsion within the first third of the mixer length to ensure proper mixing of Materials before exiting from the pugmill.

Use a self-propelled front feed and continuous loading machine with dual driving stations. Provide a remote forward speed control at the back mixing platform for the back operator to control forward speed and the level of mixture in the spreader box. Use sufficient transport units to assure a continuous operation during mix production and application.

Provide individual volume or weight controls for proportioning each Material. Position the controls for access at any time. Use the controls to calibrate the operation before production and to determine the amount of each Material used at any time.

Provide a water pressure system and nozzle type spray bar to spray water ahead of and outside the spreader box, if necessary. Dampen the surface. Do not create free flowing water ahead of the spreader box.

A.2 Spreader Box

Spread the mix uniformly, using a mechanical type spreader box, attached to the mixer and equipped with spiral augers mounted on adjustable shafts. Continually agitate and distribute the mixture to prevent stagnation, excessive Material build-up, or lumps. Equip the spreader box with front and rear flexible seals to achieve direct contact with the surface of the Road. Use a secondary strike off attached to the spreader box to provide a smooth finished surface texture. Do not use burlap drags.

A.3 Rut Filling Box

Provide a rut filling box meeting the following characteristics:

(1) Steel V-configuration screed rut box
(2) Commercially designed and manufactured to fill ruts
(3) Capable of spreading the mixture at a width from 5 feet to 6 feet
(4) Strike off to control crown

A.4 Weighing Equipment

Use portable Scales to weigh Material certified in accordance with 1901.8, "Mass," and as modified as follows:

(1) Recertify the Scale after any change in location

(2) Randomly spot check the Scale once a week or once per Project, whichever is more frequent

B Operations

B.1 Micro-surfacing Types

B.1.a Rut Fill Type 3, per 3139.2D, "Micro-surfacing"

Rut fill pavement segments longer than 1,000 feet, if the average rut depth is greater than 1/2 inch. Provide a rut box for each designated wheel track. Provide a clean overlap and straight edges between wheel tracks. Construct each rutted wheel track with a crown 1/4 inch per inch of rut depth to allow for proper consolidation by traffic.

B.1.b Scratch Course Type 2 or Type 3 per 3139.2D, "Micro-surfacing," as shown on the Plans

Apply full lane width in one course. Use a metal strike off bar on the spreader box. Do not allow excess buildup or uncovered areas.

B.1.c Surface Course Type 2, per 3139.2D, "Micro-surfacing"

Apply full lane width in one course. Do not allow excess buildup or uncovered areas.

B.2 Pre-Paving Meeting

Hold a pre-paving meeting with the Engineer on-site before beginning Work to discuss the following:

(1) JMF
(2) Equipment condition
(3) Equipment calibration
(4) Test strips
(5) Detailed Work schedule
(6) Traffic control Plan

B.3 Calibration

Calibrate each mixing machine before use. Maintain documentation showing individual calibrations of each Material at various settings relating to the machine's metering devices. Supply Materials and Equipment, including Scales and containers for calibration (*MA 1 ISSA Inspector's Manual*). Recalibrate machines on the job after a change in Aggregate, asphalt emulsion source, or repairs are made to the Aggregate feeding belt, gate, or emulsion pump.

B.4 Test Strip

Construct a test strip in a location approved by the Engineer.

For each machine used, construct a one-lane wide test strip 1,000 feet long. Begin construction after dark, at least 1 hour after sunset and at least 1 hour before sunrise. Check for variances in surface texture and appearance.

Do not construct the test strip until the emulsion temperature falls below 122°F.

If any of the following elements of the system used with a job mix change or field evidence does not meet Specifications, construct a new test strip:

(1) Type of emulsion
(2) Type and size of Aggregate

(3) Type of mineral filler
(4) The lay down machine

Allow traffic on the test strip within 1 hour after application; the Engineer will evaluate whether any damage occurs. The Engineer will inspect the completed test strip again after 12 hours of traffic to determine if it is acceptable. The Contractor may begin full production after the Engineer accepts a test strip.

The Engineer may waive the test strip requirement, if the Contractor submits evidence of the successful construction of a test strip on another project constructed during the same construction season, using the same mix design.

B.5 Surface Preparation

Clean the surface immediately before placing the micro-surfacing.

B.6 Fog Seal

Apply fog seal to concrete surfaces and bituminous surfaces if required by the Engineer before the first course of micro-surfacing. Provide and apply CSS-1h emulsion in accordance with 2355, “Bituminous Fog Seal,” and the following:

(1) Apply the diluted emulsion at a rate of 0.05 gallons per square yard to 0.10 gallons per square yard. Limit the daily application of fog seal to the pavement area receiving micro-surfacing that day. Do not open fog sealed areas to traffic until after applying and curing the first course of micro-surfacing. Allow the fog seal to cure before applying micro-surfacing.
(2) Protect drainage Structures, monument boxes, and water shut-offs during the application of the fog seal and during micro-surfacing.

B.7 Surface Quality

Construct the surface course without excessive scratch marks, tears, rippling, and other surface irregularities. Repair tear marks wider than 1/2 inch and longer than 4 inches. Repair transverse ripples or streaks deeper than 1/4 inch if measured by a 10 foot straightedge.

Construct longitudinal joints with no greater than 1/4 inch overlap thickness if measured with a 10 foot straightedge, and less than 3 inch overlap on adjacent passes. Locate longitudinal construction joints and lane edges to coincide with the proposed painted lane lines shown on the Plans. Place overlapping passes on the uphill side to prevent water from ponding.

Construct transverse joints with no greater than 1/8 inch difference in elevation across the joint if measured with a 10 foot straightedge.

Construct edgelines along curbs and Shoulders, with no greater than 2 inches of width variance in any 100 foot length. Do not allow runoff in these areas.

Stop micro-surfacing work, if requirements of this section are not being met. Make corrections as approved by the Engineer before restarting Work.

Protect drainage Structures, monument boxes, water shut-offs, and any other utility Structures within the Project or staging areas.

Make repairs to micro-surfacing defects to the full width of paving pass with spreader box. Do not perform hand repairs after micro-surfacing mix has set.

B.8 Open to Traffic

Do not open the micro-surface to traffic until the micro-surface cures sufficiently to prevent pickup by vehicle tires. The Department considers properly constructed micro-surface as micro-surface capable of carrying normal traffic within 1-hour of application without damage. Protect the new surface from potential damage at Intersections and driveways. Repair damage to the surface caused by traffic at no additional cost to the Department.

Confirm that the micro-surface cured within 1-hour on the first day of production, after the construction of the test strip. The Engineer will conduct three 1-hour spot checks. If a spot check fails, stop Work and construct a new test strip. The Department will consider any spot check or test strip failure as unacceptable Work in accordance with 1512, “Unacceptable and Unauthorized Work.”

After successful completion of three, 1-hour spot checks on the first day of production, the Engineer will perform spot checks once a day. If a 1-hour spot check fails, the Department will require the construction of a new test strip. After a test strip, the Engineer will perform the first day of production procedure.

B.9 Weather and Time Limitations

Begin construction when the air and pavement surface temperatures are at least 50°F and rising. Do not place micro-surfacing during rain, or if the forecast indicates a temperature below 32°F within 48 hours of the planned micro-surfacing. Do not start Work after September 15.

C Contractor Sampling, Testing, and Documentation

Perform Quality Control (QC) sampling and testing.

C.1 Emulsion

Provide a Material Bill of Lading (BOL) for each batch of emulsion used. Include the supplier’s name, plant location, emulsion grade, residual asphalt content, volume (gross and net, gallons), and batch number.

C.2 Aggregate

Sample and test according to the *Schedule of Materials Control*. Provide daily QC test results to the Engineer and a summary upon completion of the Work.

C.2.a Gradation and JMF Tolerance

Provide companion samples to the Engineer. The QC tolerances for the JMF are listed in Table 3139.2-10. The tolerance range may not exceed the limits set per 3139.2D, “Micro-surfacing.”

C.2.b Sand Equivalent Test

The sand equivalent Quality Control tolerance is ±7 percent of the value established in the mix design (60 percent minimum). Run the sand equivalent test at the stockpile site.

C.2.c Moisture Content

Determine the moisture content of the Aggregate. Perform additional testing upon a visible change in moisture. Use the average daily moisture to calculate the oven dry weight of the Aggregate.

C.3 Asphalt Binder Application Rate

Randomly calculate and record the percent asphalt content of the mixture from the Equipment counter readings. The asphalt tolerance is ±0.5 percent residual asphalt.

C.4 Design Application Rate

The design application rate shall be the total amount of micro-surfacing Material placed to meet the requirements for cross-section and surfacing. This amount will be the combination of all courses placed.

C.5 Documentation

Provide a daily report containing the following information to the Engineer within one Working Day:

(1) Date and air temperature at Work start up
(2) Beginning and ending locations for the day's Work
(3) Length, width, and total area (square yard) covered for the day
(4) Application rate (pounds per square yard) of Aggregate
(5) Daily asphalt spot check reports (gallons of emulsion)
(6) Asphalt emulsion bill of lading
(7) Beginning, ending, and total counter readings
(8) Control settings, calibration values, and percent residue in emulsion
(9) Percent of each Material, percent of asphalt cement
(10) Calibration forms
(11) Sand equivalence
(12) Aggregate certification or shipment of tested stock report
(13) Contractor's authorized signature

2354.4 METHOD OF MEASUREMENT

The Engineer will measure the Bituminous Material for Micro-Surfacing and undiluted Bituminous Material for Fog Seal by volume at 60°F.

The Engineer will measure the Micro-Surfacing Rut Fill, Micro-Surfacing Scratch Course, and Micro-Surfacing Surface Course by weight of oven dry weight of Aggregate.

2354.5 BASIS OF PAYMENT

The Contract gallon price for the accepted quantity of Bituminous Material for Micro-surfacing includes the costs of additives as indicated above, constructing the micro-surfacing as shown in the Plans, and all testing.

The Department will pay for bituminous Material for fog seal in accordance with 2355.5, "Bituminous Fog Seal, Basis of Payment."

A Monetary Adjustment

The Department must apply Incentives and Disincentives and may apply monetary deductions for Micro-surfacing. The amounts of these adjustments are deemed reasonable.

The Department may deduct $5,000 from the Contract amount for each spot check failure and anytime there is evidence of the system being out of specification per 2354.2E.1, "Mix Design," as determined by tests in 2354.3C, "Contractor Sampling, Testing, and Documentation."

The Engineer will calculate monetary deductions for failing gradations based on 2 percent of the Unit Price per ton for each 1 percent passing result outside of a gradation range for all Sieves (Table 3139.2-10). The monetary deduction will apply to the quantity of Material represented by the failing test(s). The Department may apply this monetary deduction schedule for micro-surfacing construction to non-warranty Work.

B Schedule

The Department will pay for micro-surfacing on the basis of the following schedule:

Item No.	Item	Unit
2354.506	Bituminous Material for Micro-surfacing	gallon
2354.509	Micro-surfacing Rut Fill	ton
2354.509	Micro-surfacing Scratch Course	ton
2354.509	Micro-surfacing Surface Course	ton

2355 BITUMINOUS FOG SEAL

2355.1 DESCRIPTION

This Work consists of constructing a fog seal on a prepared surface as shown on the Plans.

2355.2 MATERIALS

A Bituminous Material

A.1 CSS-1h.. 3151.2D.1.a

A.2 CRS-2Pd 3151.2E.2

2355.3 CONSTRUCTION REQUIREMENTS

A Weather Limitations

Perform fog seal operations only during daylight hours and not during foggy weather. Begin fog seal operations when the pavement and air temperatures are 60°F and rising. The Contractor may perform fog sealing on a damp Road surface, but not on a Road surface with standing water.

B Road Surface Preparation

Clean pavements, including depressions, before fog sealing.

Cover metal surfaces and other utility Structures in the Roadway to prevent adherence of the bituminous Material. Remove the protective coverings before opening the Road to traffic.

C Application of Bituminous Material

Provide bituminous Material as shown in the Plans. Field dilution is not allowed.

Begin using the rate of application for bituminous fog seal as shown in Table 2355.3-1 and within the temperatures specified in Table 2355.3-2.

Demonstrate a uniform application of asphalt emulsion producing 100 percent coverage of the surface after curing, as approved by the Engineer. Stop operations if the application demonstration does not meet the coverage requirements. Minimize the amount of overspray during the fog seal operation.

Using a distance of 1,000 feet perform a yield check at the beginning of each Project to verify the application rate is correct. The Engineer may require additional yield checks be performed if the application rate is questioned. The Engineer may also require the Contractor to verify application is within 10 percent of the intended application rate by *ASTM D2995, Standard Practice for Estimating Application Rate and Residual Application Rate of Bituminous Distributors*, test method A.

Table 2355.3-1
Fog Seal Application Rates

Application Rates -- gallons/square yard	
CSS-1h	CRS-2Pd
0.05 to 0.20	0.05 to 0.20

Table 2355.3-2
Fog Seal Application Temperatures

Bituminous Material	Minimum Temperature	Ideal Temperature
CRS-2Pd	140°F	170°F – 180°F
CSS-1h	100°F	100°F – 140°F

D Protection of the Surface

Do not allow traffic on the fog sealed surface until after the bituminous Material has set and will not pick up on vehicle tires.

E Equipment

E.1 Distributor **2360.3B.2.d**

E.2 Brooms

Provide motorized brooms with a positive means of controlling vertical pressure and with the capability to clean the Road surface prior to spraying bituminous Material.

2355.4 METHOD OF MEASUREMENT

The Engineer will measure the diluted bituminous Material for fog seal by volume, at 60°F.

2355.5 BASIS OF PAYMENT

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

Item No.	Item	Unit
2355.506	Bituminous Material for Fog Seal	gallon

2356 BITUMINOUS SEAL COAT AND BITUMINOUS UNDERSEAL

2356.1 DESCRIPTION

This Work applies to both a Bituminous seal coat, which goes on top of a bituminous surface and a bituminous underseal, which is placed beneath a new bituminous surface. This section applies to both processes, unless it is specified only for the Bituminous seal coat or the bituminous underseal. The Work consists of applying bituminous Material, a single Layer of Aggregate, and a fog seal on a prepared surface.

2356.2 MATERIALS

A Bituminous Material

A.1 Seal coat **3151.2E.1**

A.2 Bituminous emulsion for Fog Seal **3151.2D.1.a**

B Seal Coat Aggregate

Provide Aggregate meeting the gradation, job mix formula tolerance, and quality requirements of Table 3127.2-1and Table 3127.2-2, for the gradation specified in the Contract. If no requirements are specified in the Contract, provide Aggregate meeting the requirements of Table 3127.2-1 and Table 3127.2-2 for FA-2.5.

C Water 3906

D Seal Coat Design

Use the *Minnesota Seal Coat Handbook*, MN/RC-2006-34 available on the MnDOT website, to design the seal coat and determine the starting application rate for the bituminous Material and seal coat Aggregate. Base the mix design on the traffic volume and pavement conditions.

Provide the following to the Engineer at least 2 weeks before beginning construction:

(1) Gradation and quality test results as specified in 3127.3, “Sampling and Testing”
(2) Seal coat Aggregate design application rate
(3) Bituminous Material design application rate
(4) 150 pound sample of Aggregate from each proposed Aggregate source

The Contractor cannot start Work until submittal of the design and approval by the Engineer in accordance with the requirements of this section.

2356.3 CONSTRUCTION REQUIREMENTS

A Weather, Time and Date Limitations

A.1 Bituminous Seal Coat

Apply the bituminous seal coat in accordance with the following:

(1) From May 15 to August 10, if located in the North or North-Central Road Spring Restriction Zone (Zones are defined on the MnDOT Pavement Design website)
(2) From May 15 to August 31, if located south of the North and North-Central Spring Road Restriction Zone
(3) Work only during daylight hours
(4) Begin Work when the pavement and air temperatures are 60°F and rising
(5) The Road surface may be damp, but ensure that the Road is free of standing water
(6) Do not perform Work during foggy weather

A.2 Bituminous Underseal

Construct bituminous underseal operations (including traffic restrictions on the freshly constructed bituminous underseal) according to the following:

(1) The Road surface may be damp, but there shall be no standing water.
(2) No construction is allowed in foggy weather.
(3) Follow restrictions for weather and date per 2360.3A.4, “Weather Limitations and Paving Date”

B Equipment

B.1 Distributor 2360.3B.2.d

B.2 Aggregate Spreader

Use a self-propelled mechanical type Aggregate spreader, mounted on pneumatic-tired wheels, capable of distributing the Aggregate uniformly to the width required by the Contract and at the design application rate.

B.3 Pneumatic-Tired Rollers

Provide at least three self-propelled Pneumatic-tired rollers in accordance with 2360.3B.2.e(2), “Pneumatic Tired Rollers.”

B.4 Brooms

Provide motorized brooms with the following characteristics:

(1) Positive means of controlling vertical pressure
(2) Capable of cleaning the Road surface before applying bituminous Material
(3) Capable of removing loose Aggregate after seal coating

C Road Surface Preparation

Clean pavements, including depressions, before seal coating.

Cover iron fixtures in or near the pavement to prevent adherence of the bituminous Material.

Remove the protective coverings before opening the Road to traffic.

D Application of Bituminous Material

D.1 Pre-Treat Longitudinal Pavement Markings

Apply bituminous Material 1 foot wide over all longitudinal pavement markings. Cover centerline skip stripe with continuous coverage. Apply in a rate range of 0.10 to 0.15 gallons per square yard. Apply bituminous Material for seal coat immediately after pre-treating pavement markings.

D.2 Application of Bituminous Material for Seal Coat

Begin the rate of application for the bituminous Material as determined by the mix design. Construct a test strip 200 feet long to ensure the bituminous Material application rate is adequate given the field conditions. After applying the bituminous Material to this test strip, place the seal coat Aggregate at the design application rate. Inspect the Aggregate in the wheel paths for proper embedment. Make adjustments to the rate of application, if necessary. Construct one full lane width at a time.

Apply the bituminous Material in accordance with Table 2356.3-1:

Table 2356.3-1
Recommended Application Temperatures

Bituminous Material	Minimum Temperature
CRS-2P	140°F

E Application of Aggregate

Before construction, if required by the Engineer, calibrate the Aggregate spreader to meet the requirements of *ASTM D5624, Standard Practice for Determining the Transverse-Aggregate Spread Rate for Surface Treatment Applications*, in the presence of the Engineer. Maintain the Aggregate application rate within ±1 pound per square yard of the design.

Provide uniformly moistened Aggregates at the time of placement. Place Aggregate within 1 minute after applying the bituminous Material. Do not use previously applied Aggregates.

F Rolling Operations

Complete the initial rolling within 2 minutes after applying the Aggregate at a speed no greater than 5 mph to prevent turning over Aggregate. Make at least 3 complete passes over the entire width of the treatment area.

G Sweeping

Remove surplus Aggregate on the same day as the seal coat construction. Resweep areas the day after the initial sweeping. Dispose of the surplus seal coat Aggregate as approved by the Engineer.

H Protection of the Surface

Do not allow traffic on the seal coated Road surface until after rolling is completed and the bituminous Material has set.

I Protection of Motor Vehicles

The Contractor is responsible for claims of damage to vehicles until the Roadways and Shoulders have been swept free of loose Aggregate and permanent pavement markings have been applied. If the Department applies the permanent pavement markings, the Contractor's responsibility ends after completion of the fog seal and placement of temporary pavement markings.

J Application of Bituminous Material for Fog Sealing

A bituminous seal coat requires the application of a bituminous fog seal.

A bituminous underseal only requires the application of a fog seal if the bituminous underseal is not paved over within 7 Calendar Days.

Apply the fog seal in accordance with 2355, "Bituminous Fog Seal," and as modified as follows:

(1) Construct a 200 foot test strip
(2) Review the application of diluted bituminous Material and adjust the application rate as necessary to yield a uniform full coverage of the underlying seal coat
(3) Apply from 0.07 gallon to 0.18 gallon per square yard diluted
(4) Apply the fog seal to minimize the amount of overspray
(5) Do not allow traffic on the fog seal until it has cured

K Progress of Work

Allow the seal coat to cure for at least one Calendar Day before applying the fog seal. Place interim pavement markings after the fog seal cures and before removal of traffic control. After placing the fog seal, wait at least 3 Calendar Days before placing permanent pavement markings when using latex paint. Place all other types of permanent pavement markings at least 14 Calendar Days after placement of the fog seal.

L Contractor Sampling and Testing

Sample and test according to the rates in the *Schedule of Materials Control*.

Submit test results to the Engineer within 24 hours of test completion.

Verify and report the average daily bituminous Material application rate by dividing the volume used by the area covered.

If gradations fall outside of the job mix formula tolerance of Table 3127.2-1, but within Specifications, stop placement and submit a new mix design.

Provide a remediation Plan for all failures originating by any cause including a failing stockpile or poor handling procedures. Bucket blending of a stockpile to remediate for failing Material is not acceptable. The remediation Plan must be accepted by the Engineer.

M Department Quality Assurance (QA) Sampling and Testing

Sample and test according to the rates in the *Schedule of Materials Control*.

2356.4 METHOD OF MEASUREMENT

The Engineer will measure the bituminous Material for fog seal per 2355.4, "Bituminous Fog Seal, Method of Measurement." Conversion factors are located in the *Bituminous Manual*.

The Engineer will measure the Bituminous Material for seal coat by volume at 60°F.

The Engineer will measure the seal coat by area of pavement surfaced.

2356.5 BASIS OF PAYMENT

For Bituminous seal coat, the Department will pay for Bituminous Material for fog seal in accordance with 2355.5, “Bituminous Fog Seal, Basis of Payment.” For bituminous underseal, payment for Bituminous Material for fog seal is included in the 2356, “Bituminous Seal Coat and Bituminous Underseal,” bid item.

The Contract gallon price for accepted quantities of Bituminous Material for seal coat, including necessary additives, includes the costs of providing and applying the Material as required by the Contract.

The Contract square yard Unit Price for Bituminous seal coat includes the cost of providing and applying the Material as required by the Contract. The Contract square yard price for Bituminous seal coat includes the cost of all applied Aggregate and all testing.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Bituminous Seal Coat and Bituminous Underseal. The amounts of these adjustments are deemed reasonable.

The Engineer will calculate the monetary deduction instead of removing and replacing failing Materials in accordance with the following:

(1) The Department may reduce payment of the Contract Price for Bituminous seal coat by 10 percent for each failing quality test per Table 3127.2-2 as determined by QA testing.

(2) The Department may reduce payment of the Contract Price for Bituminous seal coat by 0.5 percent for each 1 percent passing outside of the requirements for any Sieve as specified in 3127, “Fine Aggregate for Bituminous Seal Coat,” except for the No. 200 Sieve, as determined by QA testing.

(3) The Department may reduce the Contract Price for Bituminous seal coat by 2 percent for each 0.1 percent passing outside of the requirements for the No. 200 Sieve as specified in 3127, “Fine Aggregate for Bituminous Seal Coat,” as determined by QA testing.

(4) The maximum reduction in payment is 50 percent. Material placed that has a cumulative reduced payment greater than 50 percent is subject to remove and replace per 1512.1 “Unacceptable Work.”

Subsection 2356.5A, “Monetary Adjustments,” notes (1), (2), and (3) are based upon the Contract bid price for Bituminous seal coat, however if the Contract bid price is less than 75 percent of the Department’s average bid price for Bituminous seal coat, the Engineer may use the average bid price to assess the monetary deduction.

The Engineer will add the reduced payments for all failing test results together.

B Schedule

The Department will pay for Bituminous seal coat and Bituminous underseal on the basis of the following schedule:

Item No.	Item	Unit
2356.504	Bituminous Seal Coat	square yard
2356.506	Bituminous Material for Seal Coat	gallon

2357 BITUMINOUS TACK COAT

2357.1 DESCRIPTION

This Work consists of applying bituminous Material (emulsion or cutback asphalt) on a bituminous or concrete pavement before paving a new Lift of plant mixed Asphalt.

2357.2 MATERIALS

A Bituminous Material 3151

The Bituminous Material for tack coat will be limited to one of the following kinds of emulsified asphalt. Use of medium cure cutback asphalt (MC-250) is allowed during the early and late construction season when it is anticipated the air temperature may drop below 32 degrees Fahrenheit.

Allowable grades are as follows:

Emulsified Asphalt

AASHTO M 208, “Standard Specification for Cationic Emulsified Asphalt,” dilution of the emulsion to 7 parts emulsion to 3 parts water is only allowed by the supplier. No field dilution is allowed. The storage tank for diluted emulsion must have a recirculation system or agitator that will prevent settlement or separation of the Material.

Table 2357.2-1
Residual Asphalt Content

	Minimum Residual Asphalt Content	
Emulsion	Undiluted	Diluted (7:3)
CSS-1 or CSS-1h	57 percent	40 percent

Cutback Asphalt

Medium Cure Liquid Asphalt MC-250

Use only sources listed on the *Approved/Qualified Products List* for "Asphalt Products."

2357.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Conduct tack coat operations in a manner that offers the least inconvenience to traffic. Maintain movement in at least one direction at all times without pickup or tracking of the bituminous Material.

Do not apply the tack coat when the Road surface or weather conditions are unsuitable as determined by the Engineer. Limit the daily application of tack coat to approximately the area on which construction of the subsequent bituminous course can reasonably be expected to be completed that day.

B Equipment

B.1 Distributor 2360.3B.2.d

C Road Surface Preparations

Remove all foreign matter on the Road surface before applying tack coat and dispose of as approved by the Engineer.

Apply the bituminous tack coat Material to a dry and clean Roadway surface. All necessary repairs or reconditioning must have been completed as provided for in the Contract and approved by the Engineer.

D Application of Bituminous Tack Coat Material

Unless otherwise indicated in the Plans or Special Provisions, apply the bituminous tack coat Material within the application rates shown below in Table 2357.3-1, as based on pavement type or condition and type of bituminous Material. Dilution of asphalt emulsion in the field is not allowed.

Before placing an abutting bituminous course, provide a uniform coating of liquid asphalt or emulsified asphalt to the contact surfaces of all fixed Structures and at the edge of the in-place mixture in all courses at transverse joints and in the final wearing course at longitudinal joints.

All tack coat must break and turn from brown to black, before paving the subsequent Lift or course. Do not allow vehicles to drive on tack coat that has not broken.

Apply a uniform tack coat to the existing asphalt or concrete surface and to the surface of each course or Lift constructed, except for the final course or Lift. Tack each Lift when placing multiple Lifts in the same day. Uniform application will not have streaks (corn rows), bare spots, puddles, or other irregular patterns. The Engineer will compare the freshly sprayed emulsion to a brown sheet of construction paper or a black sheet of construction paper for broken tack coat to determine conformance with tack coat application uniformity.

Using a distance of 1,000 feet perform a yield check at the beginning of each Project to verify the application rate is correct. The Engineer may require additional yield checks be performed if the application rate is questioned.

The Engineer may also require the Contractor to verify application is within 10 percent of the intended application rate by *ASTM D2995, Standard Practice for Estimating Application Rate and Residual Application Rate of Bituminous Distributors*, test method A.

Table 2357.3-1
Tack Coat Application Rates

	Application Rates - gallon/square yard		
Surface Type	**Undiluted Emulsion**	**Diluted Emulsion (7:3)***	**MC Cutback ‖**
New Asphalt	0.04 to 0.06	0.06 to 0.09	0.05 to 0.07
Old Asphalt† and PCC	0.05 to 0.09	0.075 to 0.135	0.09 to 0.11
Milled Asphalt and Milled PCC	0.06 to 0.09	0.09 to 0.135	0.09 to 0.11

Notes:
* As provided by the asphalt emulsion supplier (see 2357.2A, “Bituminous Material”)
‖ Use when approved by the Engineer
† Older than 1 year

E Bituminous Temperature

The application temperature of the bituminous Material will be:

(1) 70 to 160°F for CSS-1 and CSS-1H
(2) 165 towe can still here the 220°F for MC-250

F Bituminous Sampling

Sample asphalt emulsion from either the spigot or a nozzle on the distributor according to the *Schedule of Materials Control*.

G Pedestrian Crossings

Spread sand on newly tacked surfaces at regularly utilized and open for public use pedestrian crossings.

H Acceptance of Tack Material

The Engineer will address failures related to 3151, "Bituminous Material," in accordance with 2357.5A, "Monetary Adjustments." Deficiencies related to workmanship or application will be addressed in accordance with 1512, "Unacceptable and Unauthorized Work."

2357.4 METHOD OF MEASUREMENT

Bituminous Material used for tack coat will be measured by volume at 60°F.

2357.5 BASIS OF PAYMENT

Payment for the accepted quantity of asphalt emulsion and cutback shall be at the Contract Price per unit of measure. The cost of providing and applying sand at pedestrian crossings is included in the 2360, "Plant Mixed Asphalt Pavement," bid item.

If the Contract does not contain a Pay Item for Bituminous Material for tack Coat, the cost is included in the 2360, "Plant Mixed Asphalt Pavement," bid item.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Bituminous Tack Coat. The amounts of these adjustments are deemed reasonable.

The Department may deduct up to 5 percent of the mixture Unit Price for failures related to 3151, "Bituminous Material."

B Schedule

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

Item No.	Item	Unit
2357.506	Bituminous Material for Tack Coat	gallon

2358 BITUMINOUS PRIME COAT

2358.1 DESCRIPTION

This Work consists of treating a prepared base with bituminous Material prior to placing a bituminous pavement.

2358.2 MATERIALS

A Medium Curing Liquid Asphalt 3151.2B

MC-30 or MC-70

2358.3 CONSTRUCTION REQUIREMENTS

A Restrictions

A.1 Base Moisture Content

Place bituminous prime coat on a prepared base when the base moisture content of the upper 3 inches is less than 65 percent of Optimum Moisture Content.

A.2 Traffic

If Road is open to traffic, maintain traffic in at least one direction and only close a portion of the Traveled Way for construction, not to exceed 50 percent.

B Equipment

C Application

Apply the bituminous prime coat at a continuous uniform spread rate of 0.1 gallons per square yard to 0.3 gallons per square yard.

D Bituminous Temperature

Apply MC-30 bituminous prime coat at temperatures from 85°F to 145°F. Apply MC-70 bituminous prime coat at temperatures from 120°F to 180°F.

2358.4 METHOD OF MEASUREMENT

The Engineer will measure Bituminous Material for prime coat by volume at 60°F.

2358.5 BASIS OF PAYMENT

The Contract gallon price for Bituminous Material for prime coat includes the costs of providing and applying the Material as required by the Contract.

The Department will pay for bituminous prime coat on the basis of the following schedule.

Item No.	Item	Unit
2358.506	Bituminous Material for Prime Coat	gallon

2360 PLANT MIXED ASPHALT PAVEMENT

2360.1 DESCRIPTION

This Work consists of constructing plant mixed asphalt pavement on a prepared surface.

Plant mixed asphalt pavement designed according to a gyratory mix design method for use as a pavement surface.

A Definitions

For the purpose of the Work specified in section 2360, “Plant Mixed Asphalt Pavement,” the Department defines:

Additives

Material added to an asphalt mixture or Material that does not have a specific Pay Item.

B Mixture Designations

The Department will designate the mixture for asphalt mixtures in accordance with the following:

(1) The first two letters indicate the mixture design type:

(a) SP = Gyratory Mixture Design

(2) The third and fourth letters indicate the course:

(a) WE = Wearing and Shoulder wearing course
(b) NW = Non wearing Course

(3) The fifth letter indicates the maximum Aggregate size:

(a) A = 1/2 inch, SP 9.5
(b) B = 3/4 inch, SP 12.5
(c) C = 1 inch, SP 19.0

(d) D = 3/8 inch, SP 4.75

(4) The sixth digit indicates the traffic level (ESALs × 106) in accordance with Table 2360.1-1

Table 2360.1-1
Traffic Levels

Traffic Level	20 year Design ESALs
2 *	< 1
3 ‖	1 – < 3
4	3– < 10
5	10 – ≤ 30
6	>30 (See SMA Provision)
NOTE: The requirements for gyratory mixtures in this section are based on the 20 year design traffic level of the Project, expressed in Equivalent Single Axle Loads (ESALs) 1 × 106 ESALs * AADT < 2,300 ‖ AADT > 2,300 to < 6,000	

(5) The last two digits indicate the air void requirement:

(a) 40 = 4.0 percent for wear mixtures
(b) 30 = 3.0 percent for non wear and Shoulder

(6) The letter at the end of the mixture designation identifies the asphalt binder grade in accordance with Table 2360.1-2

Table 2360.1-2
Asphalt Grades

Letter	Grade
A	PG 52S – 34
B	PG 58S – 28
C	PG 58H – 34
E	PG 58H – 28
F	PG 58V – 34
H	PG 58V – 28
I	PG 58E – 34
L	PG 64S – 22
M	PG 49S – 34

Ex: Gyratory Mixture Designation -- SPWEB540E (mix design type, course, Aggregate size, traffic level, voids, binder)

2360.2 MATERIALS

A Aggregate 3139

B Asphalt Binder Material 3151

C Additives

Do not incorporate Additives into the mixture unless approved by the Engineer. Add anti-foaming agents to asphalt cement at the dosage rate recommended by the manufacturer. The Contractor may add mineral filler in quantities no greater than 5 percent of the total Aggregate weight. The Contractor may add hydrated lime in quantities no greater than 2 percent of the total Aggregate weight. Do not add a combination of mineral filler and hydrated lime that exceeds 5 percent of the total Aggregate weight. Use methods for adding additives as approved by the Engineer.

C.1 Mineral Filler .... *AASHTO M 17*

C.1.a Mineral Filler – Hydrated Lime

Provide hydrated lime for asphalt mixtures with no greater than 8 percent unhydrated oxides (as received basis) and meeting the requirements of *AASHTO M 216,* "Standard Specification for Quicklime and Hydrated Line for Soil Stabilization." Use a method to introduce and mix hydrated lime and Aggregate as approved by the Engineer before beginning mixture production.

C.2 Liquid Anti-Stripping Additive (Contractor Added)

If adding a liquid anti-strip Additive to the asphalt binder, complete blending before mixing the asphalt binder with the Aggregate. Only use liquid anti-strip Additives that ensure the asphalt binder meets the Performance Grade (PG) requirements in 3151, "Bituminous Material." The Contractor may use asphalt binder with liquid anti-strip added at the refinery or the Contractor may add liquid anti-strip at the plant site. If using asphalt binder with liquid anti-strip added at the refinery, ensure the supplier tests the binder and additive blend to confirm compliance with the *AASHTO M 320*, "Standard Specification for Performance-Graded Asphalt Binder." If an anti-strip agent is added at the plant, the plant mixed asphalt producer is considered a supplier and the binder must conform to the requirements of 3151, "Bituminous Material." Do not pave until the asphalt binder and Additive blend testing results meet the criteria in 2360.2B, "Asphalt Binder Material."

C.2.a Mixture Requirements at Design

Design the mixture with the same asphalt binder supplied to the plant site using mixture option 1, "Laboratory Mixture Design" or mixture option 2, "Modified Mixture Design."

Provide documentation with either design option and include the amount of anti-strip needed to meet the minimum tensile strength requirements. Verify that the binder with the anti-strip meets the PG binder requirements for the mixture.

C.2.b Contractor Production Testing Requirements

Sample and test the asphalt binder and anti-strip blend daily. The Contractor may test the blend by viscosity, penetration, or dynamic sheer rheometer (DSR) of the blend. If the Contract requires the use of a polymer modified asphalt binder in the mixture, use the DSR as the daily QC test.

Send the Engineer and Chemical Laboratory Director a weekly QC report summarizing the results of the daily testing.

Perform at least one test bi-weekly per Project to ensure the binder and anti-strip blend meets the requirements of *AASHTO M 320*, "Standard Specification for Performance-Graded Asphalt Binder." Send the test results to the Engineer and Chemical Laboratory Director.

Provide asphalt binder and anti-strip blend field verification samples in accordance with 2360.2G.7, "Production Tests."

C.2.c Liquid Anti-Strip Additive Metering System

Include a liquid anti-strip flow meter and an anti-strip pump with the metering system. Connect the flow meter to the liquid anti-strip supply to measure and display only the anti-strip being fed to the asphalt binder.

Position the meter readout so that the Inspector can easily read it.

Provide means to compare the flow meter readout with the calculated output of the anti-strip pump.

Provide a system that displays the accumulated anti-strip quantity being delivered to the mixer unit in gallons to the nearest gallon or in units of tons to the nearest 0.001 ton.

Calibrate and adjust the system to maintain an accuracy of ± 1 percent.

Calibrate each plant set-up before producing the mixture.

“Stick” the anti-strip tank at the end of the day’s production to verify anti-strip usage quantities. The Engineer may require “sticking” on a daily basis.

Ensure the system has a spigot for sampling the binder and anti-strip after blending.

Use alternative blending and metering systems only when pre-approved by the Engineer.

C.3 Coating and Anti Stripping Additive 3161

C.4 Warm Mix Asphalt (WMA)

WMA is an approved alternative to HMA. Any mix that is produced at temperatures 30°F or lower than typical HMA mixing temperature of the asphalt binder, as defined by the asphalt supplier, is considered as WMA. The WMA can be manufactured through use of foamed asphalt and/or chemical Additive processes. Notify the Engineer in advance of using any WMA Additive or process. When chemical Additives are used, provide the plant mixing and the laboratory mixing and compaction temperatures as recommended by the manufacturer of the Additive.

D Bituminous Tack Coat 2357

E Mixture Design

E.1 Submittal Location

Submit documentation and sample Aggregate Materials for review to the District Materials Laboratory.

E.2 Aggregate Quality

Provide Aggregate in accordance with 3139.2, “Graded Aggregate for Bituminous Mixtures, Requirements.”

E.3 Restrictions

Do not add Aggregates and Materials not included in the original mixture submission unless otherwise approved by the Engineer.

E.4 Responsibility

Design a gyratory mixture that meets the requirements of this Specification in accordance with the following:

(1) *Laboratory Manual* Method 1820
(2) *Asphalt Institute's Superpave Mix Design Manual* SP-2 (Use a 2 hour short term aging period for volumetric)
(3) *Laboratory Manual*

E.5 Type of Mixture Design Submittal

E.5.a Option 1 — Laboratory Mixture Design

E.5.a(1) Aggregate

Submit the Aggregate samples for option 1, at least 15 Working Days before beginning production samples for quality testing. At least 30 Calendar Days before beginning asphalt production, submit samples of Aggregates that require the magnesium sulfate soundness test to the District Materials Laboratory. Test the samples for quality of each source, class, type, and size of virgin and non-asphaltic salvage Aggregate source used in the mix design. Retain a companion sample of equal size until the Department issues a Mixture Design Report. Provide 24 hour notice of intent to sample Aggregates to the Engineer. Provide samples in accordance with the following:

Table 2360.2-1
Aggregate Sample Size

Classification	Sieve	Weight
Virgin	Retained on No. 4	80 pounds
Virgin	Passing No. 4	35 pounds
Recycled asphaltic pavement (RAP)	—	80 pounds
Recycled asphalt shingles (RAS)	—	10 pound sample of representative RAS Material

E.5.a(2) Mixture Sample

At least 7 Working Days before the start of asphalt production, submit the proposed job mix formula (JMF) in writing and signed by a Level II Quality Management Mix Designer for each combination of Aggregates to be used in the mixture. Include test data to demonstrate conformance to mixture properties as specified in Table 2360.2-4, and 3139.2, "Graded Aggregate for Bituminous Mixtures, Requirements." Use forms approved by the Department for the submission.

Submit an uncompacted mixture sample plus briquettes, in conformance with the JMF, compacted at the optimum asphalt content and required compactive effort for laboratory examination and evaluation. Provide a mixture sample size and the number of compacted briquettes and in accordance with the following:

Table 2360.2-2
Mixture Sample Requirements

Item	Gyratory Design
Uncompacted mixture sample size	75 pounds
Number of compacted briquettes	2

E.5.a(3) Tensile Strength Ratio Sample

At least 7 Working Days before actual production, submit sample to the District Materials Laboratory for verification of moisture sensitivity retained tensile strength ratio (TSR). The Engineer may test Material submitted for TSR verification for maximum specific gravity Gmm compliance in addition to TSR results. The Engineer will reject the submitted mix design if the tested Material fails to meet the Gmm tolerance. If the Engineer rejects a mix design, submit a new mix design in accordance with 2360.2E, “Mixture Design.” The Contractor may use one of the following options to verify that the TSR meets the requirements in Table 2360.2-4.

E.5.a(4) Option A

Batch Material at the design proportions including optimum asphalt. Split the sample before curing and allow samples to cool to room temperature, approximately 77°F. Submit 80 pounds of mixture to the District Materials Laboratory for curing and test verification. Use a cure time of 2 hours ±15 minutes at 290°F cure time for both groups and follow procedures *Laboratory Manual* Method 1813.

E.5.a(5) Option B

Batch and cure in accordance with Option A. Compact, and submit briquettes and uncompacted mixture in accordance with Table 2360.2-3.

Table 2360.2-3
Option B Mixture Requirements

Item	Gyratory Design
Un-compacted mixture sample size	8,200 G
Number of compacted briquettes*	6
Compacted briquette air void content	6.5 – 7.5 percent
* 6-inch specimens.	

E.5.a(6) Aggregate Specific Gravity

Determine the specific gravity of Aggregate in accordance with *Laboratory Manual* Methods 1204 and 1205.

E.5.b Option 2 — Modified Mixture Design

The Contractor may use the modified mixture design if testing shows that the Aggregates meet the requirements of 3139.2, “Graded Aggregate for Bituminous Mixtures, Requirements,” in the current construction season and if the Level II Mix Designer submitting the mixture design has at least 2 years’ experience in mixture design. The Department will not require mixture submittal.

E.5.b(1) Mixture Aggregate Requirements

Size, grade, and combine the Aggregate fractions in proportions that are in accordance with 3139.2A, “Plant Mixed Asphalt.”

E.5.b(2) JMF Submittal

At least 2 Working Days before beginning asphalt production, submit a proposed JMF in writing to the District Materials Laboratory signed by a Level II Quality Management Mix Designer for each combination of Aggregates. For each JMF submitted, include documentation in accordance with 2360.2E.5.a, “Option 1 – Laboratory Mixture Design,” to demonstrate conformance to mixture properties as specified in Table 2360.2-4 and Table 3139.2-3. Submit the JMF on forms approved by the Department.

E.5.b(3) Initial Production Test Verification

The Department will take a mix verification sample within the first four samples at the start of production of each mix type. The Engineer will notify the Contractor electronically when a sample is to be taken and tested for tensile strength ratio (TSR). Initial production testing will be done within the first 5,000 tons of the start of production.

E.5.c Option 3 –Production Mixture Design

A production mixture design is a new mixture design developed by modifying an existing approved mixture design using plant produced Material or laboratory produced Material. Production mixture designs are allowed only when approved by the Engineer and require an interactive process with the District Materials Laboratory to discuss the proposed modification. Only a Level II Mix Designer with at least 2 years' experience in mixture design can request a production mixture design.

E.5.c(1) Added Aggregate Requirements

When the production mixture design is being requested to add a new Aggregate Material not part of the original mixture design the added Aggregate must meet the requirements of 3139.2A, "Plant Mixed Asphalt."

E.5.c(2) Production Mixture Design JMF Submittal

At least 2 Working Days before beginning asphalt production with the Option 3 mix design begin the interactive process with the District Materials Engineer and submit a proposed JMF. Option 3 mix design submittals must be signed by a Level II Quality Management Mix Designer. If directed by the District Materials Engineer submit an optimum asphalt content point for the proposed JMF (new design). If the Option 3 mix design is utilized for Aggregate substitution submit an optimum asphalt content point when directed by the District Materials Engineer. When an optimum asphalt content point is required include documentation showing the mixture is in accordance with 2360.2E.5.b, "Option 2 – Modified Mixture Design," and meets the requirements of Table 2360.2-4.

If test results indicate conformance with Specification requirements the Department will provide a Mix Design Report consisting of the JMF.

E.6 Mixture Requirements

The Department will base mixture evaluation on the trial mix tests and in accordance with Table 2360.2-4

Table 2360.2-4
Mixture Requirements

Traffic Level	2	3	4	5
20 year design ESALs	< 1 million	1 – 3 million	3 – 10 million	10 – 30 million
Gyratory mixture requirements:				
Gyrations for Ndesign	40	60	90	100
percent Air voids at Ndesign, wear	4.0	4.0	4.0	4.0
percent Air voids at Ndesign, non wear and Shoulder	3.0	3.0	3.0	3.0
Adjusted Asphalt Film Thickness, minimum micrometer	8.5	8.5	8.5	8.5
TSR*, minimum percent	75‖	75‖	80†	80†
Fines/effective asphalt	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2

* Use 6-inch specimens in accordance with 2360.2G.7.i, "Field Tensile Strength Ratio (TSR)."

‖ MnDOT minimum = 65

† MnDOT minimum = 70

E.7 Minimum Ratio of Added Asphalt Binder to Total Asphalt Binder

Control recycled Materials used in mixture by evaluating the ratio of new added asphalt binder to total asphalt binder as show in Table 2360.2-5.

Table 2360.2-5
Requirements for Ratio of Added New Asphalt Binder to Total Asphalt Binder* minimum percent

Specified Asphalt Grade ‖	Recycled Material		
	RAS Only	RAS + RAP	RAP Only
PG 58X† -28, PG 52S-34, PG 49-34, PG 64S-22			
Wear	70	70	70
Non Wear	70	70	65
PG 58X†-34			
Wear & Non Wear	80	80	80

* The ratio of added new asphalt binder to total asphalt binder is calculated as (added binder/total binder) x 100

‖ The Contractor can elect to use a blending chart to verify compliance with the specified binder grade. The Department may take production samples to ensure the asphalt binder Material meets the requirements. The blending chart is on the Bituminous Office Website.

† = S, H, V, or E

E.8 Adjusted Asphalt Film Thickness (Adj. AFT) *Laboratory Manual* Method 1854

Ensure the adjusted asphalt film thickness (adjusted AFT) of the mixture at design and during production meets the requirements of Table 2360.2-4. Base the adjusted AFT on the calculated Aggregate surface area (SA) and the effective asphalt binder content.

E.9 Documentation

Include the following documentation and test results with each JMF submitted for review:

(1) Names of the individuals responsible for the QC of the mixture during production
(2) Low Project number of the Contract on which the mixture will be used
(3) Traffic level and number of gyrations
(4) The following temperature ranges as supplied by the asphalt binder supplier:

  (a) Laboratory mixing and compaction
  (b) Plant discharge
  (c) Field compaction

(5) The percentage in units of 1 percent (except the No. 200 Sieve in units of 0.1 percent) of Aggregate passing each of the specified Sieves (including the No. 16, No. 30, No. 50, and No. 100) for each Aggregate to be incorporated into the mixture; derive the gradation of the Aggregate from the RAP after extracting the residual asphalt
(6) Source descriptions of the following:

  (a) Location of Material
  (b) Description of Materials
  (c) Aggregate pit or quarry number
  (d) Proportion amount of each Material in the mixture in percent of total Aggregate

(7) Composite gradation based on (5) and (6) above. Include virgin composite gradation based on (6) and (7) above for mixtures containing RAP/RAS
(8) Bulk and apparent specific gravities and water absorption (by percent weight of dry Aggregate) of both coarse and fine Aggregate, for each product used in the mixture (including RAP/RAS). Use *Laboratory Manual* Method 1204 and 1205. The tolerance allowed between the Contractor's and the Department's specific gravities are Gsb (individual) = 0.040 (+4 and -4) and Gsb (combined) = 0.020
(9) FHWA 0.45 power chart represented by the composite gradation plotted on Federal Form *PR-1115*
(10) Test results from the composite Aggregate blend at the proposed JMF proportions showing compliance with Table 3139.2-3:

  (a) Coarse Aggregate Angularity
  (b) Fine Aggregate Angularity
  (c) Flat and Elongated

(11) Extracted asphalt binder content for mixtures containing RAP/RAS with no retention factor included
(12) Asphalt binder percentage in units of 0.1 percent based on the total mass of the mixture and the PG grade
(13) Each trial mixture design includes the following:

  (a) At least 3 different asphalt binder contents (with at least 0.4 percent between each point), with at least one point at, one point above, and one point below the optimum asphalt binder percentage
  (b) Maximum specific gravity for each asphalt binder content calculated based on the average of the effective specific gravities measured by

using at least 2 maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt binder content

(c) Test results on at least 2 specimens at each asphalt binder content for the individual and average bulk specific gravities, density, and heights

(d) Percent air voids of the mixture at each asphalt binder content

(e) Adjusted AFT for each asphalt binder content

(f) Fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent

(g) TSR at the optimum asphalt binder content

(h) Graphs showing air voids, adjusted AFT, Gmb, Gmm, and unit weight vs. percent asphalt binder content for each of the 3 asphalt binder contents submitted with trial mix

(i) Evidence that the completed mixture will conform to design air voids (Va), adjusted AFT, TSR, F/Ae (Fines to effective asphalt ratio)

(j) Gyratory densification tables and curves generated from the gyratory compactor for all points used in the mixture submittal

(k) Percent new asphalt binder to total asphalt binder

(14) The Contractor has the option of augmenting the submitted JMF with additional sand or rock. When using this option, provide samples of the Aggregate for quality analysis in accordance with 2360.2E.5, “Type of Mixture Design Submittal.” Also provide mix design data for 2 additional design points per add-material. Provide 1 point to show a proportional adjustment to the submitted JMF that includes 5 percent, by weight, add-material at the JMF optimum asphalt percent. Provide a second point to show a proportional adjustment to the submitted JMF that includes 10 percent, by weight, add Material at the JMF optimum asphalt percent. Report the following information for each of these 2 points:

(a) The maximum specific gravity determined by averaging 2 tests

(b) Test results showing the individual and average bulk specific gravity, density, and height of at least 2 specimens at the optimum asphalt binder content

(c) Percent air voids for the mixture for each point

(d) Fines to Effective Asphalt ratio calculated to the nearest 0.1 of a percent

(e) Crushing of the coarse and fine Aggregate

(f) Adj. AFT

(g) Up to 2 add-materials will be allowed

F Mixture Design Report

The Department will provide a Mixture Design Report consisting of the JMF. Include the following in the JMF:

(1) Composite gradation

(2) Aggregate component proportions

(3) Asphalt binder content of the mixture

(4) Design air voids

(5) Adjusted asphalt film thickness

(6) Aggregate bulk specific gravity values

Show the JMF limits for gradation control Sieves in accordance with Aggregate gradation broadbands shown in Table 3139.2-2, percent asphalt binder content, air voids, and adjusted AFT. If the

Department issues a Mixture Design Report, this report only confirms that the Department reviewed the mixture and that it meets volumetric properties shown in Table 2360.2-4 and Table 2360.2-5. The Department makes no guaranty or warranty, either express or implied, that compliance with volumetric properties ensures Specification compliance regarding placement and compaction of the mixture.

Provide Materials meeting the requirements of the Aggregate and mixture design before issuing a Mixture Design Report. The Department will review two trial mix designs per mix type designated in the Plan per Contract at no cost to the Contractor. The Department will verify additional mix designs at a cost of $2,000 per design.

Provide a Department-reviewed Mixture Design Report for all paving except for small quantities of Material as described in 2360.3G, "Small Quantity Paving."

For City, County, and other agency Projects, provide the District Materials Laboratory a complete Project Proposal, including Addenda, Supplemental Agreements, Change Orders, and Plans sheets, including typical sections, affecting the mix design before the Department begins the verification process.

G Mixture Quality Management

G.1 Quality Control (QC)

The Contractor will perform Quality Control (QC) as part of the production process. QC is the process control of the operations related to mixture production and determining the quality of the mixture being produced. The QC sample is the Contractor's sample taken and tested during production and used to control the production process. Provide and maintain a QC program for plant mix asphalt production, including mix design, process control inspection, sampling and testing, and adjustments in the process related to the production of an asphalt pavement.

G.1.a Plant Certification

Provide the following to obtain certification:

(1) Completed and submitted request form application for plant inspection
(2) Site map showing stockpile locations
(3) Signed asphalt plant inspection report showing the plant and testing facility passed as documented by *Asphalt Plant Inspection Report* (TP 02142-02, TP 02143-02). The inspection report must also include documentation showing plant and laboratory Equipment has been calibrated and is being maintained to the tolerance shown in the *Bituminous Manual* and sections 1200, 1800, and 2000 of the *Laboratory Manual*
(4) A Department-signed Mixture Design Report (MDR) before mixture production

G.1.b Maintaining Certification

Maintain plant certification by documenting the production and testing of the certified plant asphalt mixtures. Sample and test asphalt mixtures in accordance with this section and meeting the requirements of the *Schedule of Materials Control*.

G.1.b(1) Annual Certification

Perform annual certification after winter suspension.

G.1.b(2) Sampling Rate

Sample at the rate in accordance with 2360.2G.6, “Production Testing Rates,” and the requirements of the *Schedule of Materials Control*.

G.1.b(3) Plant Moved

Recertify the plant if the plant moves to a new or previously occupied location.

G.1.c Plant Certification Revocation

The Engineer may revoke certification for any of the following reasons:

(1) If the mix does not meet the requirements of 2360.2E.6, “Mixture Requirements,” 2360.2E.7, “Minimum Ratio of Added Asphalt Binder to Total Asphalt Binder,” and 3139.2A, “Plant Mixed Asphalt”
(2) If there is a failure to meet the testing rates
(3) If it is determined records were falsified

If the Engineer revokes plant certification, the Department may revoke the technical certification of the individual or individuals involved. The Department will maintain a list of companies with revoked certifications.

G.2 Quality Assurance (QA)

The Engineer will perform Quality Assurance (QA) as part of the acceptance process. QA is the process of monitoring and evaluating various aspects of the Contractor’s testing as described below. The QA sample is the Department’s companion sample to the Contractor’s QC sample. QA testing is performed to accept the Work. The Engineer will perform the following:

(1) Conduct QA and verification sampling and testing
(2) Observe the QC sampling and tests
(3) Monitor the required QC summary sheets and control charts
(4) Verify calibration of QC laboratory testing Equipment
(5) Communicate Department test results to the Contractor’s personnel on a daily basis
(6) Ensure Independent Assurance (IA) sampling and testing requirements are met

If the Engineer observes that the Contractor is not performing sampling and Quality Control tests in accordance with the applicable test procedures, the Engineer may stop production until the Contractor takes corrective action. The Engineer will notify the Contractor of observed deficiencies promptly, both verbally and in writing.

The Engineer may obtain additional samples, at any time and location during production, to determine quality levels in accordance with 2360.2G.3, “Verification Sample.”

The Department will post a chart with the names and telephone numbers for the personnel responsible for QA.

The Engineer will calibrate and correlate laboratory testing Equipment in accordance with the *Bituminous Manual* and *Laboratory Manual*.

Table 2360.2-6
Allowable Differences between Contractor and Department Test Results*

Item	Allowable Difference
Mixture bulk specific gravity (Gmb)	0.030
Mixture maximum specific gravity (Gmm)	0.019
Adjusted AFT (calculated)	1.2
Fine Aggregate angularity, uncompacted voids (U), percent	1
Coarse Aggregate angularity, percent fractured faces (percent)	15
Aggregate individual bulk specific gravity (+ No. 4)	0.040
Aggregate individual bulk specific gravity (- No. 4)	0.040
Aggregate combined blend Specific Gravity (Gsb)	0.020
Tensile strength ratio (TSR), (percent)	Table 2360.2-4
Asphalt binder content:	
Meter method, (percent)	0.2
Spot check method, (percent)	0.2
Chemical extraction methods, (percent)	0.4
Incinerator oven, (percent)	0.3
Chemical vs. meter, spot check, or incinerator methods	0.4
Incinerator oven vs. spot check	0.4
Gradation Sieve, (percent passing):	
1 inch, 3/4 inch, 1/2 inch, 3/8 inch	6
No. 4	5
No. 8, No. 16, No. 30	4
No. 50	3
No. 100	2
No. 200	1.2
* Test tolerances listed are for single test comparisons.	

G.3 Verification Sample

The Department will take at least one randomly determined sample daily per mix type from behind the paver or from the truck box and will consider this a verification sample. The split of this sample, given to the Contractor, must be tested by the Contractor and will replace the next scheduled QC sample. Sample enough Material to accommodate retesting in case the samples fail.

The Department will perform verification testing on production tests and will include the test results on the test summary sheet and compare test results to Specification requirements. Additionally, the Department's verification test will be compared to the Contractor's verification companion to validate compliance with Table 2360.2-6.

The Contractor may access the Department's verification test results for Gmm (mixture maximum gravity), Gmb (mixture bulk gravity), air voids (calculated), asphalt binder content, within 2 Working Days from the time the sample is delivered to the District Laboratory. The Department will provide the gradation, crushing, and Adj. AFT (calculated) results to the Contractor within 3 Working Days.

If the tolerances between the Contractor's verification companion and the Department's verification sample do not meet the requirements of Table 2360.2-6, the Department will retest the Material.

If the verification sample retests do not meet tolerances:

1) The Department will immediately investigate the cause of the difference. This will include a review of testing Equipment, procedures, worksheets, and personnel to determine the source of the problem. The Engineer may require both the Department and Contractor to perform at least one hot-cold comparison of mixture properties as discussed below.
2) The Department will test all QA samples for that day and base acceptance on QC data with substitution of Department test results for those parameters out of tolerance. Volumetric properties will be recalculated if necessary. If the Adj. AFT calculation does not meet the tolerance, equalize the Department Adj. AFT result by increasing the original Department value by 0.5 microns. Use the increased Department Adj. AFT for the individual Adj. AFT result and to calculate the moving average Adj. AFT results. The increased Department Adj. AFT will form the basis for acceptance.

Cease mixture production and placement if reestablished test results do not meet tolerances within 48 hours. Resume production and placement only after meeting the tolerances. The process for dispute resolution is available on the Bituminous Office website.

If the Engineer analyzes the data using statistical methods for determination of bias and finds a bias in the test results, the Engineer will specify which results to use. If through analysis of data, it is determined that there is a bias in the test results, the Engineer will determine which results are appropriate and will govern.

G.3.a HOT-COLD COMPARISON

To perform a hot-cold comparison, split the sample into three representative portions. The Engineer will observe the Contractor testing. The Contractor will compact and determine mix properties from one portion while still hot. Apply additional heating to raise the temperature of the sample to compaction temperature if necessary. Allow the second and third portions to cool to air temperature. One portion will be reheated and tested by the Department and the other portion will be reheated and tested by the Contractor. On the same day and at the same time as the District Materials Laboratory, reheat mix samples to 160°F to allow splitting of the sample into representative fractions for the various tests. Do not overheat the mixture portions used for testing maximum specific gravity. Heat samples to compaction temperature and compact.

Develop a calibration factor to compare the specific gravity of the hot compacted samples to reheated compacted samples. Use at least two gyratory specimens for each test. The Engineer or the Contractor may request that this test be repeated.

G.4 Contractor Quality Control

G.4.a Personnel

Submit an organizational chart listing the names and phone numbers of individuals and alternates responsible for the following:

(1) Mix design
(2) Process control administration
(3) Inspection

Provide QC technicians certified as a Level I Bituminous Quality Management (QM) Tester meeting the requirements of the MnDOT Technical Certification Program for QC testing and Level II Bituminous QM Mix Designer to make process adjustments. Provide at least one person per paving operation certified as a Bituminous Street Inspector.

Provide a laboratory with Equipment and supplies for Contractor Quality Control testing and maintain with the following:

(1) Up-to-date Equipment calibrations and a copy of the calibration records with each piece of Equipment
(2) Telephone
(3) Copy machine
(4) Internet and Email
(5) Computer
(6) Printer
(7) Microsoft Excel, version 2013 or newer

Laboratory Equipment needs to meet the requirements listed in Section 400 of the *Bituminous Manual*, *Laboratory Manual*, and these Specifications, including having extraction capabilities. Before beginning production, the laboratory Equipment needs to be calibrated and operational.

Calibrate and correlate all testing Equipment in accordance with the *Bituminous Manual* and *Laboratory Manual*. Keep records of calibration for each piece of testing Equipment in the same facility as the Equipment.

G.4.b Sampling and Testing

Take QC samples at random tonnage or locations, quartered from a larger sample of mixture. Sample randomly and in accordance with the *Schedule of Materials Control*. Determine random numbers and tonnage or locations using the *Bituminous Manual,* Section 720.4, or *ASTM D3665*, *Standard Practice for Random Sampling of Construction Materials*, Section 5, or, an Engineer approved alternate method of random number generation. Sample either behind the paver or from the truck box at the plant site. Other sampling locations can be approved by the Engineer. The Contractor must decide and notify the Engineer where samples will be taken before production begins. The Contractor and Engineer must both agree to a change of sampling location once production has begun. The procedure for truck box sampling is on the Bituminous Office website. The Contractor will obtain at least a 130 pound sample. Split the sample in the presence of the Inspector. When truck box sampling and testing is performed at the plant site, in order to account for asphalt absorption, the sample needs to be kept heated at the compaction temperature for 30 minutes before splitting and batching into test portions. The Inspector will retain possession of the portion of each split sample that is taken. Store compacted mixture specimens and loose mixture companion samples for 10 Calendar Days. Label these split companion samples with companion numbers.

If coarse and fine Aggregate angularity are not evaluated for every QC sample retain the extracted gradation samples for the respective QC samples for additional testing. Keep the Aggregate samples in containers with field identification labels for a period of 10 Calendar Days. The Engineer will identify which extracted gradation sample is the verification companion and whether it is to be tested for coarse and fine Aggregate angularity.

G.5 Production Test Requirements

Determine the planned tonnage for each mixture planned for production during the production day. Divide the planned production by 1,000 and round to the next highest whole number. The result is the number of production tests required for the mixture. Table 2360.2-8, shows the required production tests.

Split the planned production into even increments and select sample locations as described above. If actual tonnage is greater than the planned tonnage, repeat the calculation above and provide additional tests if the calculation results in a higher number of production tests. During production, the Department will not require mixture volumetric property tests if mix production is no greater than 300 tons. Provide production tests if the accumulative weight on successive days is greater than 300 tons.

If there is a choice of more than one Department approved test procedure, select one method at the beginning of the project with the approval of the Engineer and use that method for the entire Project. The Contractor and Engineer may agree to change test procedures during the construction of the Project.

G.5.a Establishing an Ignition Oven Correction Factor, *Laboratory Manual* Method 1853 Appendix

On the first day of production, for each mixture type, both the Contractor and the Department will establish an ignition oven correction factor from the produced mixture. Reestablish correction factors when:

There are Aggregate or RAP substitutions.

There are 3 or more tolerance failures on the extracted asphalt content between the Department and the Contractor as defined by Table 2360.2-6.

G.6 Production Testing Rates

G.6.a Start–up

At the start of production, for the first 2,000 tons of each mix type, perform testing at the following frequencies:

Table 2360.2-7
Production Start-Up Testing Rates

Production Test	*Laboratory Manual* Method	Section
Bulk Specific Gravity	1806	2360.2G.7.b, "Gyratory Bulk Specific Gravity, Gmb"
Maximum Specific Gravity	1807	2360.2G.7.c, "Maximum Specific Gravity, Gmm"
Air Voids (calculated)	1808	2360.2G.7.d, "Air Voids – Individual and Isolated (Calculation)"
Asphalt Content	1853	2360.2G.7.a, "Asphalt Binder Content"
Add AC/Total AC Ratio (calculated)	1853	2360.2G.7.a, "Asphalt Binder Content"
Adj. AFT (Calculated)	1854	2360.2G.7.b, "Gyratory Bulk Specific Gravity, Gmb"
Gradation	1203	2360.2G.7.f, "Gradation – Blended Aggregate"
Coarse Aggregate Angularity	1214	2360.2G.7.g, "Coarse Aggregate Angularity"
Fine Aggregate Angularity (FAA)	1206	2360.2G.7.h, "Fine Aggregate Angularity"
Fines to Effective Asphalt Ratio (calculated)	1203 & 1853	2360.2G.7.f, "Gradation – Blended Aggregate" & 2360.2G.7.a, "Asphalt Binder Content"

G.6.b Production

After producing the first 2,000 tons of each mix type test at the following frequencies:

Table 2360.2-8
Production Testing Rates

Production Test	Test Reference	Section
Bulk Specific Gravity	*Laboratory Manual* Method 1806	2360.2G.7.b, “Gyratory Bulk Specific Gravity, Gmb”
Maximum Specific Gravity	*Laboratory Manual* Method 1807	2360.2G.7.c, “Maximum Specific Gravity, Gmm”
Air Voids (calculated)	*Laboratory Manual* Method 1808	2360.2G.7.d, “Air Voids – Individual and Isolated (calculation)”
Asphalt Content	*Laboratory Manual* Method 1853	2360.2G.7.a, “Asphalt Binder Content”
Add AC/Total AC Ratio (calculated)	*Laboratory Manual* Method 1853	2360.2G.7.a, “Asphalt Binder Content”
Adj. AFT (Calculated)	*Laboratory Manual* Method 1854	2360.2G.7.e, “Adjusted Asphalt Film Thickness (AFT)(Calculation)”
Gradation	*Laboratory Manual* Method 1203	2360.2G.7.f, “Gradation – Blended Aggregate”
Coarse Aggregate Angularity	*Laboratory Manual* Method 1214	2360.2G.7.g, “Coarse Aggregate Angularity”
Fine Aggregate Angularity (FAA)	*Laboratory Manual* Method 1206	2360.2G.7.h, “Fine Aggregate Angularity”
Fines to Effective Asphalt Ratio (calculated)	*Laboratory Manual* Methods 1203 & 1853	2360.2G.7.f, “Gradation – Blended Aggregate” & 2360.2G.7.a, “Asphalt Binder Content”
TSR	*Laboratory Manual* Method 1813	2360.2G.7.i, “Field Tensile Strength Ratio (TSR)”
Aggregate Specific Gravity	*Laboratory Manual* Methods 1204, 1205, and 1815	2360.2G.7.j, “Aggregate Specific Gravity (Gsb)”
Mixture Moisture Content	*Laboratory Manual* Method 1855	2360.2G.7.k, “Moisture Content”
Asphalt Binder	*Bituminous Manual* 720.2	2360.2G.7.l, “Asphalt Binder Samples”

G.7 Production Tests

G.7.a Asphalt Binder Content

Spotchecks are required only when the Engineer has waived the requirements of 2360.2G.8, “Documentation” relating to furnishing a computerized printout of the plant blending control system. A minimum of 1 spotcheck per day per mixture blend is required to determine the new added asphalt binder.

Use an incinerator oven meeting the requirements of the *Laboratory Manual* Method 1853. Do not use the incinerator oven if the percentage of Class B Material is greater than 50 percent within the composite blend, unless the Contractor determines a correction factor approved by the Engineer.

Perform chemical extraction meeting the requirements of *Laboratory Manual* Method 1851 or 1852.

G.7.b Gyratory Bulk Specific Gravity, Gmb

Use 2 specimens to determine gyratory bulk specific gravity meeting the requirements of *Laboratory Manual* Method 1806. Set Gyratory to an internal angle of

1.16° ± 0.02° according to *AASHTO TP 71,* "Standard Method of Test for Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading."

G.7.c Maximum Specific Gravity, Gmm

Determine maximum specific gravity meeting the requirements of *Laboratory Manual* Method 1807.

G.7.d Air Voids – Individual and Isolated (Calculation)

Calculate the individual and isolated air voids meeting the requirements of *Laboratory Manual* Method 1808. Use the maximum mixture specific gravity and corresponding bulk specific gravity from a single test to calculate the isolated air voids. Use the maximum specific gravity moving average and the bulk specific gravity from a single test to calculate the individual air voids.

Compact gyratory design to Ndesign in accordance with Table 2360.2-4 for the specified traffic level.

G.7.e Adjusted Asphalt Film Thickness (AFT) (Calculation)

Calculate the Adj. AFT meeting the requirements of the *Laboratory Manual* Method 1854.

G.7.f Gradation – Blended Aggregate

Determine the gradation of blended Aggregate sample, from an extracted bituminous mixture, meeting the requirements of *Laboratory Manual* Method 1203.

G.7.g Coarse Aggregate Angularity

Test the Coarse Aggregate Angularity (CAA) meeting the requirements of *Laboratory Manual* Method 1214 to determine the CAA on composite blend from Aggregates used in production of hot mix asphalt. Ensure CAA test results meet the requirements in accordance with Table 3139.2-3.

The Contractor may test mixtures containing virgin Aggregates from composite belt samples. Test mixtures containing RAP from extracted Aggregates taken from standard production samples. Test the percentage of fractured faces of the composite Aggregate blend less than 100 percent twice a day for each mixture blend for at least two Working Days, then one test per day if the test samples meet the CAA requirements. If the CAA crushing test results are greater than 8 percent of the requirements, take one sample per day and perform one test per week.

Report CAA results on the test summary sheet.

G.7.h Fine Aggregate Angularity

Use *Laboratory Manual* Method 1206 to test the composite blend from Aggregates used in production of asphalt mixtures for Fine Aggregate Angularity (FAA) meeting the requirements of Table 3139.2-3. The Contractor may test mixtures that contain virgin Aggregates from composite belt samples. Test mixtures that contain RAP from extracted Aggregates taken from standard production samples. Perform two tests per day for each mixture blend for at least two days to test the percentage of uncompacted voids from the composite Aggregate blend, then one test per day if the samples meet FAA requirements. If FAA test results are greater than five percent of the requirement, take one sample per day and one test per week.

Report FAA results on the test summary sheet.

G.7.i Field Tensile Strength Ratio (TSR)..................*Laboratory Manual* Method 1813

If the Engineer requires sampling and testing of the mixture to verify tensile strength ratio (TSR), both the Contractor and the Department will be required to test these samples within 72 hours after sampling. The Contractor shall obtain a sample weighing at least 110 pounds and split the sample in half to provide a sample for the Department and the Contractor. Label the Department companion of this split with the following information:

(1) Date
(2) Time
(3) Project number
(4) Cumulative tonnage to date

After the sample is split and labeled, give the Department's companion sample to the Department Street Inspector or Plant Monitor or to the Materials Engineer within 24 hours of sampling as directed by the Engineer. When using Option 2, obtain the sample within the first 5,000 tons of plant mixed asphalt produced or by the second day of production, whichever comes first, to verify tensile strength ratio (TSR).Take mixture samples from the windrow or truck box. Provide a 6-inch specimen for gyratory design. The Contractor may test the sample at a permanent lab site or a field lab site.

Refer to Table 2360.2-9 for the minimum acceptable TSR values for production. Stop production immediately if the Material does not meet minimum TSR requirements. Do not resume production until after adding anti-strip to the asphalt binder. Determine the responsible party for the cost of the anti-strip in accordance with the Department and Contractor TSR values in Table 2360.2-10. If the Department is responsible for the cost of the anti-strip, the Department will only pay for the cost of the anti-strip for mixtures placed on that Project. The Department will not pay for delay costs associated with making changes related to this testing.

Table 2360.2-9
Mixture Type, Minimum TSR

Traffic Level 2 – 3, percent		Traffic Level 4 – 5, percent	
Contractor	**Department**	**Contractor**	**Department**
75	65	80	70

Table 2360.2-10
Anti-Strip Cost Responsibility

Gyratory Level	Contractor TSR	Department TSR	Responsibility
2 – 3	≥ 75	≥ 65	No anti-strip required
		< 65	Contractor
	< 75	≥ 65	Department
		< 65	Contractor
4 – 5	≥ 80	≥ 70	No anti-strip required
		< 70	Contractor
	< 80	≥ 70	Department
		< 70	Contractor

Take another sample and test within the first 500 tons after production resumes. Stop production if the retest fails to meet the minimum specified value. Discuss a proposal to resolve the problem with the Engineer before resuming production. Do not operate below the specified minimum TSR if at least 2 successive tests fail the TSR requirements.

A new sample and retest is automatically required if a proportion changes by greater than 10 percent from the currently produced mixture for a single stockpile Aggregate or the Engineer directs the Contractor to sample and retest.

G.7.j Aggregate Specific Gravity (Gsb) ....*Laboratory Manual* Methods 1204, 1205, 1815

Sample and test Aggregate stockpiles to verify Aggregate specific gravity if directed by the Engineer in conjunction with the District Materials Engineer. Provide 90 pound representative stockpile samples for each Aggregate component. Split samples in half to provide Material for both the Department and the Contractor. Label the Department companion with the following information:

(1) Date
(2) Time
(3) Project number
(4) Approximate cumulative tonnage to date

Give the Department companion to the Department Street Inspector or Plant Monitor immediately after splitting or to the Materials Engineer within 24 hours of sampling as directed by the Engineer. The Materials Engineer will compare the Aggregate specific gravity results to the Contractor's values on the current Mix Design Report. If the results deviate beyond the tolerance in accordance with Table 2360.2-6, the Materials Engineer will notify the Contractor and issue a new Mix Design Report with the current specific gravity results. Base new mixture placed after receiving notification of new specific gravity values on the Department results. The Engineer will notify the Contractor regarding new specific gravity values. The dispute resolution procedure for Aggregate specific gravity is on the Bituminous Office website.

G.7.k Moisture Content..*Laboratory Manual* Method 1855

Provide a mixture with moisture content no greater than 0.3 percent. Measure moisture content in the mixture behind the paver or, if approved by the Engineer, in the truck box. Sample and test as directed by the Engineer. Store the sample in an airtight container. Do not perform microwave testing.

Do not provide plant mixed asphalt with a moisture content greater than 0.3 percent.

G.7.l Asphalt Binder Samples

Obtain asphalt binder samples from a sampling valve located between the pump and the drum. Sample each type of asphalt binder used in mixture production after 50 tons of mixture has been produced, then sample at a rate of one per 250,000 gallons. A minimum of 1 gallon of binder must be drawn and wasted from the sampling valve before the actual sample is drawn. For batch plants, obtain the asphalt binder sample from the weigh pod. Provide a 1 quart sized sample. The Inspector will monitor the sampling the Contractor performs. Record sample information on an Asphalt Sample Identification Card. Submit the sample to the Central Materials Laboratory. Contact the Chemical Laboratory Director for disposition of failing asphalt binder samples.

G.8 Documentation

Maintain documentation, including test summary sheets and control charts, on an ongoing basis. Maintain a file of gyratory specimen heights for gyratory compacted samples and test worksheets. File reports, records, and diaries developed during the Work as directed by the Engineer. These documents become the property of the Department.

Number test results in accordance with the MDR and record on forms approved and provided by the Department.

G.8.a Production Test Results

Send production test results on test summary sheets to the District Materials Laboratory and to other sites as directed by the Engineer by 11 AM of the day following production by facsimile, or e-mail when approved by the Engineer.

Include the following production test results and mixture information on the Department approved test summary sheet:

(1) Percent passing on all Sieves in accordance with Table 3139.2-2 (including No. 16, No. 30, No. 50, and No. 100)
(2) Coarse and fine Aggregate crushing
(3) Maximum specific gravity (Gmm)
(4) Bulk specific gravity (Gmb)
(5) Percent total asphalt binder content (Pb)
(6) New added asphalt binder content
(7) Ratio of percent new added asphalt binder to total asphalt binder
(8) Calculated production air voids (Va)
(9) Calculated adjusted AFT (Adj. AFT)
(10) Composite Aggregate specific gravity (Gsb) reflecting current proportions
(11) Aggregate proportions in use at the time of sampling
(12) Tons where sampled
(13) Tons represented by a test and cumulative tons produced
(14) Fines to effective asphalt ratio (F/Ae)
(15) Signature Line for Department and Contractor Representative
(16) Mixture Moisture Content
(17) Department verification sample test result
(18) Identify, when used, the WMA additive or process and dosing rates

Submit copies of failing test results to the Engineer on a daily basis.

G.8.b Asphalt Manifest

Provide the Engineer with asphalt manifests or bill of ladings (BOL) on a daily basis.

Provide a daily plant diary, including a description of QC actions taken. Include changes or adjustments on the test summary sheets.

Provide weekly truck Scale spot checks.

Provide a Department approved accounting system for mixes and provide a daily and final project summary of Material quantities and types.

Provide a final hard and electronic copy of QC test summary sheets and control charts, and density worksheets at completion of bituminous operations on the Project to the Engineer.

Provide an automated weigh Scale and computer generated weigh ticket. Ensure the ticket indicates the following information:

(1) Project number
(2) Mix designation, including binder grade
(3) Mixture Design Report number
(4) Truck identification and tare. Truck tare weight is not required when the plant silo is equipped with a load cell to weigh the mixture independent of the truck weight. Truck tare weight is only required when a drive-over truck Scale is utilized to determine the batch weight
(5) Net mass
(6) Date and time of loading

Do not include deviations from the minimum information on the computer generated weigh ticket unless otherwise approved by the Engineer in writing.

Continue test summary sheets, charts, and records for a mixture produced at one plant site from Contract to Contract. Begin new summary sheets and charts annually for winter carry-over Projects. Begin new summary sheets and charts when an asphalt plant is reset up in the same location after it has moved out.

Furnish an electronic printout (long form recordation) from an automated plant blending control system at 20-minute intervals when the plant is producing mixture. The Engineer may waive this requirement if the plant does not have the capability to produce the automated blending control information; however, the Contractor must then perform daily spotchecks to determine percent new asphalt added.

G.8.c Drum Plants

Include the following information on the plant control printout for Drum Plants:

(1) Both the virgin and recycle belt feed rates (tons/hour)
(2) Feeder bin proportions (percent)
(3) Total percent asphalt cement in the mixture
(4) Virgin asphalt cement added (percent)
(5) Mixture temperature (°F)
(6) Mixture designation code
(7) Date and time stamp
(8) Current tons of mixture produced and daily cumulative tons of mixture produced at time of printout

Provide a daily electronic printout of the plant calibration (SPAN) numbers for each bin and meter.

G.8.d Batch Plants

Include the following information on the plant control printout for Batch Plants:

(1) Both the virgin and recycle belt feed rates (tons/hour)
(2) Feeder bin proportions (percent)
(3) Mixture temperature (°F)

(4) Mixture designation code
(5) Date and time stamp
(6) Current tons of mixture produced and daily cumulative tons of mixture produced at time of printout

Provide a daily electronic printout of the plant calibration (SPAN) numbers for each bin and meter.

G.9 Control Charts

Provide control charts and summary sheets computer generated from software approved by the Engineer.

The Contractor may use software available at the Bituminous Office website. Record the following data on standardized control charts:

(1) Blended Aggregate gradation, include Sieves in accordance with Table 3139.2-2 for specified mixture
(2) Percent asphalt binder content (Pb)
(3) Maximum specific gravity (Gmm)
(4) Production air voids (Va)
(5) Adj. AFT

Unless otherwise directed by the Engineer, plot individual test results for each test point and connect individual points with a solid line. Plot the moving average for each test variable starting with the fourth test and connect with a dashed line. Plot the Department's QA and verification test results with triangles. Plot the specification JMF limits on the control charts using a dotted line.

G.10 JMF Limits

Base the production air voids and Adj. AFT on the minimum specified requirements in accordance with Table 2360.2-4. Base gradations and asphalt binder content limits on the current Department reviewed Mixture Design Report. Provide gradation control Sieves in accordance with Table 3139.2-2. Refer to the Mixture Design Report for the mixture production targets. JMF limits are the target plus or minus the limits in accordance with Table 2360.2-11. Use JMF limits as the criteria for acceptance of Materials based on the moving average.

Table 2360.2-11
JMF Limits (N=4)

Item	JMF Limits
Adj. AFT	- 0.5
Production air voids, percent	± 1.0
Asphalt binder content, percent	- 0.4
Sieve, percent passing:	
1 inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4	Broad band limits
No. 8	Broad band limits
No. 200	Broad band limits

G.11 Moving Average Calculation

Calculate a moving average as the average of the last four test results. Continue the calculation without interruption, except begin new summary sheets and charts annually for winter carry-over Projects and if an asphalt plant is reset up in the same site after it has been moved out.

G.12 JMF Bands

JMF Bands are the area between the target, as identified on the Mixture Design Report, and the JMF limits.

G.13 JMF Adjustment

Begin mixture production with Aggregate proportions within 5 percent of the design proportions and mixture parameters in Table 2360.2-11 within the JMF limits shown. Use all the Aggregate proportions included on the Mixture Design Report unless the Aggregate proportion is shown as 0 percent. If the Contractor provides the District Materials Laboratory with prior documented production data showing how production affects the mixture properties or if the Contractor provides the District Materials Laboratory with a written justification or explanation of Material changes since the original mixture submittal waive the preceding requirements.

G.13.a JMF Request for Adjustment

The Contractor may make a request to the Bituminous Engineer or District Materials Engineer for a JMF adjustment to the mix design if the QC test results indicate a necessary change to achieve the specified properties. Do not use Aggregates or Materials not part of the original mix design to make adjustments unless otherwise approved by the Engineer, in conjunction with the District Materials Engineer or the Department Bituminous Engineer.

A Certified Level II Bituminous QM Mix Designer will review the requested change for the Department. If the request meets the design requirements in Table 3139.2-2, Table 3139.2-3, and Table 2360.2-4, the Department will issue a revised Mixture Design Report. Each trial mixture design submittal in accordance with 2360.2E, “Mixture Design,” may have three JMF adjustments per mixture per Project without charge.

Perform an interactive process with the Engineer before making JMF adjustments. Make JMF adjustments only within the mixture specification gradation design broadbands in accordance with Table 3139.2-2. Submit a new JMF if redesigning the mixture. Only reduce the JMF asphalt content if the moving average Adj. AFT is 8.5 micrometer or more and individual Adj. AFT is at least 7.5 micrometer.

The Department will not allow consecutive requests for a JMF adjustment without production data. Continue calculation of the moving average after the approval of the JMF.

G.13.b JMF Request for Adjustment for Proportion Change > 10 percent

If requesting a JMF adjustment for a proportion change greater than 10 percent from the currently produced mixture for a single stockpile Aggregate, provide supporting production test data from at least 4 tests run at an accelerated testing rate of 1 test per 500 tons with the adjustment request. The Department will base acceptable verification and approval of the requested JMF on individual and moving average test results in addition to the requirements listed above. Individual test results must be within twice the requested JMF limits for percent asphalt binder, production air voids, and Adj. AFT. Individual gradations must be within the Broad Bands. The moving average values must be within the control limits in accordance with Table 2360.2-11. Continue to calculate the moving average after the change in proportions.

If the mixture meets the design requirements as discussed in 2360.2G.13.a, “JMF Request for Adjustment,” the District Materials Laboratory will sign the request for JMF adjustment effective from the point of the proportion change. Do not make consecutive requests for JMF adjustments without production data.

G.13.c JMF Request for Adjustment When Cumulative Proportion Changes > 10 percent

Submit a request for JMF adjustment when the cumulative change on any one product exceeds 10 percent from the original MDR. The Department will issue a revised MDR provided the mixture meets the requirements in Table 3139.2-2, Table 3139.2-3, and Table 2360.2-4.

G.14 Failing Materials

The Department will base Material acceptance on individual and moving average test results. The Department will use isolated test results for acceptance of air voids at the start of mixture production. The Department will consider individual test results greater than two times the JMF bands as failing. The Department will fail moving average test results exceeding the JMF limits. Begin new summary sheets annually for winter carry-over Projects.

Stop production and make adjustments if the moving average values exceed the JMF limits. Restart production after performing the adjustments and notifying the Engineer. Resume testing at the accelerated rates and for the tests listed in Table 2360.2-7, for the next 2,000 tons of mixture produced. Continue calculating the moving average after the stop in production.

The Department will consider mixture produced where the moving average of four exceeds the JMF limits as unsatisfactory in accordance with 2360.5B.7, “Moving Average Failure at Mixture Start-Up – Production Air Voids,” 2360.5B.8, “Moving Average Failure at Mixture Start-Up — Adj. AFT,” 2360.5B.7, “Moving Average Failure - Production Air Voids,” and 2360.5B.10, “Moving Average Failure — Percent Asphalt Binder Content, Gradation, and Adj. AFT.”

If the total production of a mixture type for the entire Project requires no greater than four tests the Department will accept the Material in accordance with 2360.2G.14.b, “Isolated Failures at Mixture Start-Up — Production Air Voids,” and 2360.5B.6, “Individual Failure — Percent Asphalt Binder, Production Air Voids, and Adj. AFT.”

G.14.a Ratio of New Added Asphalt Binder to Total Asphalt Binder – Acceptance Criteria

Minimum design ratio of new added asphalt binder to total asphalt binder is shown in Table 2360.2-12. During production the ratio must meet individual and moving average requirements as listed in Table 2360.2-12. If the individual or moving average ratio drops below the minimum requirement, the Contractor must stop production and make adjustments to correct the process. Restart production only after notifying the Engineer of the adjustments made. The calculation of the moving average will continue after the stop in production.

Table 2360.2-12
Ratio of New Added Asphalt Binder to Total Asphalt Binder Acceptance Criteria

Specified Asphalt Grade	Recycled Material		
	RAS Only	RAS + RAP	RAP Only
PG 58*-28, PG 52S-34, PG 49-34, PG 64S-22 Wear (individual/moving average) Non Wear (individual/moving average)	66/70 66/70	66/70 66/70	66/70 61/65
PG 58*-34 Wear & Non Wear (individual/moving average)	76/80	76/80	76/80
* = S, H, V, or E			

G.14.b Isolated Failures at Mixture Start-Up – Production Air Voids

At the start-up of mixture production, use the first three isolated test results for production air voids before establishing a moving average of four. Calculate isolated production air voids using the maximum mixture specific gravity and the corresponding bulk specific gravity from that single test. After testing four samples and establishing a moving average of four, the Department will base acceptance on individual and moving average production air voids.

The Department will not accept the Material if any of the first three isolated test results for production air voids exceeds twice the JMF bands from the target listed on the Mixture Design Report at the start of production.

2360.3 CONSTRUCTION REQUIREMENTS

A Restrictions

A.1 Asphalt Release Agents

Do not use petroleum distillates to prevent adhesion of asphalt mixtures to Equipment. An asphalt release agent must meet the criteria for “Effect on Asphalt” as described in the most recent Asphalt Release Agent on file in MnDOT’s Office of Environmental Services.

A.2 Edge Drop Off

Protect traffic from drop-off conditions when traffic is carried during construction. Drop-off conditions are covered in the most current *Minnesota Temporary Traffic Control Field Manual*.

A.3 Surge and Storage Bins

Store the asphalt mixture for no more than 18 hours at storage facilities that prevent segregation of the mix and drainage of asphalt from the mix. Maintain the mixture at within 9°F of the temperature when discharged from the silo or mixer and prevent excessive cooling or overheating.

A.4 Weather Limitations and Paving Date

Do not perform Work within the Roadway in the spring until removal of seasonal load restrictions on roads in the vicinity unless otherwise approved by the Engineer.

Do not place asphalt mixtures when weather or Roadbed conditions or moisture conditions of the Roadway surface are judged unfavorable by the Engineer.

Do not place asphalt pavement final wearing course Lift after October 15 north of an east-west line between Browns Valley and Holyoke, or after November 1 south of an east-west line between Browns Valley and Holyoke.

The Engineer may waive these restrictions when any of the following apply:

(1) The Contractor is not placing asphalt mixture on the traveled portion of the Roadway
(2) The Roadway involved is closed to traffic during the following winter
(3) The Engineer provides written direction to place the mixture

A.5 Mixing and Discharge of Materials

Notify the Engineer of the recommended plant mixing temperatures as provided from the asphalt supplier. Unless authorized by the Engineer, do not produce the mixture more than 30°F above the recommended maximum mixing temperature. Use the automated plant control printout to monitor discharge temperature. The Department will not pay for or allow placement of any mixture produced at more than 30°F above the recommended maximum mixing temperature unless the higher mixing temperatures have been approved by the Engineer.

B Equipment

B.1 Plant

B.1.a Segregation

Provide plant mixed asphalt from a plant capable of producing a uniform mix free of segregation.

B.1.b Scales

Test and calibrate Scales in accordance with 1901, “Measurement of Quantities.”

B.1.c Mineral Filler

Add mineral filler to the mixture using a storage silo equipped with a device to ensure a constant and uniform feed.

B.1.d Storage Tanks

Provide storage tanks equipped to heat and maintain the Material at the temperatures recommended by the certified asphalt supplier. Place the discharge end of the circulating line below the surface of the asphalt Material. Provide agitation for modified asphalt as recommended by the supplier.

Provide an outage table or chart and measuring stick for each storage or working tank. Equip tanks with provisions to take asphalt binder Material samples. After delivery of asphalt binder Material to the Project, do not heat the Material at temperatures greater than 350°F. Do not store modified asphalt at temperatures greater than the manufacturer’s recommendation.

B.1.e Asphalt Binder Control

If proportioning asphalt binder Material by volume, equip the plant with either a working tank or a metering system to determine asphalt binder content of the mixture.

Provide a working tank with a capacity from 1,000 gallons to 2,000 gallons. Calibrate and supply the working tank with a calibrated measuring stick. The Contractor may connect the tank to a mixing unit and use it only during spot check operations as long as it is available at all times. Return feedback to the working tank during spot check operations.

Provide a metering system with at least one approved asphalt binder flow meter and an asphalt binder pump. Connect the flow meter to the asphalt binder supply to measure and display only the asphalt binder being fed to the mixer unit. Position the meter readout for convenient observation. Provide a means to compare the flow meter readout with the calculated output of the asphalt binder pump. Provide a system to display that shows the accumulated asphalt binder quantity being delivered to the mixer in gallons or to the nearest 0.001 ton. Calibrate and adjust the system to maintain an accuracy of ±1 percent error for each plant set-up before producing the mixture.

Provide an outage table or chart and measuring stick for each storage or working tank. Equip tanks with provisions to take asphalt binder Material samples. After delivery of asphalt binder Material to the Project, do not heat the Material at temperatures greater than 350°F. Do not store modified asphalt at temperatures greater than the manufacturer's recommendation.

B.1.e(1) Asphalt Binder Sampling Valve

Provide an asphalt binder sampling valve located between the pump and the drum. Sample asphalt binder from the weigh pod for batch plants.

B.1.f Dryer

The Department will not allow unburned fuel in the mix.

B.1.g Temperature Control

Equip the plant with enough temperature sensors to ensure temperature control of the Aggregate and asphalt binder.

B.1.h Pollution **.. 1717**

B.2 Street Equipment

B.2.a Paver

Provide a paver capable of spreading and finishing to widths as shown on the Plans and with an operational vibratory screed and automatic screed control to place mix without segregation.

Use an asphalt paver to place the mixture. When necessary, the Contractor may use a motor grader, when approved by the Engineer, to spread mixtures in areas that are inaccessible to a paver or when the quantity of mixture makes it impractical to place with a paver.

Use a shouldering machine to spread the mixture on Shoulder surfacing and uniform width widening, when the placement width is too narrow for a paver.

Using a screed or strike-off assembly, produce a finished surface of the required evenness and texture without tearing, shoving, or gouging. For mainline paving, if the paving width is greater than the basic screed, auger, and mainframe extensions, which meet manufacturer's recommendations for the paving width, are required unless otherwise directed by the Engineer. The Department will not allow strike-off only extension assemblies for mainline wearing course paving, unless the Engineer directs otherwise.

Equip all pavers with an approved automatic screed control. Sensor-operated devices need to include automatic controls that follow reference lines, or surfaces on one or both sides of the paver as required. Adjust the speed of the paver to produce the best results. A string line is only required if stated in the Contract.

Spread all mixtures without segregation to the cross-sections shown on the Plans (excluding tight blade and scratch course applications). The objective on the leveling Layer is to secure a smooth base of uniform grade and cross-section so that subsequent courses will be uniform in thickness. The Contractor may spread the leveling Layer with a properly equipped paver or, when approved by the Engineer, a motor grader equipped with a leveling device or with other means for controlling the surface elevation of the leveling Layer.

Place each course over the full width of the section under construction on each day's run, unless the Engineer directs otherwise.

B.2.b Trucks

Provide trucks with tight, clean, and smooth truck haul beds. Do not allow mixture to adhere to the truck beds. When directed by the Engineer, provide a cover that extends at least 1 foot over the truck bed sides and attach to tie-downs, if the truck is not equipped with a mechanical or automated covering system.

B.2.c Motor Graders

Use a motor grader with the following characteristics:

(1) Self-propelled
(2) Equipped with pneumatic tires with a tread depth of 1/2 inch or less
(3) Equipped with a moldboard blade that is at least 10 feet
(4) With a wheelbase of at least 15 feet

B.2.d Distributor

Provide a distributor capable of uniformly applying Material up to 15 feet wide and equipped with the following:

(1) An accurate volume measuring device with tachometer
(2) Pressure gauges
(3) Thermometer for measuring temperatures of tank contents
(4) Power-operated pump
(5) Full circulation spray bars with lateral and vertical adjustments

B.2.e Rollers

Compact each Lift of asphalt to the density require in 2360.3D, “Compaction.”

B.2.e(1) Steel Wheeled Rollers

Self-propelled steel wheeled compacting Equipment must weigh at least 8 tons. If using vibratory rollers, provide rollers that produce 3,085 lbf per foot of width and a vibratory frequency of at least 2,400 vpm using the low amplitude setting. Provide a roller capable of reversing without backlash and equipped with spray attachments for moistening rollers on both sets of wheels.

B.2.e(2) Pneumatic Tired Rollers

Self-propelled pneumatic tired compacting Equipment must have a compaction width of at least 5 feet and a gross wheel load force of at least 3,000 pounds per wheel for traffic level 2 and level 3 mixtures, 5,000 pounds per wheel for traffic level 4 and level 5 mixtures, and, if using vibratory, at least 8 tons total mass. Provide a roller with a tire arrangement that obtains full compaction over the full width with each pass of the roller.

B.2.e(3) Trench Rollers

Self-propelled trench rollers must weigh at least 2,960 pounds per foot of width.

B.3 Tack Coat

Apply a uniform asphalt tack coat to the clean and dry existing asphalt or concrete surface and to the surface of each course or Lift constructed, except for the final course or Lift, in accordance with 2357, “Bituminous Tack Coat.” Coat 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. Do not coat the longitudinal joint if a rubberized asphalt joint adhesive will be applied to the vertical face of the joint. A uniform application will not have streaks (corn rows), bare spots, puddles, or other irregular patterns. Allow emulsified asphalt tack coats to break, as indicated by a color change from brown to black, before placing subsequent Lifts. Take tack coat samples from the asphalt distributor according to rates provided in the *Schedule of Materials Control*. The Inspector will monitor the sampling the Contractor performs.

C Joints

C.1 Construction Joints

Compact joints to produce a neat, tightly bonded joint that meets surface tolerances as described in 2360.3E, “Surface Requirements.” Transverse and longitudinal joints are subject to the density requirement in accordance with 2360.3D, “Compaction.”

C.2 Transverse Joints

Construct a transverse joint, the full width of the paver, at right angles to the centerline when mixture placement operations are suspended. When Work resumes, cut the end vertically for the full depth of the Layer unless constructing a formed edge as approved by the Engineer.

C.3 Longitudinal Joint

Construct the longitudinal joint between strips and parallel to the pavement centerline. In multiple Lift construction, construct the longitudinal joints between strips in each Lift at least 6 inches measured transversely from the longitudinal joints in the previously placed Lift. If constructing a wearing course in an even number of strips, place one longitudinal joint on the centerline of the Road. When constructing a wearing course in an odd number of strips, locate the centerline of one strip on the centerline of the Road, provided that no joint is located in the wheel path area of a Traffic Lane. The Contractor will align longitudinal joints in multiple Lift construction over Portland cement concrete pavements directly over the concrete pavement longitudinal joints as approved by the Engineer.

At longitudinal joints formed by placing multiple strips, ensure the adjoining surface is higher but does not exceed 1/8 inch, after final compaction of the previously placed strip. When constructing a strip adjoining a previously placed strip or a concrete pavement, remove to the longitudinal joint line, any fresh mixture that overlaps a previously placed strip or pavement before rolling.

D Compaction

After spreading each course, compact in accordance with the Maximum Density method as described in 2360.3D.1, “Maximum Density,” unless the ordinary compaction method is called for in the Special Provisions or as described in 2360.3D.2, “Ordinary Compaction.” Do not allow rollers to stand on the uncompacted mixture or newly rolled pavement with a surface temperature greater than 140°F. Do not roll with steel-wheeled rollers if rolling produces Aggregate that is crushed, cracked, or pulverized or causes displacement of the mixture.

To maintain a true surface, correct the following by removing and replacing the Material in the defective areas as directed by the Engineer at no additional cost to the Department:

(1) Variations such as depressions or high areas, which may develop during rolling operations
(2) Lean, fat, or segregated areas

When spreading mixtures with a motor grader, compact the mixture with pneumatic tired rollers simultaneously with the spreading operation.

D.1 Maximum Density

Compact the pavement to at least the minimum required Maximum Density values in accordance with Table 2360.3-1 and Table 2360.3-2. Density evaluation will include compacted mat density and compacted longitudinal joint density. Density evaluation will not include longitudinal joint density on Lifts with a 1 percent reduced density requirement.

Table 2360.3-1
Required Minimum Lot Density (Mat)

	4 percent Design Voids*‖	3 percent Design Voids*‖	1 percent Reduced Density*	
			3 percent Design Voids	4 percent Design Voids
percent Gmm	92	93	92	91
* Reduce density required on the first Lift constructed over PCC pavements. ‖ Reduce density, when Maximum Density is waived, for the first Lift constructed on Aggregate base (mainline and Shoulder), reclaimed or cold in-place recycled base courses and first Lift of an overlay on Roadway with a spring load restriction no greater than 7 tons, including Shoulders.				

Table 2360.3-2
Longitudinal Joint Density Requirement

Location	Confined Edge of Mat*	Unconfined Edge of Mat ‖
Long joint (4 percent Design Voids)	91.0	89.5
Long joint (3 percent Design Voids)	92.0	90.5
* For the purpose of the Work specified in Table 2360.3-2 the Department defines “confined” as the edges of the placed mat abutting another mat, pavement surface, or curb and gutter. ‖ For the purpose of the Work specified in Table 2360.3-2 the Department defines “unconfined” or “unsupported” as no abutment on the side of the mat being placed with another mat or pavement surface.		

D.1.a Shoulders Greater Than 6 feet

Unless otherwise shown on the Plans or required by the Special Provisions, compact Shoulders wider than 6 feet paved using the maximum density method. When Shoulders are compacted by the Maximum Density method and are paved separately from the driving lane, or have a different required minimum density than the driving lane, delineate the lot tonnage placed on the Shoulder in separate lots from the driving lanes for the day paving was conducted.

D.1.b Shoulders Equal to or Less Than 6 feet

Unless otherwise shown on the Plans or required by the Special Provisions, use the ordinary compaction method in accordance with 2360.3D.2, “Ordinary Compaction,” to compact a narrow Shoulder no wider than 6 feet paved in the same pass as a driving lane or paved separately. The Department will exclude mixture compacted under ordinary compaction from lot density requirements and from Incentive or Disincentive payment.

When compacting a narrow Shoulder using the Maximum Density method, compact to densities in accordance with Table 2360.3-1. If the minimum required density of the Shoulder is different than the driving lane, delineate the tonnage placed on the Shoulder in separate lots from the driving lane.

D.1.c Echelon Paving

The Department considers echelon paving, two pavers running next to each other in adjacent lanes, as separate operations.

D.1.d Density Determination (Core Bulk Density)

Calculate each individual lot's Maximum Density by averaging the results of the cores within the lot expressed as the percentage of the maximum specific gravity. Use *Laboratory Manual* Method 1810 to determine core density unless the mixture is considered coarse graded. If 45 percent or less of the Aggregate Material passes the No. 4 Sieve the Engineer may require bulk specific gravity be determined in accordance with *Laboratory Manual* Method 1816.

Obtain the maximum specific gravity value for calculating the percentage density for the lot from the maximum gravity values taken from production tests during that day's paving. If the production tests during that day's paving result in only one or two maximum specific gravity values, use the moving average value at that test point. If production tests during that day's paving result in three or more maximum specific gravity values, use the average of those tests alone as indicated above.

D.1.e Timeline

Complete compaction within 8 hours of mixture placement and before obtaining core samples. Only use pneumatic tired or static steel rollers for compaction performed between 6 hours and 8 hours after mixture placement. Do not reroll compacted mixtures with deficient densities.

D.1.f Stop Production

If all the lots in a day's production or greater than 50 percent of the lots on multiple days fail to meet the minimum density requirement stop production and determine the source of the problem. Discuss with the Engineer what corrective action will be taken to bring the Work into compliance with specified minimum required density.

D.1.g Lot Determination

Table 2360.3-3
Lot Determination*

Daily Production, ton	Lots
300* – 600	1
601 – 1,000	2
1,001 – 1,600	3
1,601 – 2,600	4
2,601 – 4,600	5
> 4,600	Add one lot for each additional 900 tons or part thereof.
* If producing no greater than 300 tons of mix, establish the first lot when the total weight is greater than 300 tons.	

D.1.h Contractor Core Testing

Take and test cores at least 4 inches in diameter at locations determined and marked by the Engineer.

Mark samples with the lot number and core number or letter. Transport the cores to the laboratory daily taking care to prevent damage to them. Schedule the approximate time of testing during normal Project work hours to allow the Engineer to observe the test and to record the saturated surface dry and immersed weight of the cores.

Determine the density by the end of the next Working Day after compaction. Measure each core three times for thickness before saw cutting. Report the average Lift thickness on the core sheet. If placing multiple Layers in a single day, saw and separate cores for each Layer, test, and report by the end of the next Working Day. Place and compact mix into the coring hole to restore the surface within 24 hours after coring.

D.1.i Mat Density Cores

Obtain four cores in each lot. Take two cores from random locations as directed by the Engineer. Take the third and fourth cores, the companion cores, within one foot longitudinally from the first two cores. Submit the companion cores to the Engineer immediately after coring and sawing. If the random core location falls on a longitudinal joint, cut the core with the outer edge of the core barrel one foot away laterally from the edge of the top of the mat. Do not take cores for compacted mat density within one foot of any longitudinal joint. The Contractor is responsible for maintaining traffic, coring, patching the core holes within 24 hours, and sawing the cores to the paved Lift thickness before density testing.

The Engineer may require additional density lots to isolate areas affected by Equipment malfunction, heavy rain, or other factors affecting normal compaction operations.

D.1.j Companion Core Testing

The Department will select at least one of the two companion cores per lot to test for verification. For lots designated as longitudinal joint density lots, the Department will test at least one of the mat density companion cores and at least one of the longitudinal joint density companion cores.

D.1.k Tolerance Comparison

D.1.k(1) Tolerance Comparison – Individual

Compare the individual core bulk specific gravities obtained by the Contractor and by the Department. If the bulk specific gravity between the Contractor and the Department cores differ by more than 0.030, use the Department's bulk specific gravity.

D.1.k(2) Tolerance Comparison – Day's Shrinking Tolerance

For a second comparison of the cores that pass the individual tolerance criteria, compare the average of the Contractor's bulk specific gravities with the average of the Department's bulk specific gravities. Determine the tolerance by dividing 0.030 by the square root of the number of samples compared. Use all the Department's results for the day's paving if the cores do not fall within the determined tolerance.

D.1.l Recoring

The Engineer may allow the Contractor to recore a sample if the sample was damaged in the coring process or damaged in transit to the laboratory through no fault of the Contractor.

D.1.m Waiving Maximum Density (1 Percent Reduced Density)

The Contractor may elect to waive the Maximum Density requirement and reevaluate the density in accordance with 1 percent reduced density requirement, Table 2360.3-1. The Department will exclude Incentive payments for reduced Minimum Density in accordance with Table 2360.3-1. The Contractor must notify the Engineer, in writing, by the end of the third day of paving of their intent to waive Maximum Density. Once Maximum Density has been waived the reduced density will remain in effect for the duration of mixture placement on that Lift. For multi-year Projects, the waiving of

Maximum Density will be for that year only and will be reevaluated for subsequent years on an annual basis. The Contractor is required to comply with any construction requirements on subsequent Lifts. One percent reduced density is required for the first Lift constructed over PCC pavements.

D.1.n Longitudinal Joint Density

Evaluate longitudinal joint density on 1 lot per day unless the total daily weight is greater than 5,000 tons. If the total daily weight is greater than 5,000 tons, evaluate two lots per day. Randomly select the location to take cores for longitudinal joint density from the mat density core locations. Take six cores at this location. Take cores for longitudinal joint density with the outer edge of the core barrel within 6 inches from the edge of the top of the mat for both sides of the mat. Take a companion core 1 foot longitudinally from each core. Take two cores for mat density at either 2 feet right or 2 feet left of the center of the mat the Contractor is paving, regardless of random number generation.

D.1.o Imaginary Joint

An actual longitudinal joint will not exist if pulling the Shoulder and driving lane in the same paving pass. Do not cut a core on the imaginary line where a joint would have existed had the Shoulder and the drive lane been paved separately.

D.1.p Shoulders

D.1.p(1) Shoulder – Ordinary Compaction

If compacting the Shoulder under the ordinary density specification, do not take longitudinal joint cores in Shoulders. Core at the centerline longitudinal edge cores (6 inches from the joint) and at the mat density cores (2 feet right or left of the center of the paving pass).

D.1.p(2) Shoulder-Maximum Density Specification

Core at the following locations:

(1) Centerline longitudinal edge cores (6 inches from the joint)
(2) Mat density cores (2 feet right or left of the center of the paving pass)
(3) Edge of the Shoulder (6 inches from the outside edge)

Do not cut cores on the imaginary line at the edge of the Shoulder adjacent to the driving lane. Move coring locations on imaginary lines to 6 inches inside the edge of the Shoulder.

D.2 Ordinary Compaction

Perform ordinary compaction for the following:

(1) Layers identified in the typical sections with a minimum planned thickness less than 1 1/2 inch
(2) Thin Lift leveling
(3) Wedging Layers
(4) Patching Layers
(5) Driveways
(6) Areas the Contractor cannot compact with standard Highway construction Equipment and practices
(7) Bike paths, walking paths, and other similar non-traffic paving areas

If using the ordinary compaction method to evaluate density, use a control strip to establish a rolling pattern. Use the rolling pattern to compact the asphalt mixture for the Layer on which the control strip is constructed or until constructing a new control strip. The Engineer may waive the control strip requirement in small localized areas or other areas not conducive to its establishment.

D.2.a Control Strip

Construct a control strip at least 395 square yards and of the same thickness as the Lift the control strip represents at the beginning of the Work on each Lift of each course. Begin compacting immediately after spreading the mixture. Continue compacting until additional roller coverage does not produce appreciable increase in density. Determine densities by means of a portable nuclear testing device or approved alternate and create a growth curve to determine the optimum rolling pattern. Provide documentation of the growth curve to the Engineer. Roll the remainder of that course in accordance with the pattern developed in the test strip for that roller. Provide a new control strip in accordance with any of the following:

(1) If using a new JMF with a proportion change greater than 10 percent when compared to the currently produced mixture for a single stockpile Aggregate
(2) If changing the source of either Aggregate or binder
(3) After 10 days of production

D.2.b Equipment

Use rollers that meet the requirements in 2360.3B.2.e, “Rollers.” Use the same Equipment type and weight on the remainder of the pavement course that was used to construct the control strip. Provide at least two rollers. Provide a tandem steel wheeled roller for final rolling. The Contractor may use trench rollers or mechanical tampers to compact areas inaccessible to the conventional type rolling Equipment.

D.2.c Mixture Temperature

Refer to Table 2360.3-4 for the minimum laydown temperatures in all courses of the asphalt mixture as measured behind the paver or spreading machine. Do not pave when the air temperature is less than 32°F unless otherwise directed by the Engineer in writing.

Table 2360.3-4 *
Minimum Temperature Control

Air Temperature, °F	Compacted Mat Thickness †			
	1 inch	1 1/2 inches	2 inches	>3 inches
32 – 40	—	265 ‖	255	250
41 – 50	270 ‖	260	250	245
51 – 60	260 ‖	255	245	240
61 – 70	250 ‖	245	240	235
71 – 80	245	240	235	235
81 – 90	235	230	230	230
≥ 91	230	230	230	225

* Not applicable if using a Warm Mix Asphalt (WMA) additive or process that meets the requirements in 2360.2C.4, "Warm Mix Asphalt (WMA)."Based on the Lift thicknesses shown on the Plans.
‖ Use at least one pneumatic-tire roller for intermediate rolling unless otherwise directed by the Engineer. The Engineer may specify or modify the minimum laydown temperature in writing.
† Based on the Lift thicknesses shown on the Plans.

D.3 Mat Density Cores (Optional Department Only Core Testing)

The Contractor can request all density cores be tested by the Department. The written request should be made at the preconstruction meeting and a written response, from the Department, either approving or denying the request will be made within 5 Calendar Days from the date of the request. Once approval is granted, Department only core testing will remain in effect for the duration of the Project. For multi-year Projects, Department core testing will be for that year only. Cores will be tested in either the Department's field lab or in the Contractor's field lab. The Contractor is permitted to observe and record all weighing of the cores.

D.3.a Contractor Coring Responsibilities

Obtain 2 cores in each lot. Take cores of at least 4 inches in diameter at locations determined and marked by the Engineer. If the random core location falls on a longitudinal joint, cut the core with the outer edge of the core barrel 1 foot away laterally from the edge of the top of the mat. Do not take cores for compacted mat density within 1 foot of any longitudinal joint. Label samples with the lot number and core number or letter. The Contractor is responsible for maintaining traffic, coring, and patching the core holes.

Measure each core three times for thickness before saw cutting. Report the average Lift thickness to the Engineer. If placing multiple Layers in a single day, measure and record Lift thickness and then saw and separate cores for each Layer. Place and compact mix into the coring hole to restore the surface within 24 hours after coring.

The Engineer may require additional density lots to isolate areas affected by Equipment malfunction, heavy rain, or other factors affecting normal compaction operations.

D.3.b Department Testing Responsibilities

The Department will take possession of the cores after they have been measured and cut. The Department will test all cores. Density results will be determined by the end of the day in which the cores were cut provided they are in the Department's possession by 10:00 am, otherwise, results will be available the next Working Day. Test results will be reported on the Core Density Sheet.

D.3.c Longitudinal Joint Density

Evaluate longitudinal joint density in one lot per day unless the total daily weight is greater than 5,000 tons. If the total daily weight is greater than 5,000 tons, evaluate two lots per day. Randomly select the location to take cores for longitudinal joint density from the mat density core locations. Take three cores at this location. Take cores for longitudinal joint density with the outer edge of the core barrel within 6 inches from the edge of the top of the mat for both sides of the mat. Take one core for mat density at either two feet right or two feet left of the center of the mat the Contractor is paving, regardless of random number generation.

E Surface Requirements

After compaction, the finished surface of each Lift shall be reasonably free of segregated, open and torn sections, and shall be smooth and true to the grade and cross-section shown on the Plans with the following tolerances:

Table 2360.3-5
Surface Requirements

Course/Location	Description	Tolerance
Leveling/1st Lift using automatics	Tolerance also applies to 1st Lift placed other than leveling when automatics are used.	1/2 inch
Wear	Tolerance of final 2 Lifts from the edge of a 10 foot straightedge laid parallel to or at right angles to the centerline.	1/4 inch
Shoulder wear, temporary wear, & bypasses	Tolerance from the edge of a 10 foot straightedge laid parallel to or at right angles to the centerline.	1/4 inch
Transverse joints/construction joints	Tolerance from the edge of a 10 foot straightedge centered longitudinally across the transverse joint. Correction by diamond grinding required unless approved by the Engineer.	1/4 inch
20 foot pavement section excluded from Smoothness and ALR testing in Table 2401.3-3.	Tolerance from the edge of a 10 foot straightedge placed parallel to or at right angles to centerline.	1/4 inch
Transverse slope	Tolerance for surface of each Lift exclusive of final Shoulder wear.	Not to vary by more than 0.4 percent from Plans
Distance from edge of each Lift and established centerline	No less than the Plan distance or more than 3 inches greater than the Plan distance. The edge alignment of the wearing Lift on tangent sections and on curve sections of 3 degrees or less cannot deviate from the established alignment by more than 1 inch in any 25 foot section.	See Description
Final wear adjacent to concrete pavements	After compaction, the final Lift wear adjacent to concrete pavements must be slightly higher but not to exceed 1/4 inch higher than the concrete surface.	See Description
Final wear adjacent to fixed Structures	After compaction, the final Lift wear adjacent to gutters, manholes, pavement headers, or other fixed Structures must be slightly higher but not to exceed 1/4 inch higher than the surface of the Structure.	See Description
Finished surface of each Lift*	Must be free of segregated and open and torn sections and deleterious Material.	See Description
* Excluding tight blade and scratch courses.		

Cut or saw and then remove and replace Material placed outside the described limitations at no additional cost to the Department. The Department will consider any single occurrence of Material outside the limitations to have a minimum dimension of at least 1 square yard in any dimension.

E.1 Lift Thickness

After compaction, the thickness of each Lift shall be within a tolerance of 1/4 inch of the thickness shown on the Plans, except that, if automatic grade controls are used, this thickness requirement will not apply to the first Lift placed. This thickness requirement will not apply to a leveling Lift whether or not automatic grade controls are required. The Engineer may require removal and replacement of any part of any Lift that is constructed to less than the minimum required thickness, at no additional cost to the Department.

Measure cores taken for density determination for thickness also. Measure each core three times for thickness before sawing. Report the average of these three measurements. Document each lot's average core thickness and submit to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The Engineer will use the average of all core thickness measurements per day per Lift to determine daily compliance with thickness specifications.

On that portion of any Lift constructed to more than the maximum permissible thickness, the Materials used in the excess mixture above that required to construct that portion of the Lift to the Plan thickness plus 1/4 inch may be excluded from the pay quantities or at the discretion of the Engineer and at the Contractor's expense may be required to be removed and replaced.

F Asphalt Mixture Production (FOB Department Trucks)

Produce asphalt mixture for the Department. Load the mixture being produced onto Department furnished trucks at the mixing plant at a time agreed on by the Engineer and Contractor. The Engineer will notify the Contractor of the total quantity of mixture required not less than 2 weeks prior to completion of the final wearing course. The Engineer will not accept the asphalt mixture if it is unsuitable for the intended use.

G Small Quantity Paving

An MDR is not required for planned Project quantities less than 9,000 square yard inches (4,500 square yards per 2-inch thickness, etc.) or 500 tons. Verify in writing that the asphalt mixture delivered to the Project meets the requirements of Table 3139.2-3 and Table 2360.2-4. The Department will obtain samples, as determined by the Engineer, to verify mixture requirements and to perform Material acceptance in accordance with 2360.2G.14.b, “Isolated Failures at Mixture Start-Up — Production Air Voids,” 2360.5B.6, “Individual Failure — Percent Asphalt Binder, Production Air Voids, and Adj. AFT,” and 2360.5B.11, “Coarse and Fine Aggregate Crushing Failure.”

2360.4 METHOD OF MEASUREMENT

When paying for Material by weight, the Engineer will measure separately asphalt mixture of each type by weight based on the total quantity of Material hauled from the mixing plant. The Engineer will not make deductions for the asphalt Materials.

When paying for Material by area, the Engineer will separately measure asphalt mixture of each type and for each specific Lift by area and by thickness on the basis of actual final dimensions placed.

2360.5 BASIS OF PAYMENT

The Contract Unit Price for asphalt mixture used in each course includes the cost of constructing the asphalt surfacing and providing and incorporating asphalt binder, mineral filler, and hydrated lime. Anti-stripping additives may be permitted or required as indicated in 2360.2C, “Additives.”

The Department will pay for additives required by the Contract at the relevant Contract Unit Price for the mixture. The Department will pay for additives incorporated as directed by the Engineer as Extra Work in accordance with 1402, "Contract Revisions."

If the Plans do not show a Contract Pay Item for Shoulder surfacing and other special construction, the Department will include payment for the quantities of Material used for these purposes in the payment for the wearing course Materials.

Complete yield checks and monitor thickness determinations to construct the Work as shown on the Plans. Use the tolerances for Lift thickness in accordance with 2360.3E, "Surface Requirements" for occasional variations and not for continuous over-running or under-running, unless otherwise required by the Engineer.

The Contract Unit Price for asphalt mixture production includes the cost of the Material and loading onto Department-provided trucks at the mixing plant.

A Mixture Design and Mixture Adjustment Costs

A.1 Mixture Design Report

The Department may verify additional mix designs at a cost of $2,000 per design.

A.2 JMF Request for Adjustment

The Department may charge the Contractor $500 for each additional JMF adjustment requests.

B Monetary Adjustment

The Department must apply Incentives and Disincentives and may apply monetary deductions for Plant Mixed Asphalt Pavement. The amounts of these adjustments are deemed reasonable.

B.1 Coarse Aggregate Angularity

The Department may apply monetary deductions in accordance with Table 2360.5-1, for mixture placed and represented by results below the minimum requirement in accordance with Table 3139.2-3. The Engineer may calculate tonnage subjected to monetary deduction as the tons placed from the sample point of the failing test to the sampling point where the test result meets the Specifications.

B.2 Fine Aggregate Angularity

The Department may apply monetary deductions in accordance with Table 2360.5-1 for mixture placed and represented by results below the minimums in accordance with Table 3139.2-3. The Engineer may calculate tonnage subjected to monetary deductions as the tons placed from the sample point of the failing test to the sampling point where the test result meets the Specifications.

B.3 JMF Request for Adjustment for Proportion Change > 10 percent

If the mixture fails to meet the design requirements, the Department may either apply a monetary deduction or direct the Contractor to remove and replace.

B.4 Failing Materials

If the Contractor's testing data fails to meet the tolerances in accordance with Table 2360.2-6 the Engineer may substitute QA and verification data to determine the monetary deduction factor.

B.5 Isolated Failures at Mixture Start-up – Production Air Voids

The Department may apply monetary deductions for unacceptable Material in accordance with Table 2360.5-1. The Engineer may calculate the quantity of unacceptable

Material on the tonnage placed from the sample point of the failing test to the sample point when the isolated test result is back within twice the JMF bands. If the failure occurs at the first test after the start of production, the Engineer may calculate the tonnage subject to monetary deduction as described above, including the tonnage from the start of production.

If isolated air voids are less than 1.0 percent or greater than 7.0 percent, the Department may apply monetary deductions for the Material at 50 percent of the Contract Unit Price or order the Material removed and replaced at no additional cost to the Department. The Engineer may require the Contractor to test in-place mixture to better define the removal and replacement limits. The Engineer may require the Contractor to test in-place mixture placed before the failing test result

B.6 Individual Failure – Percent Asphalt Binder, Production Air Voids, and Adj. AFT

Table 2360.5-1
Monetary Deduction Schedule for Individual Test Results

Item	Monetary Deduction, percent *
Coarse and fine Aggregate crushing	10
Asphalt binder content	10
Production air voids, individual‖ and isolated†	20

* Apply the lowest monetary deduction factor when using multiple reductions on a single test.

‖ Calculate individual air voids using the moving average maximum specific gravity and the bulk specific gravity from that single test.

† Calculate the isolated air voids from the maximum specific gravity and the bulk specific gravity from that single test. The Engineer will only use isolated void test results for acceptance for the first three tests after mixture production start-up.

If the individual test result for adjusted AFT is less than 7.5 micrometer, the Department may either apply monetary deductions in accordance with Table 2360.5-2 or order the Material removed and replaced represented by the individual test. This tonnage includes all Material placed from the sample point of the failing test to the sample point when the test result meets Specification requirements. If the failure occurs at the first test after the start of daily production, the Engineer may include the tonnage from the start of production that day with the tonnage subject to monetary deduction or removal and replacement.

Table 2360.5-2
Monetary Deduction Schedule for Individual Test Results, Adjusted AFT

Individual Adjusted AFT, micrometer	Monetary Deduction, percent
≥ 7.5	0
7.4 – 7.0	10
6.9 – 6.1	25
≤ 6.0	Remove and replace at no expense to the Department.

The Department will not accept Material if the individual tests for percent asphalt binder content or production air voids exceeds twice the JMF bands from the target listed on the Mix Design Report. The Department may apply monetary deductions in accordance with Table 2360.5-1. The Department may calculate the Material subject to monetary deduction as the Material placed from the sample point of the failing test until the sample point when the test result is back within twice the JMF limits. If the failure occurs at the first test after the start of daily production, the Department may include tonnage from the start of production that day with the tonnage subjected to monetary deduction.

The Department will not accept Material if individual air voids are less than 1.0 percent or greater than 7.0 percent, Remove and replace unacceptable Material at no additional cost to the Department as directed by the Engineer. Test in-place mixture to better define the area to be removed and replaced as directed by the Engineer. Test mixture placed before the failing test result as directed by the Engineer. The Department may apply monetary deductions to reduce payment for unacceptable Material at 50 percent of the relevant Contract Unit Price.

B.7 Moving Average Failure at Mixture Start-Up — Production Air Voids

If a moving average failure occurs within any of the first three moving average results after mixture start-up (tests 4, 5, 6), the Engineer may accept the mixture if the individual air void corresponding to the moving average failure meets the JMF limits. The Department may not accept Material if the individual air void fails to meet the JMF limit. The Department may apply monetary deductions for unacceptable Material unless the Engineer determines that the isolated air void corresponding to the individual air void meets the JMF limit. The Department may apply a monetary deduction for unacceptable Material at 70 percent of the relevant Contract Unit Price. The Engineer will calculate the quantity of Material subject to monetary deductions as the tons placed from the sample point of the failing moving average result and corresponding individual air void beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit. If the failure occurs at the first test after the start of daily production, the Department will include tonnage from the start of production that day with the tonnage subjected to monetary deductions.

B.8 Moving Average Failure at Mixture Start-Up — Adj. AFT

The Engineer will calculate the moving average (n=4) Adj. AFT during the sixth test after the beginning of mixture production of that specific mixture. The Engineer will include the individual results of calculations for tests No. 3, No. 4, No. 5, and No. 6 with this calculation.

B.9 Moving Average Failure — Production Air Voids

A moving average production air void failure occurs when the individual production air void moving average of four exceeds the JMF limit. The Department may consider the mixture unacceptable and subject to monetary deductions. The Department may apply a monetary deduction for unacceptable mixture at 70 percent of the Contract Unit Price. The Engineer will calculate the quantity of mixture subject to monetary deduction as the tons placed from the sample point of all individual test results beyond the JMF limits, which contributed to the moving average value that exceeded the JMF limit, to the sampling point where the individual test result meets the JMF limits. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subject to monetary deductions.

Table 2360.5-3
Monetary Deductions Schedule for Moving Average Test Results

Item	Monetary Deduction, percent *
Gradation	10
Coarse and fine Aggregate crushing	Not Applicable (individual failures only)
Adjusted AFT	20
Asphalt binder content	20
Production air voids	30
* Lowest monetary deduction factor applies when there are multiple reductions on a single test.	

B.10 Moving Average Failure - Percent Asphalt Binder Content, Gradation, and Adj. AFT

The Engineer will consider the mixture unacceptable and subject to monetary deductions for mixture properties, including asphalt binder content and gradation, where the moving average of four exceeds the JMF limits. The Department may apply monetary deductions for unacceptable mixture properties in accordance with Table 2360.5-3. The Department may calculate the quantity of Material subject to replacement or monetary deductions as the tons placed from the sample point of all individual test results beyond the JMF limits, which contributed to the moving average value that exceeded the JMF limit, to the sampling point when the individual test result is back within the JMF limits. If the failure occurs at the first test after the start of daily production, the Department may include the tonnage from the start of production that day with the tonnage subjected to monetary deductions.

The Engineer will calculate the moving average (n=4) Adjusted AFT during the sixth test after the beginning of mixture production of that specific mixture. The Engineer will include the individual results of calculations for tests No. 3, No. 4, No. 5, and No. 6 with this calculation. The Department may consider Material with the moving average (n=4) of the Adjusted AFT is less than 8.0 micrometers as unsatisfactory and apply monetary deductions of 80 percent of the relevant Contract Unit Price. The Department may calculate the quantity of Material subject to replacement or monetary deductions as the tons placed from the sample point of all Individual Adjusted AFT results less than 8.0 micrometers, which contributed to the moving average value that was less than 8.0 micrometer, to the sample point where the Individual Adjusted AFT is at least 8.0 micrometer. If the failure occurs at the first test after the start of daily production, the Engineer will include the tonnage from the start of production that day with the tonnage subject to monetary deductions.

B.11 Coarse and Fine Aggregate Crushing Failure

If any CAA or FAA test results do not meet the requirements specified in Table 3139.2-3, the Department may apply monetary deductions for the placed Material in accordance with Table 2360.5-1. The Engineer will calculate the quantity of Material subject to monetary deductions as the tons placed from the sample point of the failing test until the sampling point where the test result meets the Specifications. If the failure occurs at the first test after the start of daily production, the Department will include the tonnage from the start of production that day with the tonnage subjected to monetary deductions.

B.12 Contractor Core Testing

The Department may apply monetary deductions of $100 per Working Day per lot until surface is restored.

B.13 Compaction – Maximum Density

B.13.a Incentive and Disincentive Schedule

Table 2360.5-4
Incentive and Disincentive Schedule for Maximum Mat Density

Density (4 percent Design Void), percent *	Density (3 percent Design Void), percent *	Mat Density Pay Factor A	
		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 93.6	≥ 94.6	1.03 ‖	1.05 ‖
93.1 – 93.5	94.1 – 94.5	1.02 ‖	1.04 ‖
92.0 – 93.0	93.0 – 94.0	1.00	1.00
91.0 – 91.9	92.0 – 92.9	0.98	0.98
90.5 – 90.9	91.5 – 91.9	0.95	0.95
90.0 – 90.4	91.0 – 91.4	0.91	0.91
89.5 – 89.9	90.5 – 90.9	0.85	0.85
89.0 – 89.4	90.0 – 90.4	0.70	0.70
< 89.0	< 90.0	†	†

* Calculate the percent of maximum specific gravity to the nearest tenth.

‖ Payment will only apply if the day's weighted average individual production air voids fall within – 1/2 percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2G.7, “Production Tests” for the corresponding day and weight by the tons the corresponding test represents.

† The Department will pay for the HMA Material represented by the lot at 70 percent of the relevant Contract Unit Price; unless a single core density in the lot is less than 87.0 percent of the maximum specific gravity (Gmm). If a single core density is less than 87.0 percent of Gmm, the Engineer will decide if the mixture is subject to removal and replacement or if a monetary deduction of 50 percent of the relevant Contract Unit Price will be applied. If the Engineer decides the Material is to be removed and replaced, the Contractor will do so at no additional cost to the Department. Take additional core samples to determine the limits of the removal and replacement area or 50 percent monetary deduction using the same offset from centerline as the original core. If the original low density core was taken within 1 1/2 feet of an edge of the paver pass, take the additional cores at 1 1/2 feet from the edge of the paver pass. Determine the densities at 50 foot intervals both ahead and behind the point of unacceptable core density until finding a point of acceptable core density (>89.0 percent for 4 percent void and 1 percent reduced voids and >90.0 percent for 3 percent voids). If the 50 foot incremental testing extends into a previously accepted lot, removal and replacement may be required, but, these results will not be used to recalculate the previously accepted lot density.

Perform the additional coring and testing at no cost to the Department. The Engineer will calculate the area of unacceptable pavement as the product of the longitudinal limits as determined by the 50 foot cores and the full width of the paver pass, laying in the Traffic Lane or Lanes. The Engineer will exempt Shoulders from this calculation unless density failure occurred in the Shoulder area.

Establish an additional density lot for the pavement that has been removed and replaced. Cut 2 cores randomly with companions for the Department (total 4 cores) and determine average density. Make payment in accordance with Table 2360.5-4 or Table 2360.5-5 excluding any Incentive payment.

Determine the density for the remainder of the lot by averaging the original acceptable core density value with the first two acceptable core densities taken ahead and behind the unacceptable core density. Make payment in accordance with Table 2360.5-4 or Table 2360.5-5 excluding any Incentive payment.

Table 2360.5-5
1 percent Reduced Table*

Density (4 percent Design Void), percent ‖	Density (3 percent Design Void), percent ‖	Payment, percent
≥ 91.0	≥ 92.0	100
90.0 – 90.9	91.0 – 91.9	98
89.7 – 89.9	90.5 – 90.9	95
89.4 – 89.6	90.0 – 90.4	91
89.2 – 89.3	89.5 – 89.9	85
89.0 – 89.1	89.0 – 89.4	70
< 89.0†	< 89.0	†

* The Contractor can elect to waive Maximum Density and evaluate with 1 percent reduced density for the first Lift constructed on Aggregate base (mainline and Shoulder), reclaimed or cold in-place recycled base courses and first Lift of an overlay on a Roadway with a spring load restriction (including Shoulders) no greater than 7 tons. Reduce the minimum by 1 percent on the first Lift constructed on PCC pavements (reduced density cannot be waived on PCC).

‖ Calculate the percent of maximum specific gravity to the nearest tenth.

† The Department may apply monetary deductions for the HMA Material represented by the lot at 70 percent of the relevant Contract Unit Price; unless a single core density in the lot is less than 87.0 percent of the maximum specific gravity (Gmm). If a single core density is less than 87.0 percent of Gmm, the Engineer will decide if the mixture is subject to removal and replacement or if will be accepted at a monetary adjustment of 50 percent of the relevant Contract Unit Price. If the Engineer decides the Material is to be removed and replaced, the Contractor will do so at no additional cost to the Department. Take additional core samples to determine the limits of the removal and replacement area or 50 percent monetary adjustment using the same offset from centerline as the original core. If the original low density core was taken within 1 1/2 feet of an edge of the paver pass, take the additional cores at 1 1/2 feet from the edge of the paver pass. Determine the densities at 50 foot intervals both ahead and behind the point of unacceptable core density until finding a point of acceptable core density (>89.0 percent for 4 percent void and 1 percent reduced voids and >90.0 percent for 3 percent voids). If the 50 foot incremental testing extends into a previously accepted lot, removal and replacement may be required, but, these results will not be used to recalculate the previously accepted lot density.

Perform the additional coring and testing at no cost to the Department.

The Engineer will calculate the area of unacceptable pavement as the product of the longitudinal limits as determined by the 50 foot cores and the full width of the paver pass, laying in the Traffic Lane or Lanes. The Engineer will exempt Shoulders from this calculation unless density failure occurred in the Shoulder area.

Establish an additional density lot for the pavement that has been removed and replaced. Cut 2 cores randomly with companions for the Department (total 4 cores) and determine average density. Make monetary adjustments in accordance with Table 2360.5-4 or Table 2360.5-5 excluding any Incentive payment.

Determine the density for the remainder of the lot by averaging the original acceptable core density value with the first two acceptable core densities taken ahead and behind the unacceptable core density. Make monetary adjustments in accordance with Table 2360.5-4 or Table 2360.5-5 excluding any Incentive payment.

Table 2360.5-6
Incentive and Disincentive Schedule for Longitudinal Joint Density, 4 percent Design Void*

Longitudinal Joint (Confined Edge) Density, percent ‖	Pay Factor B Longitudinal (Confined Edge)		Longitudinal Joint (Unsupported Edge) Density, percent ‖	Pay Factor C (Unsupported Edge)	
	Traffic Level 2 & 3	Traffic Level 4 & 5		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 92.1	1.02 †	1.03 †	≥ 91.0	1.02 †	1.03 †
91.6 – 92.0	1.01 †	1.02 †	90.1 – 90.9	1.01 †	1.02 †
89.5 – 91.5	1.00	1.00	88.1 – 90.0	1.00	1.00
88.5 – 89.4	0.98	0.98	87.0 – 88.0	0.98	0.98
87.7 – 88.4	0.95	0.95	86.0 – 86.9	0.95	0.95
87.0 – 87.6	0.91	0.91	85.0 – 85.9	0.91	0.91
< 87.0	0.85	0.85	< 85.0	0.85	0.85

* The Department will limit Incentive payment for longitudinal joint density to lots with evaluated longitudinal joint densities.

‖ Calculate the percent of maximum specific gravity to the nearest tenth.

† Payment will only apply if the day's weighted average individual production air voids fall within -1/2 percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2G.7, "Production Tests" for the corresponding day and weight by the tons the corresponding test represents.

Table 2360.5-7
Incentive and Disincentive Schedule for Longitudinal Joint Density, 3 percent Design Void*

Longitudinal Joint (Confined Edge) Density, percent ‖	Pay Factor B Longitudinal (Confined Edge)		Longitudinal Joint (Unsupported Edge) Density, percent ‖	Pay Factor C (Unsupported Edge)	
	Traffic Level 2 & 3	Traffic Level 4 & 5		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 93.1	1.02 †	1.03 †	≥ 92.0	1.02 †	1.03 †
92.6 – 93.0	1.01 †	1.02 †	91.1 – 91.9	1.01 †	1.02 †
90.5 – 92.5	1.00	1.00	89.1 – 91.0	1.00	1.00
89.5 – 90.4	0.98	0.98	88.0 – 89.0	0.98	0.98
88.7 – 89.4	0.95	0.95	87.0 – 87.9	0.95	0.95
88.0 – 88.6	0.91	0.91	86.0 – 86.9	0.91	0.91
< 88.0	0.85	0.85	< 86.0	0.70	0.85

* The Department will limit Incentive and Disincentive payment for longitudinal joint density to lots with evaluated longitudinal joint densities.
‖ Calculate the percent of maximum specific gravity to the nearest tenth.
† Payment will only apply if the day's weighted average individual production air voids fall within 1/2 percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2G.7, "Production Test" for the corresponding day and weight by the tons the corresponding test represents.

B.13.b Monetary Adjustment Factor Determination

Determine the Incentive and Disincentive factor in accordance with the following:

(1) Case 1: total pay factor = (pay factor A) × (pay factor B) × (pay factor C)
(2) Case 2: total pay factor = (pay factor A) × (pay factor B) × (pay factor B)
(3) Case 3: total pay factor = (pay factor A) × (pay factor C) × (pay factor C)

Where:

Pay factor A = mat density
Pay factor B = confined edge density
Pay factor C = unsupported edge density

Use a pay factor of 1.00 for pay factor B, pay factor C, or both in lots where no cores are taken at the longitudinal joint.

B.14 Mat Density Cores

The Department may apply monetary deduction of $100 per Working Day per lot until surface is restored.

B.15 Surface Requirements

The Department may apply monetary deduction of $1,500 for transverse joints/construction joints and 20 foot pavement section excluded from Smoothness and ALR testing for finished surface not meeting the tolerances in Table 2360.3-5.

If the Engineer determines the Material can remain in place outside the limits in Table 2360.3-5, the Department may pay for the Material at a monetary deduction of $10 per square yard.

B.16 Steel Slag

The Department may apply monetary adjustments if the mixture includes steel slag as one of the Aggregate proportions and the production lab density at the design gyrations at the recommended or established asphalt content is greater than 160 pounds per cubic foot. The Department may pay for the mixture at the Contract Unit Price, calculated as follows:

$$\%Payment = \frac{100 - (100 \times (production\_density\_at\_design\_gyrations - 160)}{160}$$

C Schedule

The Department will pay for plant mixed asphalt pavement on the basis of the following schedule:

Item No.	Item	Unit
2360.504	Type SP*‖ Course Mixture (†,‡) #	square yard
2360.509	Type SP* Bituminous Mixture for Specified Purpose	ton
2360.509	Type SP* Bituminous Mixture Production	ton
2360.509	Type SP* ‖ Course Mixture (†,‡)	ton

* Aggregate size designation: 9.5, 12.5, 19 or 4.75 as appropriate, see 2360.1B(3), “Mixture Designations.”
‖ “Wearing” or “Non Wearing” as appropriate.
† Traffic level in accordance with Table 2360.1-1.
‡ AC binder grade designation (Table 2360.1-2).
# Lift thickness shown on the Plans.

2363 PASSRC AND PASB

2363.1 DESCRIPTION

Permeable Asphalt Stabilized Stress Relief Course (PASSRC) is typically constructed on the in-place concrete or bituminous surface to act as a separation Layer and move water rapidly from beneath the unbonded concrete overlay.

Permeable Asphalt Stabilized Base (PASB) is typically constructed on a prepared base under a new concrete or bituminous surface to quickly drain surface infiltrated water accumulating under the pavement.

2363.2 MATERIALS

A Aggregate **3139.2B**

B Asphalt Binder **3151**

Use PG 64S-22

C Mixture Design

C.1 Sample Submittal

At least 15 Working Days prior to the beginning of mixture production, submit representative samples of Aggregate and the asphalt binder to perform the PASSRC or PASB mix design in District Materials Laboratory where the Project is located. Submit Aggregates that require magnesium sulfate soundness at least 30 Calendar Days prior to the start of asphalt production.

C.2 Aggregate

C.2.a Submittal

Submit to the District Materials Engineer a 100 pound sample of Aggregate retained on the No. 4 Sieve and 35 pounds of Aggregate passing the No. 4 Sieve. The Contractor will obtain and store an equal size sample until the Mixture Design Report (MDR) is issued.

C.2.b Intent to Sample

Provide the Department with 24 hour advance notification.

C.2.c Testing

Test for the quality of each source, class, type, and size of virgin and non-asphaltic salvage Aggregate source for the mix design.

C.3 Asphalt Binder

C.3.a Submittal

Submit four 1-quart samples of the same PG grade as required and also from the same supplier as production will come from.

C.4 Mixture

Provide the proposed job mix blend for each combination of Aggregates to be used in the mixture. Include the following information:

C.4.a Composite gradation

Based on the proportions of each Material, determine the composite gradation in percent of total Aggregates.

C.4.b Individual gradation

Determine the gradation for each individual component.

C.4.c Source

Document the Aggregate source, pit number, and a description of all Materials.

C.5 Mixture Design Report

The Engineer will issue a Mixture Design Report (MDR) when the mixture design is successfully completed. The MDR will include the job mix formula (JMF) requirements for gradation and asphalt cement content. Paving without an MDR is not allowed.

D Mixture Quality Management

D.1 Sampling and Testing

Production sampling and testing rates for start-up and production are shown in the *Schedule of Materials Control* (MCS). Take Aggregate quality samples as directed by the Engineer. Sample the following items in accordance with the MCS:

(1) Gradation
(2) Coarse Aggregate angularity
(3) Asphalt content (spot check)

D.2 Documentation

Include the following production test rests, and mixture on the Department approved Test Summary sheet.

(1) Gradation; Sieves listed in 3139.2B.2, “Gradation”
(2) Coarse Aggregate angularity
(3) Percent asphalt binder content (spot check)
(4) Aggregate proportions in use at the time of sampling
(5) Tons where sampled
(6) Cumulative tons
(7) Tons represented by test
(8) Signature line for Department and Contractor representative
(9) Department verification sample test result

D.3 JMF Limits

The mixture production targets and JMF limits, as shown in Table 2363.2-1, are listed on the MDR. Field results may deviate from the JMF target; however, JMF limits as show below are used as the Specification limits for acceptance.

Table 2363.2-1
JMF Limits

Item	JMF Limits
Gradation	Gradation Broadband
Asphalt Binder Content	-0.4 percent

2363.3 CONSTRUCTION REQUIREMENTS

A Handling and Placement

A.1 Mixing and Compaction Temperature

Use binder supplier recommended temperatures. Unless authorized by the Engineer, do not produce the mixture no more than 30°F above the recommended maximum mixing temperature. The Department will not pay for or allow placement of any mixture produced at more than 30°F above the recommended maximum mixing temperature.

A.2 Rutting of Existing Surface

Equipment used to deliver or place the mixture cannot rut the in-place Aggregate base (filter) Layer or Subgrade, or tear or displace the geotextile if used. Any ruts formed must be repaired and leveled to satisfaction of the Engineer, at no cost to the Department, prior to placing the mixture so that water draining through the mixture will not pond and create soft spots in the base/Subgrade.

B Surface Preparation

Remove loose or deteriorated surfacing and clean the surface by power sweeping and air blasting. Removal of deteriorated areas from joints, cracks, bituminous patched areas, etc. may require air blasting, the use of a small milling machine, or handwork as directed by the Engineer. Air blasting must be performed with at least 100 psi Equipment.

C Maintenance

The Contractor is responsible to maintain the integrity of the PASSRC or PASB until the concrete or bituminous pavement is placed on it. Any deficiencies in thickness, Smoothness, or density need to be corrected.

C.1 Contamination

Keep the PASSRC and PASB and associated drains free of soils or other contaminates. Contaminated Material shall be removed and replaced by the Contractor to the satisfaction of the Engineer at no cost to the Department.

C.2 Drainage

Maintain drainage so water is not allowed to pond in the PASSRC or PASB.

C.3 Construction Equipment

Concrete hauling units, either loaded or empty, are permitted on the PASSRC. Only the paver, rollers, and bituminous haul trucks are allowed to drive on the PASB. The bituminous haul trucks can only drive on the PASB immediately in front of the paver to unload, and then leave the PASB as soon as the bituminous is unloaded.

C.4 Density

PASSRC and PASB need to be dense and stable after construction so it will not rut when the overlying pavement is placed.

C.5 Damage

The Contractor will repair the PASB or PASSRC promptly by the Contractor, as directed by the Engineer, at no expense to the Department.

D Pavement Density

D.1 Method.. 2360.3D.2

D.2 Temperature

The Contractor is advised that it may be necessary to permit the permeable asphalt Layer to cool sufficiently before compaction rolling to prevent rutting and shoving. In no case will compaction be allowed at less than 110°F.

D.3 Water

Water may not be used to accelerate the cooling process.

D.4 Rollers

Self-propelled steel wheeled compacting Equipment must weigh at least 8 tons. Rollers must be steel wheeled both front and back and capable of reversing without backlash and equipped with spray attachments for moistening both rollers. Vibratory compaction will not be allowed. When the mixture placed exceeds 100 tons per hour, at least two rollers must be used.

Adequacy of compaction to provide stability will be judged by the Engineer. Over rolling, to the extent that Aggregate particles degrade, is not permitted.

E Verification Testing

Verification testing will be performed on the Quality Assurance samples for gradation and coarse Aggregate angularity. The Department will monitor 1 asphalt binder content spotcheck per day. Allowable differences (tolerances) between Contractor and Department test results are specified below in Table 2363.3-1. Substitute the Department results for acceptance when the tolerance is exceeded.

Table 2363.3-1
Allowable Differences between Contractor and Department Test Results

Item	Allowable Difference
Coarse Aggregate angularity, percent fractured faces (percent P)	15 percent
Gradation Sieve, percent passing No. 4 and larger	5 percent
Gradation Sieve, percent passing No. 30	3 percent
Gradation Sieve, percent passing No. 200	2 percent

F Thickness and Smoothness Requirements

F.1 Elevation

The finished surface of permeable asphalt Layer at any point of measurement must not vary be more than ±5/8 inch from the prescribed elevation for that point as determined from the grades staked by the Engineer and the cross-section in the Plan.

F.2 Thickness

Within ±1/4 inch of the compacted depth shown on the typical section in the Plan.

F.3 Deficient

The Contractor will correct any areas which are deficient by more than 1/4 inch by scarifying, adding mixture, compacting, shaping, and finishing in accordance with these Specifications, or directed by the Engineer.

F.4 Tolerances

Normal Specification tolerances apply for bituminous and concrete.

2363.4 METHOD OF MEASUREMENT

Measurement for PASB and PASSRC will be in accordance with the following.

Bituminous mixture and bituminous Material for mixture will be paid for separately.

Measurement will be made by the weight of bituminous mixture for the permeable asphalt Layer. Payment will be made at the Contract bid price per ton. Payment for the accepted bituminous mixture will be payment in full for all costs of constructing the permeable asphalt Layer, including the costs of mixture production, Aggregate incorporation, placement, and compaction. Cost for bituminous Material is specifically excluded. Measurement will be made by the weight of bituminous Material incorporated into the permeable asphalt Layer. Payment will be made at the Contract bid price per ton. Payment for bituminous Material, based on the acceptance of the permeable asphalt Layer, will be payment in full for bituminous Material, any additives, and the incorporation of the bituminous Material into the mixture.

2363.5 BASIS OF PAYMENT

Payment for the accepted quantity of permeable asphalt Layer at the Contract Unit Price of measure will be compensation in full for all costs of furnishing and applying all Materials required in this Specification. The Unit Price includes all labor, Materials, and Equipment necessary to complete the Work.

Payment for geotextile, when required for widening designs, is included in the 2363, "PASSRC and PASB," bid item.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for PASSRC and PASB. The amounts of these adjustments are deemed reasonable.

A.1 Failing Materials

The determination of monetary deductions for failing Materials will be based on the Specification limits outlined in Table 2363.5-1 as shown below for that specific test. Reduced payment as shown in the table below will be applied to all tonnage represented by the individual test results that do not meet the limits. The Contractor cannot continue to produce failing mixture. A continual basis is defined as all lots in a day's production failing to meet Specification requirements for gradation, crushing, or binder content, or more than 50 percent of the lots on two or more consecutive days which fail to meet Specification requirements for gradation, crushing, or binder content.

Table 2363.5-1
Reduced Payment Schedule

Item	Monetary Deduction, percent *
Gradation	5
Coarse Aggregate crushing	10
Asphalt binder content‖	10
* Apply the lowest monetary deduction when using multiple reductions on a single test. ‖ Not for asphalt content in excess of allowable tolerance provided there is no visual observation of asphalt drain down.	

B Schedule

The Department will pay for PASSRC and PASB on the basis of the following schedule:

Item No.	Item	Unit
2363.509	Bit Mix for Perm Asphalt Stabilized Stress Relief Crse	ton
2363.509	Bit Mix for Perm Asphalt Stabilized Base	ton
2363.509	Bit Material for Mixture	ton

2365 STONE MATRIX ASPHALT

2365.1 DESCRIPTION

This Work consists of constructing a stone matrix asphalt wearing course mixture (SMA) placed on a prepared surface in accordance with these Specifications.

Construct the SMA to the lines, grades, thicknesses, and typical cross-sections shown on the Plans or established by the Engineer.

Stone matrix asphalt mixture designation code: SMWEE640H.

2365.2 MATERIALS

A Aggregates

Use only virgin Aggregates.

A.1 Aggregate Requirements

Provide mineral Aggregate meeting the requirements of Table 2365.2-1 and Table 2365.2-2.

Table 2365.2-1
Stone Matrix Asphalt Aggregate Gradation Broad Bands
(percent passing of total washed gradation)

Sieve Size	percent Passing
3/4 inch	100
1/2 inch	86-96
3/8 inch	60-85
No. 4	25-35
No. 8	15-25
No. 200	8.0-12.0

Table 2365.2-2
Stone Matrix Asphalt Mixture Aggregate Requirements

Aggregate Blend Property	Requirements
Coarse Aggregate angularity (one face/two face), percent wear, *Laboratory Manual* Method 1214	100/90
Fine Aggregate Angularity	Use manufactured sand
Coarse Aggregate absorption, percent, *Laboratory Manual* Method 1204	< 2
Voids in coarse Aggregate (VCADRC), *Laboratory Manual* Method 1211 & *AASHTO T19, Standard Method for Bulk Density ("Unit Weight") and Voids in Aggregate*	$VCA_{mix}<VCA_{DRC}$
Flat and elongated particles, max percent by weight, *Laboratory Manual* Method 1208	10 (3:1 ratio)
Clay content (MnDOT 1215)	45
Total spall in fraction retained on the No. 4 Sieve, *Laboratory Manual* Method 1209	1.0
Maximum spall content in total sample, *Laboratory Manual* Method 1209	1.0
Maximum percent lumps in fraction retained on the No. 4 Sieve	0.5
Class B Carbonate restrictions: maximum percent -No. 4 Sieve	50
Class B Carbonate restrictions: maximum percent +No.4 Sieve	0

A.2 Los Angeles Ratter

The Los Angeles Rattler loss on the coarse Aggregate fraction Material retained on the No. 4 Sieve cannot exceed 35 percent for any individual source used within the mix (*Laboratory Manual* Method 1210).

A.3 Magnesium Sulfate loss on coarse aggregate fraction for each source 3139.2C.2

A.4 Mineral Filler ....*AASHTO M17*

B Additives

An additive is any Material added to an asphalt mixture or Material, such as mineral filler, asphalt additives, anti-strip, stabilizers, and similar products that do not have a specific Pay Item. When the Contract requires additives, compensation is included with the Pay Items for the appropriate mixture. If directed to incorporate additives, the compensation will be as Extra Work, at the Unit Price specified in the Proposal. No compensation will be made for additives incorporated at the Contractor's option.

Do not incorporate additives into the mixture without approval of the Engineer. Add anti-foaming agents to asphalt cement at the manufacturer's recommended dosage rate.

C SMA Asphalt Stabilizer .... *AASHTO 305*

Use a cellulose fiber asphalt stabilizer additive to control drain-down in the SMA mixture. Feed the stabilizing additive through a separate system that proportions the required amount of stabilizer in uniform distribution at a dosage rate within 0.2-0.4 percent by weight of the total mix. The system must have low-level and no-flow indicators and a printout of the feed rate in pounds/minute. Additionally, the stabilizer supply line must include a section of transparent pipe for observing consistency of flow or feed.

D Asphalt Binder Material 3151

Use PG 58V-28, meeting the requirements of *AASHTO MP 19-10,* "Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test."

E Mixture Design

E.1 General Design

Design the mixture in conformance with *AASHTO R 46-08*, "Standard Practice for Designing Stone Matrix Asphalt (SMA)." Additional information on SMA mix design is found in Appendix B of the National Asphalt Pavement Association quality information Series 122, *Designing and Constructing SMA Mixtures State-of-the-Practice*.

Use *Laboratory Manual* Method 1816 (Corelok) to determine mixture bulk specific gravity.

E.2 Aggregate

At least 15 Calendar Days before beginning production, submit to the District Materials Laboratory a minimum of 100 pounds for Aggregate quality testing.

At least 30 Calendar Days prior to production, submit to the District Materials Laboratory 100 pounds of each Aggregate that require magnesium sulfate soundness testing.

At least 7 Working Days prior to the start of asphalt production, submit a minimum of 150 pounds of the coarse Aggregate fraction from the selected design blend (JMF). This fraction will be tested for the voids in coarse Aggregate (VCAdrc) (*Laboratory Manual* Method 1211 & *AASHTO T19,* "Standard Method of Test for Buk Density ("Unit Wight") and Voids in Aggregate").

E.3 Mixture Sample

At least 7 Working Days before the start of asphalt production, submit the proposed job mix formula (JMF) in writing and signed by a Level II Quality Management Mix Designer for each combination of Aggregates to be used in the mixture. Include test data to demonstrate conformance to mixture properties as specified in Table 2365.2-1, Table 2365.2-2 and Table 2365.2-5. Use forms approved by the Department for the submission. Submit the design as a laboratory mix design (Option 1).

Submit an uncompacted mixture sample plus briquettes, in conformance with the JMF, compacted at the optimum asphalt content and required compactive effort for laboratory examination and evaluation. Provide a mixture sample size and the number of compacted briquettes and in accordance with the following:

Table 2365.2-3
Stone Mastic Asphalt Mixture Sample Requirements

Item	Gyratory Design
Uncompacted mixture sample size	75 pounds
Number of compacted briquettes	2
Coarse Aggregate fraction	150 pounds

F Mixture Moisture Sensitivity

F.1 Tensile Strength Ratio

At least 7 Working Days before actual production, submit sample to the District Materials Laboratory for verification of moisture sensitivity retained tensile strength ratio (TSR). The Engineer may test Material submitted for TSR verification for maximum specific gravity (Gmm) compliance in addition to TSR results. The Engineer will reject the submitted mix design if the tested Material fails to meet the Gmm tolerance. If the Engineer rejects a mix design, resubmit a new mix design as described above. The Contractor may use one of the following options to verify that the TSR meets the requirements in Table 2365.2-5.

F.1.a Option A

Batch Material at the design proportions including optimum asphalt. Split the sample before curing and allow samples to cool to room temperature, approximately 77°F. Submit 80 pounds of mixture to the District Materials Laboratory for curing and test verification. Use a cure time of 2 hours ±15 minutes at 290°F cure time for both groups and follow *Laboratory Manual* Method 1813 procedures.

F.1.b Option B

Batch and cure in accordance with Option A. Compact and submit briquettes and uncompacted mixture in accordance with Table 2365.2-4.

Table 2365.2-4
Option B Mixture Requirements

Item	Gyratory Design
Uncompacted mixture sample size	8,200 G
Number of compacted briquettes*	6
Compacted briquette air void content	5.5 – 6.5 percent
* 6-inch specimens.	

G Mixture Requirements

The Department will base initial mixture evaluation on the trial mix tests in accordance with Table 2365.2-5 and Table 2365.2-6.

Table 2365.2-5
Stone Matrix Asphalt Mixture Requirements

Item	Gyratory Design
Gyrations for Ndesign	75
Air Voids, % -- wear	4.0 percent
Fines/effective asphalt	1.2-2.0
Tensile strength ratio, min %	70
VMA, percent	17.0
VFA, percent -- wear	70-80
Draindown - based on a 1 hour reading at the anticipated production temperature	< 0.3 percent
Stabilizer by weight of total mix, percent	0.2 – 0.4
VCA ratio	$VCA_{MIX} < VCA_{DRC}$
Minimum asphalt requirement, percent by weight of mix	See Table 2365.2-6

G.1 Minimum Asphalt Content

Asphalt content is established based on the combined Aggregate bulk specific gravity, (Gsb). Use Table 2365.2-6 to determine the minimum asphalt content.

Table 2365.2-6
Stone Matrix Asphalt Minimum Asphalt Content

Combined Aggregate Bulk Specific Gravity	Minimum Asphalt Content, Percent
<2.400	6.8
2.401-2.450	6.7
2.451-2.500	6.6
2.501-2.550	6.5
2.551-2.600	6.3
2.601-2.650	6.2
2.651-2.700	6.1
2.701-2.750	6.0
2.751-2.800	5.9
2.801-2.850	5.8
2.851-2.900	5.7
2.901-2.950	5.6
2.951-3.000	5.5

G.2 Documentation

Include the following documentation and test results for each JMF submitted for review.

(1) Names of the individuals responsible for the QC of the mixture during production
(2) Low Project number of the Contract on which the mixture will be used
(3) The following temperature ranges as supplied by the asphalt binder supplier:

(a) Laboratory mixing and compaction
(b) Plant discharge
(c) Field compaction

(4) The percentage in units of 1 percent (except the No. 200 Sieve in units of 0.1 percent) of Aggregate passing each of the specified Sieves for each Aggregate to be incorporated into the mixture

(5) Source descriptions of the following:

(a) Location of Material
(b) Description of Materials
(c) Aggregate pit or quarry number
(d) Proportion amount of each Material in the mixture in percent of total Aggregate

(6) Composite gradation based on (4) and (5) above
(7) Bulk and apparent specific gravities and water absorption (by percent weight of dry Aggregate) of both coarse and fine Aggregate, for each product used in the mixture (including RAP/RAS). Use *Laboratory Manual* Method 1204 and 1205. The tolerance allowed between the Contractor's and the Department's specific gravities are Gsb (individual) = 0.040 (+4 and -4) and Gsb (combined) = 0.020
(8) Test results from the composite Aggregate blend at the proposed JMF proportions showing compliance with Table 2365.2-2:

(a) Coarse Aggregate angularity
(b) For the trial blend(s), determine the unit weight of Aggregates (pound/feet cubed), voids in the Coarse Aggregate-Dry Rodded Condition (VCADRC) according to *AASHTO T19*. The VCA ratio (VCAmix/VCADRC) shall be less than 1.0, i.e. VCAmix< VCADRC
(c) Flat and elongated determined at 3:1 ratio

(9) Asphalt binder percentage in units of 0.1 percent based on the total mass of the mixture and the PG grade
(10) Each trial mixture design includes the following:

(a) Use the selected design gradation, prepare mixes at the three binder contents in increments of 0.5 percent with at least one point above and one point below the optimum asphalt binder percentage
(b) Conduct draindown test (*AASHTO T305,* “Standard Method of Test for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures”) on loose mix
(c) Calculate the maximum specific gravity for each asphalt binder content based on the average of the effective specific gravities measured by using at least two maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt binder content
(d) Test results on at least two specimens at each asphalt binder content for the individual and average bulk specific gravities, density, and heights
(e) Percent air voids of the mixture at each asphalt binder content
(f) VMA for each asphalt binder content
(g) Fines to effective asphalt (F/A) ratio calculated to the nearest 0.1 percent
(h) Evidence that the completed mixture will conform to the specified VCA ratio of less than 1.0

(11) Percent and manufacturer’s data for type of stabilizer used

G.3 Mixture Design Report

The Department will issue an initial Mixture Design Report (MDR) consisting of the JMF after review of the submitted design. The review will include the Department’s test results submitted Aggregate and mixture. A preliminary MDR will provide the JMF limits to begin production of a test strip.

G.4 Initial SMA Test Strip Verification

Do not begin full-scale production of the SMA mixture until it is shown, in a test strip, that the mixture can be produced, placed, and compacted to the requirements of this Specification. Limit the test strip to 500 tons with a minimum requirement of 200 tons placed at the specified thickness and width indicated in the Contract. During construction of the test strip take a minimum of 2 mixture samples to determine mixture properties as shown in the Production Start-Up Testing Rate table shown above. Take 1 sample within the first 100 tons of mixture produced and the other randomly within the remaining mixture produced. After both samples are obtained cease production of the SMA until mixture properties are tested and evaluated by both the Contractor and the Department. Resume production when:

(1) The Contractor's and the Department's test results are within the allowable testing tolerances shown in Table 2365.2-7
(2) Each of the Contractor's test results are within the JMF limits as indicated on the Mixture Design Report
(3) The average of the two Contractor test results meets the requirements shown in the table for SMA mixture requirements
(4) The average of two cores from the Roadway meets the minimum density requirement as specified in this provision. One core shall be taken at random in the area representative of where the first mixture sample was obtained. The other core shall be taken at random in the area representative of the second mixture sample.

If the Material in the test strip does not meet the requirements listed above another test strip will be required. With the approval of the Engineer, the test strip may be placed within the Project limits. A final MDR will be issued once the test strip meets Specification requirements.

H Mixture Quality Management

H.1 Quality Control

Perform Quality Control (QC) as part of the production process. QC is the process control of the operations related to mixture production and determining the quality of the mixture being produced. The QC sample is the Contractor's sample taken and tested during production and used to control the production process. Provide and maintain a QC program for stone matrix asphalt pavement production, including mix design, process control inspection, sampling and testing, and adjustments in the process related to the production of the stone matrix asphalt pavement.

H.2 Plant Certification

Provide the following to obtain certification:

(1) Completed and submitted request form application for plant inspection
(2) Site map showing stockpile locations
(3) Signed asphalt plant inspection report showing the plant and testing facility passed as documented by *Asphalt Plant Inspection Report* (TP 02142-02, TP 02143-02). The inspection report must also include documentation showing plant and laboratory Equipment has been calibrated and is being maintained to the tolerance shown in the *Bituminous Manual* and sections 1200, 1800, and 2000 of the *Laboratory Manual*.
(4) A Department-signed Mixture Design Report (MDR) before mixture production

H.3 Quality Assurance

The Engineer will perform Quality Assurance (QA) as part of the acceptance process. QA is the process of monitoring and evaluating various aspects of the Contractor's testing as described below. The QA sample is the Department's companion sample to the Contractor's QC sample. QA testing is performed to accept the Work. The Engineer will perform the following:

(1) Conduct QA and verification sampling and testing
(2) Observe the QC sampling and tests
(3) Monitor the required QC summary sheets and control charts
(4) Verify calibration of QC laboratory testing Equipment
(5) Communicate Department test results to the Contractor's personnel on a daily basis
(6) Ensure Independent Assurance (IA) sampling and testing requirements are met

H.4 Verification Sample

The Department will take at least one random sample daily and call this the verification sample. The Department will provide the Contractor a verification companion, which is defined as a companion sample to the verification sample Department uses. Take all verification samples from the truck box at the plant site. Test and use this verification companion sample as part of the QC program. Use the verification companion sample to replace the next scheduled QC sample. The Department recommends sampling enough Material to accommodate retesting in case the samples fail.

Perform verification testing on at least one set of production tests daily to verify the requirements of Table 2365.2-1, Table 2365.2-2, and Table 2365.2-5. Compare the verification companion sample to the verification sample for compliance with allowable tolerances in Table 2365.2-7. The Department will consider the verification process complete if the Contractor's verification companion meets the tolerances in Table 2365.2-7.

If the tolerances between the Contractor's verification companion and the Department's verification sample do not meet the requirements of Table 2365.2-7, the Department will retest the Material. If the retests fail to meet tolerances, the Department will substitute the Department's verification test results for the Contractor's results in the QC program and use those results for acceptance.

Table 2365.2-7
Allowable Differences between Contractor and Department Test Results

Item	**Allowable Difference**
Mixture bulk specific gravity (Gmb)	0.030
Mixture maximum specific gravity (Gmm)	0.019
VMA	1.2
Coarse Aggregate angularity, percent fractured faces (percent P)	15
Asphalt binder content:	
Ignition oven percent	0.3
Gradation Sieve, percent passing:	
3/4 inch, 1/2 inch, 3/8 inch	6
No. 4	5
No. 8	4
No. 200	2.0

I Contractor Quality Control

Provide QC technicians certified as a Level I Bituminous Quality Management (QM) Tester meeting the requirements of the MnDOT Technical Certification Program for QC testing and Level II Bituminous QM Mix Designer to make process adjustments. Provide at least one person per paving operation certified as a Level II Bituminous Street Inspector.

Provide a laboratory with Equipment and supplies for Contractor Quality Control testing and maintain with the following:

(1) Up-to-date Equipment calibrations and a copy of the calibration records with each piece of Equipment
(2) Telephone
(3) Fax and copy machine; however, the Engineer may waive the requirement to have a fax machine if internet and email are available
(4) Internet and Email
(5) Computer
(6) Printer
(7) Microsoft Excel, version 2013 or newer

Laboratory Equipment needs to meet the requirements listed in Section 430.1 of the *Bituminous Manual*, *Laboratory Manual*, and these Specifications, including having extraction capabilities. Before beginning production, the laboratory Equipment needs to be calibrated and operational.

J Sampling and Testing

Take QC/QA samples from the truck box at the plant site. Sample randomly and in accordance with the *Schedule of Materials Control* and this provision. QC/QA samples are to be quartered from a larger sample of mixture. In order to account for asphalt absorption, the sample needs to be kept heated at the compaction temperature for 30 minutes before splitting and batching into test portions. The procedure for truck box sampling is on the Bituminous Office website. Store compacted QC mixture specimens and loose QC and Department's QA mixture companion samples for 10 Calendar Days. Label these split companion samples with companion numbers. Determine random numbers and locations using the *Bituminous Manual*, Section 720 or *ASTM D3665*, *Standard Practice for Random Sampling of Construction Materials*, Section 5.

K Start-Up and Production Test Rates

K.1 Start-Up Testing Rates

At the start of production, for the first 2,000 tons of mix, perform testing at the following frequencies:

Table 2365.2-8
Stone Matrix Asphalt Production Start-Up Testing Rates

Production Test	Testing Rates	Lab Manual Method & AASHTO number
Bulk specific gravity	1 test per 500 tons	1816 (Corelok) ‖
Maximum specific gravity	1 test per 500 tons	1807 ‖
Air voids (calculated)	1 test per 500 tons	1808 ‖
Asphalt content	1 test per 500 tons	1852 & 1853 ‖
VMA (calculated)	1 test per 500 tons	*AASHTO R46 & SP 2*
Gradation	1 test per 500 tons	1203 ‖
Fines to effective AC (calculation)	1 test per 500 tons	
Fine Aggregate angularity*		1206 ‖
Coarse Aggregate angularity	1 test per 1000 tons	1214 ‖
VCA ratio (calculation)	1 test per 500 tons	*AASHTO R46 & T19*
Draindown	1 test per 500 tons	*AASHTO T305*
* No FAA requirement, however, fine Aggregate shall be 100 percent crushed. ‖ *Laboratory Manual* Method		

K.2 Production Test Rates

After producing the first 2,000 tons of each mix type test at the following frequencies:

Table 2365.2-9
Stone Matrix Asphalt Production Testing Rates

Production Test	Sampling/Testing Rates	Lab Manual Method & AASHTO number
Bulk specific gravity	1 test per 1000 tons	1816 (Corelok) ‖
Maximum specific gravity	1 test per 1000 tons	1807 ‖
Air voids (calculated)	1 test per 1000 tons	1808 ‖
Asphalt content	1 test per 1000 tons	1852 & 1853 ‖
VMA (calculated)	1 test per 1000 tons	*AASHTO R46 & SP 2*
Gradation	1 test per 1000 tons	1203 ‖
Fines to effective AC (calculated)	1 test per 1000 tons	*AASHTO R46 & SP 2*
Coarse Aggregate angularity	2 tests/day for a minimum of 2 Working Days, then 1 per day if CAA is met. If CAA >8 percent of requirement, 1 sample/day but test 1/week.	1214 ‖
Fine Aggregate angularity (FAA)*		1206 ‖
TSR	As directed by the Engineer	1813 ‖
Aggregate SpG & absorption	As directed by the Engineer	1204, 1205 ‖
Mixture moisture content	As directed by Engineer	1855 ‖
Asphalt binder	Sample 1st load then 1 per 250,000 gallon -sample size 1 quart	5-693.920 ‖
Draindown	1 test per day	*AASHTO T305*
VCA ratio (calculated)	1 test per 1000 tons	*AASHTO R46*
* No FAA requirement, however, fine Aggregate shall be 100 percent crushed. ‖ *Laboratory Manual* Method		

L Documentation:

Maintain documentation, including test summary sheets and control charts, on an ongoing basis. File reports, records, and diaries developed during the Work as directed by the Engineer. These documents become the property of the Department.

Number test results in accordance with the MDR and record on forms approved and provided by the Department.

Include the following production test results and mixture information on the Department approved test summary sheet:

(1) Percent passing on all Sieves in accordance with Table 2365.2-1
(2) Coarse Aggregate crushing (1 & 2 face)
(3) Maximum specific gravity (Gmm)
(4) Bulk specific gravity (Gmb)
(5) Percent total asphalt binder content
(6) Calculated production air voids (Va)
(7) Aggregate proportions in use at the time of sampling
(8) Individual Aggregate Gsb (both minus No. 4 and combined)
(9) Tons where sampled
(10) Tons represented by a test and cumulative tons produced
(11) Signature line for Department and Contractor representative
(12) Mixture moisture content
(13) MnDOT verification sample test result
(14) VCA ratio
(15) Drain-down value in percent
(16) VMA
(17) Fines to effective asphalt ratio (F/E)
(18) Amount of stabilizer

Submit copies of failing test results to the Engineer on a daily basis.

Provide the Engineer with asphalt manifests or bill of ladings (BOL) on a daily basis.

Provide a daily plant diary, including a description of QC actions taken. Include changes or adjustments on the test summary sheets.

Provide an automated weigh Scale and computer generated weigh ticket. Ensure the ticket indicates the Project number, mix designation (including binder grade), mixture design report number, truck identification and tare, net mass, and date and time of loading.

Furnish an electronic printout (long form recordation) from an automated plant blending control system at 20 minute intervals when the plant is producing mixture. The Engineer may waive this requirement if the plant does not have the capability to produce the automated blending control information; however, the Contractor must then perform daily spotchecks to determine percent new asphalt added.

L.1 Drum Plant Requirements

Include the following information on the plant control printout for drum plants:

(1) Both the virgin and recycle belt feed rates (tons/hour)
(2) Feeder bin proportions (percent)
(3) Total percent asphalt cement in the mixture
(4) Virgin asphalt cement added (percent)

(5) Mixture temperature (°F)
(6) Mixture code
(7) Date and time stamp
(8) Current tons of mixture produced and daily cumulative tons of mixture produced at time of printout

Provide a daily electronic printout of the plant calibration (SPAN) numbers for each bin and meter.

M JMF Limits

Table 2365.2-10
Stone Matrix Asphalt JMF Limits (N=4)

Item	**JMF Limits**
Production air voids, percent	±1.0
Asphalt binder content, %	±0.4
VMA	-0.3
Sieve - percent Passing	
3/4 inch, 1/2 inch, 3/8 inch	± 4
No. 4, No. 8	± 3
No. 200	± 2.0

The mixture production targets and JMF limits are listed on the Mixture Design Report. JMF limits are used as the criteria for acceptance of Materials based on individual (single) test results. Gradation JMF limits are not allowed outside the broadband requirements in Table 2365.2-1

M.1 Moving Average Calculation

Calculate a moving average as the average of the last four test results. Continue the calculation without interruption, except begin new summary sheets and charts annually for winter carry-over Projects and if an asphalt plant is reset up in the same site after it has been moved out.

M.2 JMF Bands

JMF Bands are the area between the target, as identified on the Mixture Design Report, and the JMF limits.

N JMF Adjustment

Begin mixture production with Materials within 5 percent of the design proportions and other mixture parameters within the JMF limits in accordance with Table 2365.2-10 for gradation, asphalt content, and Aggregate proportions meeting the requirements of the reviewed Mixture Design Report. Use all Aggregate proportions meeting the requirements of the Mixture Design Report unless the Aggregate proportion is 0 percent.

O JMF Request for Adjustment

Make a request to the Bituminous Engineer or District Materials Engineer for a JMF adjustment to the mix design if the QC test results indicate a necessary change to achieve the specified properties. Do not use Aggregates or Materials not part of the original mix design to make adjustments unless otherwise approved by the Engineer, in conjunction with the District Materials Engineer or the Department Bituminous Engineer.

A Certified Level II Bituminous QM Mix Designer will review the requested change for the Department. If the request meets the design requirements in Table 2365.2-1, Table 2365.2-2, and Table 2365.2-5, the Department will issue a revised Mixture Design Report.

Use an interactive communication process with the Engineer before making JMF adjustments. Make JMF adjustments only within the mixture specification gradation design broadbands in accordance with Table 2365.2-1. Submit a new JMF if redesigning the mixture.

The Department will not allow consecutive requests for a JMF adjustment without production data.

P Failing Materials – Gradation, Coarse Aggregate Angularity, Air Voids, VMA, and Percent Asphalt Binder

Material acceptance is based on individual and moving average test results. Use isolated test results for acceptance of air voids and VMA at the start of mixture production. The Department will consider individual test results greater than two times the JMF bands as failing. The Department will fail moving average test results exceeding the JMF limits.

Stop production and make adjustments if the moving average values exceed the JMF limits. Restart production after performing the adjustments and notifying the Engineer. Resume testing at the accelerated rates and for the tests listed in Table 2365.2-8, for the next 2,000 tons of mixture produced. Continue calculating the moving average after the stop in production.

The Department will consider mixture produced where the moving average of four exceeds the JMF limits as unsatisfactory in accordance with 2365.2P.3, “Moving Average Failure at Mixture Start-Up – Production Air Voids,” 2365.2P.4, “Moving Average Failure at Mixture Start-Up — VMA,” 2365.2P.5, “Moving Average Failure - Production Air Voids,” and 2365.2P.6, “Moving Average Failure — Percent Asphalt Binder Content, VMA, and Gradation.”

P.1 Isolated Failures at Mixture Start-Up – Production Air Voids

At the start-up of mixture production, use the first three isolated test results for production air voids before establishing a moving average of four. Calculate isolated production air voids using the maximum mixture specific gravity and the corresponding bulk specific gravity from that single test. After testing four samples and establishing a moving average of four, the Department will base acceptance on individual and moving average production air voids.

The Department will not accept the Material if any of the first three isolated test results for production air voids exceeds twice the JMF bands from the target listed on the Mixture Design Report at the start of production.

P.2 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 individual test results for VMA will be used for acceptance. After four 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 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.

P.3 Moving Average Failure at Mixture Start-Up – Production Air Voids

If a moving average failure occurs within any of the first three moving average results after mixture start-up (tests four, five, and six), the Department will accept the mixture if the individual air void, corresponding to the moving average failure meets the JMF limits. The Department will not accept Material if the individual air void fails to meet the JMF limit. The Department may apply a monetary deductions for unacceptable Material unless the Engineer determines that the isolated air void corresponding to the individual air void meets the JMF limit.

P.4 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, and 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 a monetary deduction. If the mixture is to be removed and replaced, the Contractor will perform the Work at Contractor's expense.

P.5 Moving Average Failure – Production Air Voids

A moving average production air void failure occurs when the individual production air void moving average of four exceeds the JMF limit. The Department will consider the mixture unacceptable and subject to a monetary deduction.

P.6 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 will perform the Work at Contractor's expense.

P.7 Coarse Aggregate Crushing Failure

If any CAA test results do not meet the requirements specified in Table 2365.2-2, the Department may reduce payment for the placed Material in accordance with Table 2365.5-1.

2365.3 CONSTRUCTION REQUIREMENTS

A Restrictions

A.1 Asphalt Release Agents

Do not use petroleum distillates to prevent adhesion of asphalt mixtures to Equipment. An asphalt release agent must meet the criteria for "Effect on Asphalt" as described in the most recent Asphalt Release Agent on file in MnDOT's Office of Environmental Services. Drain excess release agents from truck boxes prior to loading.

A.2 Edge Drop Off

Protect traffic from drop-off conditions when traffic is carried during construction. Drop-off conditions are covered in the most current *Minnesota Temporary Traffic Control Field Manual*.

A.3 Surge and Storage Bins

Store the asphalt mixture for no more than 1 hour at storage facilities that prevent segregation of the mix and drainage of asphalt from the mix. Maintain the mixture at within 9°F of the temperature when discharged from the silo or mixer and prevent excessive cooling or overheating.

A.4 Weather Limitations and Paving Date

Do not perform Work within the Roadway in the spring until removal of seasonal load restrictions on roads in the vicinity unless otherwise approved by the Engineer.

Do not place SMA when weather or Roadbed conditions or moisture conditions of the Roadway surface are judged unfavorable by the Engineer.

Place SMA mixtures only when the ambient air temperatures are at least 50°F.

A.5 Mixing and Discharge of Materials

Notify the Engineer of the recommended mixing temperatures as provided from the asphalt supplier. Unless authorized by the Engineer, do not produce the mixture more than 30°F above the recommended maximum mixing temperature. Use the automated plant control printout to monitor discharge temperature. The Department will not pay for or allow placement of any mixture produced at more than 30°F above the recommended maximum mixing temperature unless authorized by the Engineer.

A.6 Asphalt Binder Sampling Valve

Obtain asphalt binder samples from a sampling valve located between the pump and the drum. Sample each type of asphalt binder used in mixture production after 50 tons of mixture has been produced, then sample at a rate of one per 250,000 gal. A minimum of 1 gallon of binder must be drawn and wasted from the sampling valve before the actual sample is drawn. Provide a 1-quart sized sample. The Inspector will monitor the sampling the Contractor performs. Record sample information on an Asphalt Sample Identification Card. Submit the sample to the Central Materials Laboratory. Contact the Chemical Laboratory Director for disposition of failing asphalt binder samples.

B Distributor 2360.3B.2.d

C Tack Coat

Apply a uniform asphalt tack coat to the clean and dry existing asphalt or concrete surface and to the surface of each course or Lift constructed, except for the final course or Lift, in accordance with 2357, "Bituminous Tack Coat." Coat 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. A uniform application will not have streaks (corn rows), bare spots, puddles, or other irregular patterns. Allow emulsified asphalt tack coats to break, as indicated by a color change from brown to black, before placing subsequent Lifts. Take tack coat samples from the asphalt distributor according to rates provided in the *Schedule of Materials Control*. The Inspector will monitor the sampling the Contractor performs.

D Rollers

D.1 Steel-Wheeled Rollers

Use self-propelled steel wheeled compacting Equipment weighing at least 8 tons.

D.2 Pneumatic Tired Rollers

Self-propelled pneumatic tired compacting Equipment is only allowed when approved by the Engineer.

E Compaction

After spreading each course, compact in accordance with the Maximum Density method as described below, unless the ordinary compaction method is otherwise specified in the Special Provisions. Do not allow rollers to stand on the uncompacted mixture or newly rolled pavement with a surface temperature greater than 140°F.

To maintain a true surface, correct the following by removing and replacing the Material in the defective areas as directed by the Engineer at no additional cost to the Department:

(1) Variations such as depressions or high areas, which may develop during rolling operations
(2) Lean, fat, or segregated areas

E.1 Maximum Density

Compact the pavement to at least the minimum required Maximum Density values in accordance with Table 2365.3-1.

Table 2365.3-1
Required Minimum SMA Lot Density

	All SMA Mixtures
percent Gmm	93.0

E.1.a Density Determination (Core Bulk Density)

Calculate each individual lot's Maximum Density by averaging the results of the cores within the lot expressed as the percentage of the maximum specific gravity. Use *Laboratory Manual* Method 1816, Corelok, to determine core density.

E.1.b Timeline

Complete compaction within 8 hours of mixture placement and before obtaining core samples. Only use pneumatic tired or static steel rollers for compaction performed between 6 hours and 8 hours after mixture placement. Do not reroll compacted mixtures with deficient densities.

E.1.c Stop Production

If all the lots in a day's production or greater than 50 percent of the lots on multiple days fail to meet the minimum density requirement stop production and determine the source of the problem. Discuss with the Engineer what corrective action will be taken to bring the Work into compliance with specified minimum required density.

E.1.d Lot Determination

Table 2365.3-2
Lot Determination

Daily Production, tons	Lots
300* – 600	1
601 – 1,000	2
1,001 – 1,600	3
1,601 – 2,600	4
2,601 – 4,600	5
> 4,600	‖

* If producing no greater than 300 tons of mix, establish the first lot when the total weight is greater than 300 tons.
‖ Add one lot for each additional 900 tons or part thereof.

E.1.e Mat Density Cores

Obtain four cores in each lot. Take two cores from random locations as directed by the Engineer. Take the third and fourth cores, the companion cores, within one foot longitudinally from the first two cores. Submit the companion cores to the Engineer immediately after coring and sawing. If the random core location falls on a longitudinal joint, cut the core with the outer edge of the core barrel one foot away laterally from the edge of the top of the mat. Do not take cores for compacted mat density within one foot of any longitudinal joint. The Contractor is responsible for maintaining traffic, coring, patching the core holes within 24 hours, and sawing the cores to the paved lift thickness before density testing.

The Engineer may require additional density lots to isolate areas affected by Equipment malfunction, heavy rain, or other factors affecting normal compaction operations.

E.1.f Contractor Core Testing

Take and test cores at least 4 inches in diameter at locations determined and marked by the Engineer.

Mark samples with the lot number and core number or letter. Transport the cores to the laboratory daily taking care to prevent damage to them. Schedule the approximate time of testing during normal Project Work Hours to allow the Engineer to observe the test and to record the Corelok testing of the cores.

Determine the density by the end of the next Working Day after compaction. Measure each core three times for thickness before saw cutting. Report the average Lift thickness on the core sheet. If placing multiple Layers in a single day, saw and separate cores for each Layer, test, and report by the end of the next Working Day. The Contractor is responsible for maintaining traffic, coring, patching the core holes within 24 hours, and sawing the cores to the paved Lift thickness before density testing.

E.1.g Companion Core Testing

The Department will select at least one of the two companion cores per lot to test for verification.

E.1.h Tolerance Comparison

E.1.h(1) Tolerance Comparison – Individual

Compare the individual core bulk specific gravities obtained by the Contractor and by the Department. If the bulk specific gravity between the Contractor and the Department cores differ by more than 0.030, use the Department's bulk specific gravity.

E.1.h(2) Tolerance Comparison – Day's Shrinking Tolerance

For a second comparison of the cores that pass the individual tolerance criteria, compare the average of the Contractor's bulk specific gravities with the average of the Department's bulk specific gravities. Determine the tolerance by dividing 0.030 by the square root of the number of samples compared. Use all the Department's results for the day's paving if the cores do not fall within the determined tolerance.

E.1.i Recoring

The Engineer may allow the Contractor to recore a sample if the sample was damaged in the coring process or damaged in transit to the laboratory through no fault of the Contractor.

F Surface Requirements

After compaction, the finished surface of each Lift shall be reasonably free of segregated, open and torn sections, and shall be smooth and true to the grade and cross-section shown on the Plans with the following tolerances:

Table 2365.3-3
Surface Requirements

Course/Location	Description	Tolerance
Wear	Tolerance of final 2 lifts from the edge of a 10 foot straightedge laid parallel to or at right angles to the centerline.	1/4 inch
Transverse joints/construction joints	Tolerance from the edge of a 10 foot straightedge centered longitudinally across the transverse joint. Correction by diamond grinding required unless approved by the Engineer.	1/4 inch
20 foot pavement section excluded from IRI and ALR testing in Table 2399.3-2	Tolerance from the edge of a 10 foot straightedge placed parallel to or at right angles to centerline. Does not include measurement at terminal header, Bridge deck, and approach panels. Corrective Work required unless approved by the Engineer.	1/4 inch
Transverse Slope	Tolerance for surface of each Lift exclusive of final Shoulder wear.	Not to vary by more than 0.4 percent from Plans
Distance from edge of each Lift and established centerline	No less than the Plan distance or more than 3 inches greater than the Plan distance. The edge alignment of the wearing Lift on tangent sections and on curve sections of 3 degrees or less cannot deviate from the established alignment by more than 1 inch in any 25 foot section.	See Description
Final wear adjacent to concrete pavements	After compaction the final Lift wear adjacent to concrete pavements must be slightly higher but not to exceed 1/4 inch than the concrete surface.	See Description
Final wear adjacent to fixed Structures	After compaction the final Lift wear adjacent to gutters, manholes, pavement headers, or other fixed Structures must be slightly higher but not to exceed 1/4 inch higher than the surface of the Structure.	See Description
Finished surface of each Lift	Must be free of segregated, open and torn sections and deleterious material.	See Description
Finished surface	No flushing or “fat” spots	See Description

Cut or saw and then remove and replace Material placed outside the described limitations at no additional cost to the Department.

F.1 Lift Thickness

After compaction, the thickness of the SMA will be within a tolerance of 1/4 inch of the thickness shown on the Plans. The Engineer may require removal and replacement of any part of any Lift that is constructed to less than the minimum required thickness, at no additional cost to the Department.

Measure cores taken for density determination for thickness also. Measure each core three times for thickness before sawing. Report the average of these three measurements. Document each lot's average core thickness and submit to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The Engineer will use the average of all core thickness measurements per day per Lift to determine daily compliance with thickness Specifications.

On that portion of any Lift constructed to more than the maximum permissible thickness, the Materials used in the excess mixture above that required to construct that portion of the Lift to the Plan thickness plus 1/4 inch may be excluded from the pay quantities or at the discretion of the Engineer and at the Contractor's expense may be required to be removed and replaced.

2365.4 METHOD OF MEASUREMENT

When paying for Material by weight, the Engineer will measure separately asphalt mixture of each type by weight based on the total quantity of Material hauled from the mixing plant. The Engineer will not make deductions for the asphalt Materials.

2365.5 BASIS OF PAYMENT

The Contract Unit Price for asphalt mixture used in each course includes the cost of constructing the asphalt surfacing and providing and incorporating asphalt binder, mineral filler, and asphalt stabilizer.

The Department will pay for additives required by the Contract at the relevant Contract Unit Price for the mixture. The Department will pay for additives incorporated as directed by the Engineer as Extra Work in accordance with 1402, “Contract Revisions.”

If the Plans do not show a Contract Pay Item for Shoulder surfacing and other special construction, the Department will include payment for the quantities of Material used for these purposes in the payment for the wearing course Materials.

Complete yield checks and monitor thickness determinations to construct the Work as shown on the Plans. Use the tolerances for Lift thickness in accordance with Table 2365.3-3 for occasional variations and not for continuous over-running or under-running, unless otherwise required by the Engineer.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Stone Matrix Asphalt. The amounts of these adjustments are deemed reasonable.

A.1 Isolated Failures at Mixture Start-Up – Production Air Voids

The Department may apply monetary deductions for unacceptable Material in accordance with Table 2365.5-1. The Engineer will calculate the quantity of unacceptable Material on the tonnage placed from the sample point of the failing test to the sample point when the isolated test result is back within twice the JMF bands. If the failure occurs at the first test after the start of production, the Engineer will calculate the tonnage subject to monetary deduction as described above, including the tonnage from the start of production.

If isolated air voids are less than 1.0 percent or greater than 7.0 percent, the Engineer will either calculate a monetary deduction or order the Material removed and replaced at no additional cost to the Department. The Engineer may require the Contractor to test in-place mixture to better define the removal and replacement limits. The Engineer may require the Contractor to test in-place mixture placed before the failing test result. If the Department applies a monetary deduction, the Department will pay for the Material at 50 percent of the Contract Unit Price.

A.2 Individual Failure – Gradation, Percent Asphalt Binder, Production Air Voids, and VMA

Table 2365.5-1
Payment Schedule for Individual Test Results

Item	Payment Factor, percent *
Gradation	95
VMA	85
Coarse Aggregate crushing	90
Asphalt binder content	90
Production air voids, individual‖ and isolated†	80

* Apply the lowest payment factor when using multiple reductions on a single test.
‖ Calculate individual air voids using the moving average maximum specific gravity and the bulk specific gravity from that single test.
† Calculate the isolated air voids from the maximum specific gravity and the bulk specific gravity from that single test. The Engineer will only use isolated void test results for acceptance for the first three tests after mixture production start-up.

A.3 Individual Failure at Mixture Start-Up – VMA

Monetary deductions as outlined in Table 2365.5-1 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 monetary deduction shall be calculated as described above and shall include the tonnage from the start of production.

A.4 Moving Average Failure at Mixture Start-Up – Production Air Voids

The Department may apply monetary deductions for unacceptable Material at 30 percent of the relevant Contract Unit Price. The Engineer will calculate the quantity of Material subject to monetary deduction as the tons placed from the sample point of the failing moving average result and corresponding individual air void beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit. If the failure occurs at the first test after the start of daily production, the Engineer will include tonnage from the start of production that day with the tonnage subjected to the monetary deduction.

A.5 Moving Average Failure at Mixture Start-Up – VMA

Monetary deduction will be 25 percent of the Contract bid price. Tonnage subjected to replacement or monetary deduction 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.

A.6 Moving Average Failure – Production Air Voids

The Department may apply monetary deductions for unacceptable mixture at 30 percent of the Contract Unit Price. The Engineer will calculate the quantity of mixture subject to monetary deduction as the tons placed from the sample point of all individual test results beyond the JMF limits, which contributed to the moving average value that exceeded the JMF limit, to the sampling point where the individual test result meets the JMF limits. If the failure occurs at the first test after the start of daily production, the Engineer will include the tonnage from the start of production that day with the tonnage subject to the monetary deduction.

Table 2365.5-2
Payment Schedule for Moving Average Test Results

Item	Monetary Deductions, percent *
Gradation	10
Coarse and fine Aggregate crushing	Not Applicable (individual failures only)
VMA	20
Asphalt binder content	20
Production air voids	30
* Lowest Pay Factor applies when there are multiple reductions on a single test.	

A.7 Moving Average Failure – Percent Asphalt Binder Content, VMA, and Gradation

Payment, percent of the Contract bid price, is shown in Table 2365.5-2. Tonnage subjected to replacement or monetary deduction is calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving average value that exceeded the JMF limit, to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to monetary deduction shall include the tonnage from the start of production that day.

A.8 Coarse Aggregate Crushing Failure

The Engineer will calculate the quantity of Material subject to monetary deduction as the tons placed from the sample point of the failing test until the sampling point where the test result meets the Specifications. If the failure occurs at the first test after the start of daily production, the Engineer will include the tonnage from the start of production that day with the tonnage subjected to the monetary deduction.

A.9 Mat Density Cores

The Department may apply monetary deduction of $100 per Working Day per lot until surface is restored.

A.10 Maximum Density

Determine Pay Factor for density in accordance with Table 2365.5-3.

Table 2365.5-3
Pay Factor Schedule for Maximum Density

Percent of Maximum Specific Gravity	Pay Factor, Percent
Above 97.0	98
93.0 – 97.0	100
91.0 – 92.9	98
89.0-90.9	95
Less than 89.0	remove and replace

A.11 Surface Requirements

If the Engineer determines the Material can remain in-place outside the limits, the Department will pay for the Material at a monetary deduction of $10 per square yard. The Department will consider any single occurrence of Material outside the limitations to have a minimum dimension of at least 1 square yard in any dimension.

B Schedule

The Department will pay for plant mixed SMA on the basis of the following schedule:

Item No.	Item	Unit
2365.509	Type SM 12.5 Wearing Course Mixture (6,H)	ton

2390 COLD-IN-PLACE RECYCLED AND COLD CENTRAL PLANT RECYCLING BITUMINOUS

2390.1 DESCRIPTION

This Work consists of the construction of Cold-in-place (CIR) and Cold central plant recycling (CCPR) Bituminous pavement on a prepared surface.

A General

See MnDOT Grading and Base website for forms and *Grading and Base Manual.*

Bituminous Material for mixture is the liquid bituminous Material added to Recycled asphalt pavement (RAP) to produce the CIR/CCPR mixture.

Cold in-place recycled (CIR) bituminous Layer is constructed by milling the existing bituminous which produces RAP. The RAP is mixed with a bituminous Material for mixture, placed and compacted to produce a CIR Layer. Additional additives, if required, such as rock or cement, are placed on the pavement prior to milling.

Cold central plant recycling (CCPR) bituminous is constructed by milling the existing bituminous or using previously milled HMA to produce RAP. The RAP is crushed, screened, mixed with a bituminous Material for mixture (and other additives if required), hauled to the placement destination, placed and compacted to produce a CCPR Layer.

B Design Parameters

A CIR/CCPR mix design is recommended to determine the method (foaming or emulsion), bituminous grade, and amount of additives needed to construct CIR/CCPR. The mix design criteria for CIR/CCPR is located in the *Grading and Base Manual*.

Design requirements are listed on Form *G&B-408*.

Contractor is required to meet the mix design.

2390.2 MATERIALS

A CIR/CCPR Mix Design Parameters .... **Form *G&B-408***

B Cement **3101**

C Aggregate for Surface an Base Course **3138**

D Bituminous Material for Mixture **3151**

E Bituminous Material for Fog Seal **3151**

F Water for Concrete and Mortar **3906**

2390.3 CONSTRUCTION REQUIREMENTS

A General

Correct and retest all failing areas.

Before beginning operations, remove vegetation and topsoil adjacent to the surface.

The gradation requirement for RAP is 97 - 100 percent passing the 1 1/4 inch Sieve and 99 - 100 percent passing the 1 1/2 inch Sieve.

Correct, at no additional cost to the Department, bumps and dips in the profile greater than 1 inch in 25 feet.

Do not allow rollers or other construction equipment to remain stationary on CIR/CCPR.

Do not permit traffic (including construction traffic) on the CIR/CCPR Layer for at least two hours after final rolling or emulsion breaks (if applicable), whatever is longer.

Repair structures damaged by Contractor operations, neglect, or negligence.

Provide water in order to obtain Optimum Moisture Content.

Atmospheric temperature and predicted weather requirements are determined by the Engineer.

CIR or place CCPR when:

(1) The atmospheric temperature is 50°F and rising when using emulsions or 60°F and rising when using foamed asphalt
(2) It is not foggy or rainy
(3) Freezing temperatures are not predicted within 48 hours after placement

Mill the existing pavement to the Plan depth and width.

Process paving fabric encountered during milling operations to less than 5 inches in any dimension.

Additional requirement for CCPR: Place material in even Lifts no greater than 4 inches in thickness.

B Equipment

For foamed asphalt applications, the Equipment must accurately foam bituminous Material, uniformly add specified water, and provide samples of the foamed bituminous Material through a sampling nozzle.

Additional requirement for CIR: Use self-propelled Equipment with the ability to mill, crush, screen, size, and mix the RAP along with the required recycling agents to produce a uniform homogeneous product.

Additional requirement for CCPR: Use Equipment with the ability to crush, screen, size, and mix the RAP along with the required recycling agents to produce a uniform homogeneous product.

B.1 Milling Unit

Use a self-propelled milling machine with a minimum 6 foot ski or multi point measuring device for milling control, equipped with automatic depth and cross-slope controls, and ability to maintain a constant cutting depth within ±1/4 inch of Plan depth in one pass.

B.2 Crushing/Sizing Unit

Use a crushing/sizing unit with the ability to crush and size RAP to the gradation requirement in 2390.3A, “General,” and equipped with a “closed loop” system that returns oversized Materials to the crusher.

B.3 Mixing Unit

Use a pug mill mixing unit with the ability to thoroughly mix the RAP while injecting the bituminous Material for mixture and automatically metering it to within 0.1 percent.

B.4 Single Train Crushing and Mixing Unit

In lieu of meeting the Equipment requirements of 2390.3B.1, “Milling Unit,” 2390.3B.2,”Crushing/Sizing Unit,” and 2390.3B.3, “Mixing Unit,” the Contractor may use a single milling, crushing, sizing, and mixing unit with the following characteristics:

(1) The mill must operate in a down-cut mode, with proven safety device(s), such as a down-pressure monitoring system to ensure the recycler stays in the cut
(2) The recycler must be able to crush and size all RAP to the gradation requirements of 2390.3A, “General”
(3) The recycler must be able to thoroughly mix RAP while injecting compaction water and bituminous Material for mixture and automatically meter the Material within 0.1 percent
(4) The recycler must have a visible speed display
(5) The recycler can either:

(a) Drop the cold mix on the ground, allowing the Material to be picked up by a Material transfer machine and placed into a paver
(b) Load Material on conveyors and place the recycling Material directly into a paving hopper

B.5 Vane Feeder

When cement is required for CIR, use a vane feeder capable of uniformly spreading the cement on the Road surface before recycling.

B.6 Paver

Use a paver equipped with a 20 foot ski meeting the requirements of 2360.3B.2.a, “Paver.”

B.7 Bituminous Material for Mixture Supply Tankers

If foaming is required, equip the tankers with a visible thermometer that measures the temperature of the liquid bituminous Material for mixture.

B.8 Rollers

B.8.a Steel Wheeled Rollers

Compact with a steel wheeled roller(s) meeting the requirements of 2360.3B.2.e(1), “Steel Wheeled Rollers” equipped with a water spray system.

B.8.b Pneumatic Tired Roller

Compact with a pneumatic tired roller(s) with a minimum weight of 25 tons meeting the requirements of 2360.3B.2.e(2), “Pneumatic Tired Rollers.”

C Bituminous Material for Mixture Parameters

Incorporate the bituminous Material for mixture at the rate designated on the mix design. However, after consultation with the Contractor, the Engineer may direct the Contractor to vary the application rate of bituminous Material for mixture compared to the mix design for areas of pulverized bituminous which the Engineer believes are either too rich or too dry.

Maintain bituminous Material for foaming within ± 10°F of the optimum temperature recommended by the mix design (note that bituminous must also meet expansion ratio and half-life foaming tests). If the mix design does not provide a recommendation, maintain the foamed asphalt temperature between 305°F and 325°F.

D Cement Control

For CIR, spread cement using a computerized vane feeder in a manner that minimizes dusting, i.e. do not spread when the wind is strong enough to coat vehicles and/or the environment.

For CIR and CCPR, control the cement content to within ± 0.5 pounds/square yard, of the design target.

For CIR, start mixing operations, no longer than 1/2 hour after cement placement on Roadway.

For CCPR, place and compact, no longer than 2 hour after cement incorporation.

E Mixing

Mix the crushed RAP, bituminous Material for mixture, and cement into a homogenous mixture. Adjust the water application rate based on mixture consistency, coating, and dispersion of the recycled Materials.

F Placement

Do not heat the paver screed. Spread the CIR Material in one continuous pass to the Plan width in one Lift. Ensure that the mix does not segregate. Pave before emulsion breaks.

G Compaction

G.1 General

Correct, at no additional cost to the Department, bumps and dips in the profile greater than 1 inch in 25 feet.

Do not allow rollers or other construction Equipment to remain stationary on CIR/CCPR.

Do not permit traffic (including construction traffic) on the CIR/CCPR Layer for at least two hours after final rolling or emulsion breaks (if applicable), whatever is longer.

Use visual observations of check cracking and shoving to prevent over-rolling.

Compact using the criteria in 2390.3G.2, “Control Strip.”

Within 48 hours of CIR/CCPR, recompact areas represented by density measurements below 98 percent of the target density determined from the control strip, roll until ≥98 percent density is achieved. Do not over-roll to the point where checking of the surface occurs. Some areas may not achieve 98 percent density due to field conditions.

G.2 Control Strip

Comply with 2215.3F.7, “Control Strip,” except establish a new rolling pattern by performing a new control strip when 98 percent of target density is not achieved on two consecutive QC readings. If using 2390.3B.4, “Single Train Crushing and Mixing Unit,” note speed during the control strip and do not subsequently exceed that speed during further operations.

H Contractor Quality Control (QC)

Perform Contractor QC testing and submit required forms, required in the *Schedule of Materials Control*. Submit results to the Engineer electronically within 24 hours of the completion of the tests.

I Department Quality Assurance (QA)

Test according to the *Schedule of Materials Control*.

J Profile, Curing and Surface Requirements

Maintain the CIR layer in a smooth, compacted condition free of ruts, distortions, potholes, loose Aggregate, and to the profile and cross-section until the placement of the bituminous.

Remove loose Aggregate on the surface immediately before placing the bituminous.

Repair ruts, potholes, washboarding, and other distortions.

K Fog Seal and Bituminous Requirements

If requested by the Engineer, apply a CSS-1h bituminous fog seal per 2355, “Bituminous Fog Seal” at a rate of 0.08 – 0.16 gallons per square yard.

L Bituminous Requirements

Place the bituminous:

(1) No sooner than three Calendar Days and no later than 14 Calendar Days after the CIR/CCPR, at any location, has been injected and compacted (note that the 14 Calendar Day requirement may be extended with concurrence of the Engineer, if large rainfall events hinder the curing of the CIR)
(2) When the CIR/CCPR surface does not deflect under construction Equipment and meets Quality Compaction per 2106.3G.2, “Quality Compaction”
(3) When the CIR/CCPR is capable of meeting the required strength to place and compact the next Layer, and the moisture content of the CIR/CCPR does not cause a failure to the next Material placement
(4) When the moisture content of the CIR/CCPR is low enough to not migrate into and damage the new surface

2390.4 METHOD OF MEASUREMENT

Measure the CIR/CCPR Layer by the square yard.

Measure the cement in accordance with 2215, “Reclamation.”

Measure the Aggregate in accordance with 2215, “Reclamation.”

Measure the bituminous Material for mixture in accordance with 2215, “Reclamation.”

Measure the bituminous Material for fog seal in accordance with 2355, “Bituminous Fog Seal.”

2390.5 BASIS OF PAYMENT

The Department will pay for the correction of in-situ areas that are unstable through no fault of the Contractor’s operations, if directed by the Engineer, as Extra Work in accordance with 1402, “Contract Revisions.”

The Department will pay for cement in accordance with 2215, “Reclamation.”

The Department will pay for Aggregate in accordance with 2215, “Reclamation.”

The Department will pay for bituminous Material for mixture in accordance with 2215, “Reclamation.”

The Department will pay for bituminous Material for fog seal in accordance with 2355, “Bituminous Fog Seal.”

The Contract Unit Price for the CIR/CCPR includes the cost of milling, production, testing, placement, occasional variations in bituminous pavement thickness, compacting, removing vegetation and topsoil adjacent to the surface, water, and required and necessary maintenance including cleaning the surface.

The Department will pay for CIR/CCPR Layer on the basis of the following schedule:

Item No.	Item	Unit
2390.504	Cold-In-Place Recycled/Cold Central Plant Recycling Bituminous	square yard

2399 PAVEMENT SURFACE SMOOTHNESS

2399.1 DESCRIPTION

This Work consists of measuring the final concrete or bituminous surface for Smoothness and potential Areas of Localized Roughness (ALR).

A Definitions

For the purpose of the Work specified in section 2399, "Pavement Surface Smoothness," the Department defines:

Corrective Work
Any pavement fix – including diamond grinding, milling and inlaying, and overlaying – that is required by the Department when the quality of a new pavement surface fails to meet acceptable Smoothness or ALR thresholds.

2399.2 MATERIALS REQUIREMENTS

A Inertial Profiler (IP)

Provide a Department certified, calibrated, and documented IP meeting the requirements of *ASTM E950/E950M, Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference*, Class 1 and procedures maintained by the MnDOT Pavement Engineering Section. Refer to the procedures maintained by the MnDOT Pavement Engineering Section or to the MnDOT Smoothness website for the required settings for individual certified IPs.

Provide an IP capable of exporting raw profile data in an unfiltered electronic Pavement Profile File (PPF) format. Produce PPF filenames in the YYMMDD-T-N-D-L-B-E.PPF standardized format in accordance with Table 2399.2-1:

Table 2399.2-1
Standardized Naming Convention for PPF Files

Abbreviation	Definition
YY	Two-digit year
MM	Month (include leading zeros)
DD	Day of month (include leading zeros)
T	Route type (I, MN, US, CSAH, etc.)
N	Route number (no leading zeros) and auxiliary ID (if applicable)
D	Primary route direction (I or D)
L	Lane number (1 for driving lane, increasing by one for each lane to the left; 0 for other lanes such as acceleration/deceleration lanes, Ramps, Loops)
B	Beginning station
E	End station

B Profile Analysis Software

Use ProVAL software to conduct a profile analysis to determine Smoothness and ALR. Report MRI values in units of inches per mile to one digit right of the decimal in accordance with conventional rounding procedures.

C Operator Certification

Provide an operator, trained in the operation of the particular IP in accordance with 2399.2A, “Inertial Profiler (IP),” and knowledgeable in the use of the required profile analysis software in accordance with 2399.2B, “Profile Analysis Software.” Ensure profiler operators pass a proficiency test and possess a current certification issued by the Department. The Contractor may access a list of certified operators on the MnDOT Smoothness website. Provide documentation of operator certification to the Engineer.

D Submittals

D.1 Before Profiling

Provide the Engineer with current, valid documentation, issued by the Department, indicating both the IP and the operator certification.

D.2 Day of Profiling

Submit a printout containing the IP’s settings, each segment’s left and right wheel path International Roughness Index (IRI) values, and the signature of the operator to the Engineer on the same day of the profiling.

Submit electronic files in PPF format representing the raw profile data from each pass on the same day of the profiling.

Submit electronic data files in Keyhole Markup Language (KML) format representing the geographic location data from each pass on the same day of the profiling.

If the Contractor fails to submit actual data to the Engineer on the day of profiling, the Department will require the Contractor to reprofile the measured segments.

D.3 Upon Completion of Pavement Placement

Within 5 Calendar Days of the placement of all mainline pavement and before beginning Corrective Work, submit a paper ProVAL summary report for each lane, indicating the results of the “Smoothness Assurance” analyses. Use the PPF filenames in accordance with 2399.2A, “Inertial Profiler (IP)” to create ProVAL summary reports.

If the summary reports indicate no ALR, or 0.1 mile Corrective Work segments, submit a final *Profile Summary* worksheet in accordance with 2399.2D.5, “After Corrective Work.”

D.4 Before Corrective Work

If the summary reports indicate any ALR, submit a written Corrective Work Plan to the Engineer in accordance with 2399.3E, “Corrective Work.” Include the beginning and ending points of the locations planned for correction in the Corrective Work Plan. Do not begin Corrective Work before the Engineer approves the Plan.

If the Department applies a monetary deduction for ALR in accordance with Table 2399.5-4 instead of requiring Corrective Work, submit a final *Profile Summary* worksheet in accordance with 2399.2D.5, “After Corrective Work.”

D.5 After Corrective Work

After reprofiling, submit a paper summary ProVAL report for each lane, indicating the results of updated “Smoothness Assurance” analyses to the Engineer. Submit the appropriate

MnDOT *Profile Summary* worksheet available on the Department Smoothness website. The worksheet should match the type of construction and the letting year of the Project.

2399.3 CONSTRUCTION REQUIREMENTS

Using an IP, measure the final pavement surface for MRI unless otherwise excluded in Table 2399.3-2.

Unless otherwise approved by the Engineer, perform profiling in the presence of the Engineer. Schedule profiling with the Engineer. Reprofile any pavement profiled in the absence of the Engineer as directed by the Engineer at no additional cost to the Department.

The Engineer will use a 10 foot straightedge to evaluate areas excluded from surface testing with the IP in accordance with Table 2399.3-2.

A Pavement Surface Testing

Remove objects and foreign Material from the pavement surface before performing the pavement surface evaluation. Provide traffic control required for testing and performing Corrective Work on the final pavement surface.

Run the IP in the direction of traffic. Measure profiles in the left and right wheel paths of each lane.

Test and evaluate each lane separately. The Engineer will determine the length in miles of each mainline Traffic Lane. Operate the IP at the optimum speed as recommended by the manufacturer.

Separate each lane into segments 0.1 miles in length. Evaluate the remainder segment less than 0.1 miles in each lane as an independent segment. The Engineer will prorate Incentive/Disincentive for length.

Make each pass continuously, regardless of length, and end passes before exclusions in accordance with Table 2399.3-2.

For percent improvement Projects, measure Smoothness before the beginning of construction and after the completion of construction. Use the same stationing for the final profiling as the stationing used for the initial profiling to allow for a direct comparison of Smoothness when calculating the percent improvement. Measure the Smoothness Before Paving and the Smoothness After Paving values with the same IP.

The Engineer will use a 10 foot straightedge to measure for surface deviations in accordance with 2301, “Concrete Pavement,” and 2360, “Plant Mixed Asphalt Pavement.”

B Exclusions

Table 2399.3-1 indicates areas that are excluded from Smoothness evaluation, but still require measurement with an IP, and are subject to evaluation for ALR and the 10 foot straightedge.

Table 2399.3-2 indicates areas that are excluded from surface testing with the IP, but are subject to evaluation with the 10 foot straightedge.

Table 2399.3-1
Areas Excluded from Smoothness Evaluation

Pavement	Excluded Areas
Bituminous or concrete	Paving in areas with a posted vehicle speed less than or equal to 45 mph
	Ramps, Loops
	Acceleration and deceleration lanes less than 1,000 feet in length
	Physically isolated segments less than 1,000 feet in length
	Projects less than 1,000 feet in length
Bituminous	Single Lift overlays placed directly on concrete
Concrete	Intersections constructed under traffic – begin and end exclusion 100 feet from the Intersection radius
	Doweled Shoulders greater than or equal to 10 feet in width

Table 2399.3-2
Areas Excluded from Smoothness and ALR Evaluation

Pavement	Excluded Areas
Bituminous or concrete	Paving in areas with a posted vehicle speed less than or equal to 35 mph
	Paving in areas with a cautionary vehicle speed less than or equal to 35 mph
	Turn Lanes, crossovers
	20 feet on either side of obstructions in lane that obstruction is located
	Side Streets, side connections
	150 feet before stop signs at an Intersection
	150 feet before yield signs at a roundabout
	Bridge decks, approach panels
	20 feet from Bridge decks or approach panels
	20 feet from terminal headers tying into existing pavement
Bituminous	Paved Shoulders
	Intersections where mainline profiles are merged or blended into the cross Street profile – begin and end exclusion 100 feet from the Intersection radius
Concrete	Doweled Shoulders less than 10 feet in width
	Undoweled Shoulders
	Headers adjacent to colored concrete

C Calculations

C.1 Smoothness

Obtain Smoothness values in an individual lane using the ProVAL "Smoothness Assurance" analysis with the 250 millimeter filter.

For percent improvement Projects, use the Smoothness Before Paving and Smoothness After Paving values to calculate the percent ride improvement.

C.2 Areas of Localized Roughness

Identify ALR using the ProVAL "Smoothness Assurance" analysis, calculating MRI with a continuous short interval of 25 feet with the 250 millimeter filter.

D Pavement Surface Evaluations

D.1 Smoothness

Evaluate Smoothness requirements using the equations and criteria in accordance with Table 2399.5-1 for bituminous pavements, Table 2399.5-2 for concrete pavements, or Table 2399.5-3 for percent improvement Projects.

The Engineer will determine Incentive/Disincentive on the segment Smoothness value (or percent improvement value, for percent improvement Projects) measured at the completion of surface pavement, unless Corrective Work is required by the ProVAL summary report results. If a segment is less than 100 feet in length and Table 2399.5-1, Table 2399.5-2, or Table 2399.5-3 requires Corrective Work, the Engineer will waive the Corrective Work requirement for the segment and instead assess a prorated Disincentive. The Engineer will still subject the segment to ALR analysis in accordance with Table 2399.5-4.

For segments requiring Corrective Work, reprofile the entire 0.1 mile segment after performing Corrective Work as directed by the Engineer and enter the reprofiled Smoothness values into the final *Profile Summary* worksheet.

D.1.a Bituminous Pavements

See Section 2360, “Plant Mixed Asphalt Pavement” of the Special Provisions for the Smoothness equation requirements. If no Smoothness equation is specified in the Contract, evaluate with equation HMA-B.

D.1.b Concrete Pavements

Evaluate with equation PCC-A.

D.1.c Percent Improvement Projects

Calculate the segment percent improvement in accordance with the following equation:

$$\%I = \frac{Smoothness\ Before\ Paving - Smoothness\ After\ Paving}{Smoothness\ Before\ Paving} \times 100$$

Determine the Smoothness Before Paving value before patching or other repair. Determine the Smoothness After Paving value after the completion of paving and any Corrective Work.

Correct segments with a percentage improvement of less than 0.0 percent at no additional cost to the Department as required by the Engineer.

D.2 Areas of Localized Roughness

The Engineer will consider areas of ALR acceptable if the reprofiled segment contains no ALR. The Department may apply monetary deductions for ALR remaining after reprofiling as determined by the Engineer and in accordance with Table 2399.5-4.

E Corrective Work

Notify the Engineer at least 24 hours before beginning Corrective Work. Do not begin Corrective Work before the Engineer approves the methods and procedures in writing.

Perform Corrective Work using a surface diamond grinding device consisting of multiple diamond blades, unless otherwise approved by the Engineer. Fog-seal diamond ground bituminous surfaces as required by the Engineer and at no additional cost to the Department. Repair and replace joint sealant damaged by diamond grinding on concrete pavement as directed by the Engineer and at no additional cost to the Department.

The Contractor may correct bituminous pavements by overlaying the area or replacing the area by milling and inlaying as approved by the Engineer. If milling and inlaying or overlaying, perform Corrective Work in accordance with 2399, “Pavement Surface Smoothness,” over the entire length of the correction. If milling and inlaying or overlaying, use a transverse saw cut to begin and end the surface correction.

Perform Corrective Work across the entire lane width. Maintain the pavement cross slope through corrective areas.

Perform coring to determine if diamond grinding Corrective Work results in thin pavements, as directed by the Engineer. Provide additional coring for thickness verification at no additional cost to the Department. Handle residue and excess water resulting from diamond grinding in accordance with 1717, “Air, Land, and Water Pollution.”

Perform surface corrections before placing permanent pavement markings. Replace permanent pavement markings damaged or destroyed by Corrective Work at no additional cost to the Department.

Reprofile segments containing corrected areas with the same certified IP in accordance with 2399.2A, “Inertial Profiler (IP)” within 5 Calendar Days of the completion of Corrective Work required by the Engineer.

F Retesting

The Department may retest the pavement surface within 30 Calendar Days of the Contractor’s profiling.

If the retested weighted mean Smoothness value differs by less than or equal to 10 percent or 3 inches per mile of the Contractor’s weighted mean Smoothness value, the Engineer will use the Contractor’s segment Smoothness and ALR values as the basis for acceptance, Incentive/Disincentive, and Corrective Work monetary deductions.

If the retested weighted mean Smoothness value is greater than 10 percent and 3 inches per mile of the Contractor’s weighted mean Smoothness value, the Engineer will use the retested segment Smoothness and ALR values as the basis for acceptance, Incentive/Disincentive, and Corrective Work monetary deductions.

2399.4 METHOD OF MEASUREMENT — BLANK

2399.5 BASIS OF PAYMENT

The Department will include the cost of the IP, testing, and traffic control in the relevant Contract Unit Price in accordance with 2301, “Concrete Pavement,” and 2360, “Plant Mixed Asphalt Pavement.”

A Monetary Adjustments

The Department must apply incentives and Disincentives and may apply monetary deductions for Pavement Surface Smoothness. The amounts of these adjustments are deemed reasonable.

A.1 Smoothness

A.1.a Bituminous Pavements

Table 2399.5-1 contains Smoothness Incentive/Disincentive for bituminous pavements.

Table 2399.5-1
Smoothness Incentive/Disincentive and Corrective Work for Bituminous Pavements

Equation	Smoothness inches/mile	Incentive/Disincentive $/0.1 mile
HMA-A	< 25.0	400.00
	25.0 – 75.0	800.00 − 16.000 × Smoothness
	> 75.0	Corrective Work to ≤ 50.0 inches per mile
HMA-B	< 30.0	270.00
	30.0 – 80.0	594.00 − 10.800 × Smoothness
	> 80.0	Corrective Work to ≤ 55.0 inches per mile
HMA-C	< 35.0	180.00
	35.0 – 95.0	390.00 − 6.000 x Smoothness
	> 95.0	Corrective Work to ≤ 65.0 inches per mile

For bituminous Projects, the Department will not pay any total Smoothness Incentive if greater than 25 percent of all mainline density lots for the Project fail to meet the minimum density requirements in accordance with 2360, “Plant Mixed Asphalt Pavement.” Use the composite pay factor for mainline density lots with longitudinal joint density.

A.1.b Concrete Pavements

Table 2399.5-2 contains Smoothness Incentive/Disincentive for concrete pavements.

Table 2399.5-2
Smoothness Incentive/Disincentive and Corrective Work for Concrete Pavements

Equation	Smoothness inches/mile	Incentive/Disincentive $/0.1 mile
PCC-A	< 45.0	890.00
	45.0 – 85.0	2892.50 – 44.500 × Smoothness
	> 85.0	Corrective Work to ≤ 65.0 inches/mile

If the Contractor adds water to the pavement surface without approval by the Engineer, the Engineer will not pay any Incentives for 0.1 mile segments where the water was added and the Engineer may reject the pavement in accordance with 1512, “Unacceptable and Unauthorized Work.”

A.1.c Percent Improvement Projects

Table 2399.5-3 contains Smoothness Incentive/Disincentive for percent improvement Projects.

Table 2399.5-3
Smoothness Incentive/Disincentive and Corrective Work for Percent Improvement Projects

Equation	Percent Improvement (%I)	Incentive/Disincentive $/0.1 mile
PI	> 70.0	180.00
	0.0 to 70.0	−180.00 + 5.143 × (%I)
	< 0.0	Corrective Work to %I of at least 0.0

For bituminous percent improvement Projects, the Department will not pay any total Smoothness Incentive if greater than 25 percent of all mainline density lots for the Project fail to meet minimum density requirements in accordance with 2360, "Plant Mixed Asphalt Pavement." Use the composite pay factor for mainline density lots with longitudinal joint density.

A.1.d Areas of Localized Roughness

Table 2399.5-4 contains monetary deductions for Areas of Localized Roughness.

Table 2399.5-4
ALR Monetary Deductions and Corrective Work Requirements

Equation	25 foot Continuous MRI inches/mile	Corrective Work or Monetary Deduction, per linear 1.0 foot
HMA-A or HMA-B, and a posted vehicle speed > 45 mph	< 175.0	Acceptable
	≥ 175.0 to < 225.0	Corrective Work unless both the Engineer and the Contractor agree to a monetary deduction of $25.00
	≥ 225.0	Corrective Work unless both the Engineer and the Contractor agree to a monetary deduction of $125.00
PCC-A and a posted vehicle speed > 45 mph	< 175.0	Acceptable
	≥ 175.0 to < 225.0	Corrective Work unless both the Engineer and the Contractor agree to a monetary deduction of $25.00
	≥ 225.0	Corrective Work
HMA-C, PI, Ramps, Loops, concrete Intersections constructed under traffic, or any paving with a posted vehicle speed ≤ 45 mph	< 225.0	Acceptable
	≥ 225.0	$25.00

Bridges and Structures

2401 CONCRETE BRIDGE CONSTRUCTION

2401.1 DESCRIPTION

This Work consists of constructing portions of a Bridge made of concrete, except for concrete piling (2452, "Piling"), special wearing courses (2404, "Concrete Wearing Course for Bridges"), precast concrete members (2405, "Prestressed Concrete Beams"), and 2412, "Precast Concrete Box Culverts").

A Definitions

For the purpose of the Work specified in section 2401, "Concrete Bridge Construction," the Department defines:

Bridge Deck Slab
Complete Structural slab and wearing course constructed monolithically.

Bridge Structural Slab
Structural unit upon which will be constructed a separately cast concrete wearing course.

Bridge Slab
Either Bridge Deck Slab or Bridge Structural Slab.

Well Lighted
A minimum of 50 foot candles of artificial light or natural daylight. Use a light meter with readings in foot candles to verify the adequacy of the lighting.

2401.2 MATERIALS

A Reinforcement Bars **3301**

B Welded Wire Reinforcing **3303**

C Spiral Reinforcement **3305**

D Basic Requirement for Paint **3501**

E Preformed Joint Filler **3702**

F Concrete Joint Sealer, Hot Poured Type **3723**

G Concrete Joint Sealer, Preformed Type **3721**

H Special Surface Finish

Use only one Department-approved product to apply a concrete coating to the entire Structure that meets the need for aesthetics and chloride protection as listed on the *Approved/Qualified Products List* for "Special surface finish II coatings."

I Concrete **2461**

J Expansion Joint Devices **2473**

K High Performance Concrete Bridge Decks

K.1 Concrete Aggregate Requirements

Test each Aggregate fraction proposed for use in accordance with Table 2401.2-1.

Table 2401.2-1
Aggregate Testing Requirements

Aggregate Fraction	Testing Required
Tested by Department in the last 3 years	No additional testing unless required by the Concrete Engineer
Not tested by the Department in the last 3 years	Preliminary Aggregate testing in accordance with 2401.2K.1.a, “Required Preliminary Aggregate Testing”
New source	New source concrete Aggregate testing in accordance with 3126, “Fine Aggregate for Portland Cement Concrete,” 3131, “Intermediate Aggregate for Portland Cement Concrete,” and 3137, “Coarse Aggregate for Portland Cement Concrete”

K.1.a Required Preliminary Aggregate Testing

After the Department awards the Contract and as soon as coarse and fine Aggregates are available for testing, contact the Engineer to coordinate preliminary sampling of Aggregate for concrete. The Engineer, in conjunction with the Concrete Engineer, will sample and test the Aggregate to verify specific gravity, absorption data, and Aggregate quality. The Department will perform other tests as determined necessary by the Engineer, in conjunction with the Concrete Engineer.

K.2 Fine Aggregate Requirements

Provide fine Aggregates complying with quality requirements of 3126.2B, "Quality."

The Department will routinely test fine Aggregate sources for alkali silica reactivity (ASR) in accordance with the following:

(1) Multiple sources of certified Portland cement in accordance with *ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*, MnDOT Modified.

(2) Multiple combinations of certified Portland cement and supplementary cementitious Materials in accordance with *ASTM C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)*, MnDOT Modified.

The Concrete Engineer, in conjunction with the Engineer, will review the 14 Calendar Day fine Aggregate expansion test results to determine the acceptability of the proposed fine Aggregate and cement combination in accordance with the following:

(1) For fine Aggregate and cement combinations previously tested by the Department, the Concrete Engineer will use the average of all 14 Calendar Day unmitigated test results for an individual source to determine necessary mitigation in accordance with Table 2401.2-2.

(2) If the previously tested proposed fine Aggregate and cement combination requires less mitigation than the average 14 Calendar Day unmitigated test result, the Concrete Engineer will allow mitigation at the lesser rate in accordance with Table 2401.2-2.

(3) Alkali silica reactivity (ASR) *ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*, MnDOT Modified and *ASTM C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)*, MnDOT Modified test results are available on the MnDOT Concrete Engineering Unit website. The Concrete Engineer considers the average 14 Calendar Day expansion result to represent all fine and intermediate Aggregates from a single source.

Table 2401.2-2
Fine and Intermediate Aggregate ASR Mitigation Requirements

<table>
<tr><th rowspan="2">14 Calendar Day Fine and Intermediate Aggregate Unmitigated Expansion Limits</th><th rowspan="2">Class F Fly Ash</th><th rowspan="2">Class C Fly Ash</th><th rowspan="2">Slag</th><th colspan="4">Ternary (Maximum of 40 percent)</th></tr>
<tr><th>Slag/Class F Fly Ash</th><th>Slag/Class C Fly Ash</th><th>IS(20)/Class F Fly Ash</th><th>IS(20)/Class C Fly Ash</th></tr>
<tr><td>≤ 0.150</td><td colspan="7">No mitigation required</td></tr>
<tr><td>> 0.150 – 0.200</td><td>Minimum 20 percent</td><td>Minimum 20 percent</td><td>35 percent</td><td rowspan="2">20 percent Slag with a minimum of 15 percent Class F fly ash</td><td rowspan="2">20 percent Slag and 20 percent Class C fly ash</td><td rowspan="2">Type IS(20) with a minimum of 15 percent Class F</td><td rowspan="2">Type IS(20) with a minimum of 15 percent Class C</td></tr>
<tr><td>> 0.200 – 0.300</td><td>Minimum 20 percent</td><td>Minimum 30 percent</td><td>35 percent</td></tr>
<tr><td>> 0.300</td><td colspan="7">The Department will reject the fine Aggregate</td></tr>
</table>

The Concrete Engineer may reject the fine Aggregate if mortar bar specimens exhibit an indication of external or internal distress not represented by the expansion results. The Concrete Engineer will make the final acceptance of the Aggregate.

K.3 Intermediate Aggregate Requirements

Provide intermediate Aggregates complying with the quality requirements of 3131.2D, "Quality."

For any intermediate Aggregate size not previously tested by the Department, the Concrete Engineer reserves the right to test for alkali silica reactivity, in accordance with *ASTM C1260*, *Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*, MnDOT Modified, prior to allowing incorporation into the concrete mix design.

K.4 Coarse Aggregate Requirements

Provide Class A, B, or C coarse Aggregate meeting the quality requirements in accordance with 3137.2D, "Quality," for each individual fraction.

When providing Class B Aggregate, the maximum absorption percent by weight is 1.10 percent.

K.4.a Coarse Aggregate Alkali Silica Reactivity (ASR) Requirements

When using coarse Aggregate identified as quartzite or gneiss, the Concrete Engineer will review *ASTM C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction* testing to determine the necessary ASR mitigation requirements in accordance with Table 2401.2-3.

ASR *ASTM C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction* test results are available on the MnDOT Concrete Engineering Unit website.

Table 2401.2-3
Coarse Aggregate ASR Mitigation Requirements*

***ASTM C1293‖* Expansion Results**	**Class F Fly Ash**	**Class C Fly Ash**	**Slag**	**Slag/Class F Fly Ash**	**Slag/Class C Fly Ash**	**IS(20)/Class F Fly Ash**	**IS(20)/Class C Fly Ash**
≤ 0.040	No mitigation required						
> 0.040	Minimum 30 percent	Not Allowed	35 percent	20 percent Slag with a minimum of 15 percent Class F fly ash	20 percent Slag and 20 percent Class C fly ash	Type IS(20) with a minimum of 15 percent Class F	Type IS(20) with a minimum of 15 percent Class C

* The Engineer will allow the Contractor to substitute a portion of the minimum required supplementary cementitious Material with up to 5 percent silica fume by weight for mitigation purposes.
‖ *ASTM C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction*

K.5 Cementitious Materials
Provide only cementitious Materials from the *Approved/Qualified Products List*

K.5.a Portland Cement .... 3101 or 3103
Use Type I or Type I/II cement complying with the following:

(1) Total alkalis (Na2Oe) no greater than 0.60 percent in the Portland cement
(2) Total alkalis (Na2Oe) no greater than 3.0 pounds per cubic yard of concrete resulting from the Portland cement

K.5.b Fly Ash.. 3115
The Concrete Engineer defines Class F fly ash for the purposes of ASR mitigation as having a maximum CaO content of 18.0 percent.

K.5.c Ground Granulated Blast Furnace Slag 3102

K.5.d Silica Fume .... *ASTM C1240*

K.5.e Ternary Mixes
Ternary mixes are defined as Portland cement and two other supplementary cementitious Materials, or blended cement and one other supplementary cementitious Material with a maximum replacement of 40 percent by weight.

K.6 Additional Ingredients
Combine and blend as required.

K.6.a Allowable Admixtures
Use any of the following admixtures on the *Approved/Qualified Products List,* Concrete Admixtures A-S:

1. Type A, Water Reducing Admixture
2. Type B, Retarding Admixture
3. Type C, Accelerating Admixture
4. Type D, Water Reducing and Retarding Admixture
5. Type F, High Range Water Reducing Admixture

6. Type S, Specific Performance Based Admixture

Obtain a written statement from the manufacturer of the admixtures verifying:

1. Compatibility of the combination of Materials
2. Manufacturer recommended sequence of incorporating the admixtures into the concrete

The manufacturer will further designate a technical representative to dispense the admixture products.

Utilize the technical representative in an advisory capacity and have them report to the Contractor any operations or procedures which are considered as detrimental to the integrity of the placement. Verify with the Engineer whether the manufacturer’s technical representative’s presence is required during the concrete placement.

K.6.b Fiber Reinforcement ....*Approved/Qualified Products List*
The following fiber addition methods are acceptable on all jobs:

1. Open bag and distribute fibers on Aggregate belt at Ready-mix Concrete plant
2. Open bag, break apart any fiber clumps, and introduce fibers into Ready-mix Concrete truck in a well-distributed manner

Any alternate methods to add fibers to the concrete mix must be submitted for acceptance by the Engineer and be demonstrated by a successful trial placement. Allowing bags to dissolve in the Ready-mix Concrete trucks will not be allowed. Balling of fibers is defined as a 2-inch diameter or greater conglomerate of fibers at the point of placement. Any balling more prevalent than 1 location in 20 cubic yards will be considered a failed trial placement. Ensure the manufacturer’s technical representative is available by phone or in person to troubleshoot fiber inclusion into the mix during the trial placement and Bridge deck placement.

K.7 Concrete Mix Design
Submit the concrete mixes using the appropriate MnDOT Contractor mix design submittal workbook available on the Department’s website at least 21 Calendar Days before the initial concrete placement. For mix design calculations, the Engineer, in conjunction with the Concrete Engineer, will provide specific gravity and absorption data.

The Concrete Engineer, in conjunction with the Engineer, will review the mix design submittal for compliance with the Contract.

K.7.a Concrete Mix Design Requirements
Design and produce 3YHPC-M or 3YPHC-S concrete mixes based on an absolute volume of 27.0 cubic feet in accordance with the Table 2401.2-4.

Table 2401.2-4
High Performance Bridge Deck Concrete Mix Design Requirements

Concrete Grade	Mix Number*	Intended Use	W/C Ratio	Target Air Content	Maximum percent SCM (Fly Ash/Slag/ Silica Fume/ Ternary) ‖	Slump Range†, inches	Minimum Compressive Strength, f'c (28 Calendar Day)	3137, "Coarse Aggregate for Portland Cement Concrete"
HPC	3YHPC-M	Bridge Deck – Monolithic	0.42-0.45	6.5 percent	30/35/5/40	2 - 5	4000 psi	2.D.2
	3YHPC-S	Bridge – Structural Slab						

* Provide a Job Mix Formula in accordance with 2401.2K.8, "Job Mix Formula." Use any good standard practice to develop a job mix formula and gradation working range by using procedures such as but not limited to 8-18, 8-20 gradation control, Shilstone process, FHWA 0.45 power chart, or any other performance related gradation control to produce a workable and pumpable concrete mixture meeting all the requirements of the Contract.
‖ The individual limits of each SCM shall apply to ternary mixtures.
† Keep the consistency of the concrete uniform during entire placement.

K.7.b Required Preliminary Testing

Prior to placement of any 3YHPC-M or 3YHPC-S concrete, the Engineer will require preliminary batching and testing of the concrete mix design.

Submit the concrete mixes using the appropriate MnDOT Contractor mix design submittal workbook available on the Department's website at least 14 Calendar Days prior to the beginning of preliminary laboratory mixing and testing of the proposed mix designs. Any changes or adjustments to the Material or mix design require a new Contractor mix design submittal. For mix design calculations, the Engineer, in conjunction with the Concrete Engineer, will provide specific gravity and absorption data.

The Concrete Engineer, in conjunction with the Engineer, will review the mix design submittal for compliance with the Contract.

Test the concrete for the following hardened concrete properties in accordance with Table 2401.2-5.

Table 2401.2-5
Required Hardened Concrete Properties for Mixes 3YHPC-M and 3YHPC-S

Test	Requirement	Test Method
Required Strength (Average of 3 cylinders)	4000 psi at 28 Calendar Days	*ASTM C31**
Rapid Chloride Permeability	≤ 2500 coulombs at 28 Calendar Days (for Preliminary Approval) ≤ 1500 coulombs at 56 Calendar Days	*ASTM C1202‖*
Freeze-Thaw Durability	Greater than 90 percent at 300 cycles	*ASTM C666†,* Procedure A
Shrinkage	No greater than 0.040 percent at 28 Calendar Days	*ASTM C157‡*
Scaling	Visual rating not greater than 2 at 50 cycles	*ASTM C672#*

* *ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field*
‖ *ASTM C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration*
† *ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing*
‡ *ASTM C157, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete*
# *ASTM 672, Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals*

The Engineer will allow the maturity method for subsequent strength determination. Perform all maturity testing in accordance with *ASTM C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method,* and the *Concrete Manual*.

If a mix is approved, the Concrete Engineer will consider the mix design and testing as acceptable for a period of 5 years provided the actual concrete mixed and placed in the field meets the Contract requirements. The Concrete Engineer will not require new testing within that 5-year period as long as all the constituents (including the Aggregates) of the proposed mix design are the same as the original mix design.

The Engineer determines final acceptance of concrete for payment based on satisfactory field placement and performance.

K.8 Job Mix Formula

A job mix formula (JMF) contains the following:

(1) Proportions for each Aggregate fraction
(2) Individual gradations for each Aggregate fraction
(3) Composite gradation of the combined Aggregates including working ranges on each Sieve in accordance with Table 2401.2-6

Table 2401.2-6
Job Mix Formula Working Range

Sieve Sizes	Working Range, percent *
1 inch and larger	±5
3/4 inch	±5
1/2 inch	±5
3/8 inch	±5
No. 4	±5
No. 8	±4
No. 16	±4
No. 30	±4
No. 50	±3
No. 100	±2
No. 200	≤ 1.6
* Working range limits of the composite gradation based on a moving average of 4 tests (N=4).	

K.8.a Verification of JMF

Prior to beginning placements of Bridge deck concrete, perform gradation testing to ensure current Materials comply with the approved JMF. Perform gradation testing in accordance with the *Schedule of Materials Control*.

(1) Take samples at the belt leading to the weigh hopper or other locations close to the incorporation of the Work as approved by the Engineer
(2) Add fill-in Sieves as needed during the testing process to prevent overloading

The Producer and Engineer will test and record the individual gradation results using the *Concrete Aggregate Worksheet*.

Using the *JMF Moving Average Summary* worksheet, calculate the moving average of Producer Aggregate gradation test results during production.

The Engineer will randomly verify Producer combined Aggregate gradation results as defined in the *Schedule of Materials Control*.

If, during production, the approved JMF falls outside of the allowable working range immediately sample and test additional gradation and continue production.

K.8.b JMF Adjustment

If it is determined that the current Aggregates do not meet the approved JMF, submit a new mix design including JMF to the Concrete Engineer in accordance with 2401.2K.8, "Job Mix Formula."

K.9 Laboratory Batching, Testing Requirements and Submittals

To determine the characteristics of the Contractor proposed mix design, the Concrete Engineer will require the Contractor to prepare test batches and do laboratory testing. Conduct all batching and testing of concrete at a single AMRL certified laboratory using the exact Materials proposed in the mix design.

Lab testing requirements:

(1) Slump and air content at <5 minutes, 15 minutes, and 30 minutes after the completion of mixing
(2) Compressive strength (Make cylinders in accordance with *AASHTO T126,* "Standard Method of Test for Making and Curing Concrete Test Specimens in the Laboratory," and tested in accordance with *AASHTO T22,* "Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens") at 1, 3, 7, 28, 56 Calendar Days (sets of 3)
(3) Hardened air content (*ASTM C457, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*) at a minimum of 7 Calendar Days
(4) Rapid chloride permeability (*ASTM C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration*) at 28 Calendar Days and 56 Calendar Days (2 specimens for 28 Calendar Day test and 2 test specimens for 56 Calendar Day test (Take 2 specimens from each batch of a 2 batch mix))
(5) Concrete Durability (*ASTM C666*, *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing,* Procedure A) at 300 cycles
(6) Concrete Shrinkage (*ASTM C157, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete*) at 28 Calendar Days
(7) Concrete Scaling (*ASTM C672, Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals*) at 50 cycles

The Contractor is required to contact the MnDOT Concrete Engineering Unit a minimum of 2 Calendar Days prior to any mixing so that a MnDOT representative can observe the process. This same Calendar Day notification is required prior to any physical testing on hardened concrete samples. Additionally, retain any hardened concrete test specimens for a minimum of 90 Calendar Days and make available for Department to examine.

Perform all testing for plastic concrete after all admixtures additions to the concrete mixture.

After completion of the laboratory testing specified herein and, at least, 15 Working Days prior to the trial placement, submit the laboratory test data to the Department for review and acceptance.

Include the following information in the laboratory reports of the design mixes:

(1) Exact batch weights and properties of all ingredients used and all Aggregate gradations
(2) Slump and air content
(3) Cylinder identification, including mix designation
(4) Date and time of cylinder preparation
(5) Date and time cylinder specimen was tested
(6) Compressive strength of each cylinder specimen at 1, 3, 7, 28, and 56 Calendar Day (sets of 3)
(7) A graphic plot of age, from 0 to 56 Calendar Days, vs. strength for each mix design
(8) Hardened air content at a minimum of 7 Calendar Days
(9) Rapid chloride permeability at 28 Calendar Days and 56 Calendar Days
(10) Concrete durability at 300 cycles
(11) Concrete shrinkage at 28 Calendar Days
(12) Concrete scaling at 50 cycles

2401.3 CONSTRUCTION REQUIREMENTS

A General

Refer to 2402, "Steel Bridge Construction," 2404, "Concrete Wearing Course for Bridges," 2451, "Structure Excavations and Backfills," 2452, "Piling," 2471, "Structural Metals," and 2472, "Metal Reinforcement," for constructing Bridges.

B Falsework and Forms

Use forms for concrete except portions of footings that extend into solid rock. Do not cast concrete against the side of an earth excavation instead of forming. If the Special Provisions allow driving the sheets along the neat line of a footing, the Contractor may use cofferdam sheets as forms for footings.

B.1 Material Requirements, with Allowable Stresses or Loads

B.1.a Falsework Piling

Calculate safe pile-bearing capacities in accordance with 2452, "Piling."

B.1.b Structural Shapes and Fabricated Assemblies

Reduce the safe load capacity for Material or fabricated assembly that has a loss of section due to corrosion, damage, or previous fabrication. Splices in beams or girders must be at points of one-half maximum bending stress or less. Splices shall develop yield on the gross section and fracture on the net section.

Design trusses, other fabricated sections, and steel beams to meet the requirements of the *AASHTO* Guide *Design Specifications for Bridge Temporary Works* and the *AASHTO Standard Specifications for Highway Bridges*. The Contractor may increase the allowable stresses in the *AASHTO Standard Specifications for Highway Bridges* by no greater than one-third.

Design and use form ties and other steel devices planned for casting into concrete so that the major part, or the entire device, remains permanently in the concrete. If using a device that passes through a concrete surface exposed to view in the completed Structure, use a device removable to a depth of at least 1 inch from the concrete face without spalling or damaging the concrete.

B.1.c Lumber

Provide lumber free of defects that may adversely affect its strength or the appearance of exposed concrete lines and surfaces, such as crooks, twists, warps, and variations in dimensions. Surface the side of lumber pieces that will contact concrete. If not using form lining, surface or dress and match abutting edges to prevent mortar leakage.

Working stresses for lumber shall not exceed the maximum stresses specified in the *Bridge Construction Manual*, Falsework and Forms section. Provide sheathing lumber, either with or without form lining, at least 1 inch Nominal thickness and no greater than 8 inches wide for exposed concrete surfaces. If a single piece of lumber will completely cover a concrete surface and the lumber is not cupped or warped, the Contractor may use wider lumber. For curved surfaces with a radius of less than 5 feet, the Contractor may use sheathing thinner than 1 inch Nominal as long as the sheathing maintains its shape during concrete placement.

B.1.d Plywood Sheathing

Provide plywood for form sheathing meeting the following requirements and characteristics:

(1) Consisting of at least five plies
(2) Nominal thickness of at least 3/4 inch
(3) Plyform exterior grade with sanded or overlaid surfaces specially manufactured for use as form sheathing
(4) Strength requirements as specified in the *Bridge Construction Manual*, Falsework and Forms section

The Contractor may use the plywood without backing if it meets the above requirements.

For curved surfaces with a radius of less than 5 feet and for slab sections between girders or beams, the Contractor may provide plywood sheathing thinner than 3/4 inch Nominal, as long as the sheathing maintains its shape during concrete placement.

B.1.e Form Lining

If the Contract requires form lining, use plywood sheathing with a smooth surfaced Material that will produce a concrete surface substantially as smooth and uniform as that obtained using sanded or overlaid plywood sheathing in good condition with no warps or damaged areas. Use the same kind of form lining Material throughout an exposed concrete face. Place the form lining to produce a smooth contact surface that is free of defects. Provide smooth form lining free of defects that cause irregularities that the specified concrete finishing operations in 2401.3F, “Finish of Concrete,” cannot remove.

Provide form lining Material with a uniform thickness and edges that form mortar tight joints.

Ensure that bolt, nail, or rivet heads and weld deposits are flush with the form lining face in contact with concrete.

If using form lining sheets or sections, use Material that minimizes the number of joints.

B.1.f Forms for Circular Columns

Use forms that can withstand design concrete pressures without distortion. Use forms to produce a concrete surface free of visible ridges and depressions. If form lining is shown on the Plans, the Contractor may use fiber molds. When using form brands not previously used, provide the Engineer with the manufacturer’s data.

B.1.g Chamfer Strips

Provide smooth chamfer strips uniform in cross-section dimensions without rounded corners. If using wood strips, provide wood strips made of straight grain soft wood. Size chamfer strips as shown on the Plans and in accordance with 2401.3B.6, “Form Construction.”

B.2 Design of Falsework and Forms

Submit detailed Plans for falsework and forms to the Engineer. Submit design calculations for falsework if included in special provisions or if requested by the Engineer.

B.2.a Falsework

Provide falsework members designed to safely carry the following forces:

(1) Dead load of the falsework members only

(2) Dead load of the uncured concrete, computed at 150 pounds per cubic foot
(3) A vertical live load of 20 pounds per square foot applied on the upper concrete surface
(4) Dead load of the forms and other falsework members supported by the members
(5) Equipment loads and Material stockpile loads anticipated for use during construction

B.2.b Forms

Provide forms designed to safely carry the following forces:

(1) Dead load of the forms only
(2) The dead load of uncured concrete, computed at 150 pounds per cubic foot
(3) Hydrostatic pressure on vertical form faces from wet concrete
(4) A vertical live load of 50 pounds per square foot applied on the upper concrete surface
(5) All Equipment loads and Material stockpile loads anticipated for use during construction

Consider the specified live load as the minimum. Adjust for concentrated loads that may produce higher live loads on a member than the minimums specified.

B.2.c Falsework and Forms

Provide falsework and forms designed in accordance with the following as specified in the *Bridge Construction Manual*, Falsework and Forms section:

(1) Concrete pressures
(2) Standard formulas
(3) Allowable stresses
(4) Deflections
(5) Deviations of alignment

Provide credible information regarding the performance of the proposed falsework and forms under concrete load construction for any type of construction not included in the *Bridge Construction Manual*, Falsework and Forms section, as requested by the Engineer.

Before using devices or fabrications that the Engineer determines the Department does not have sufficient performance information on, conduct full scale field or laboratory testing of falsework and forms at no additional cost to the Department.

B.3 Form Lining Requirements

Nail form lining backed by sheathing to prevent bulging. Fasten plywood at least 3/4 inch thick to its supports to ensure stiffness and close contact between the plywood and supports.

Tightly butt edges of plywood sheets and form panels without offset to form a mortar tight joint. The Engineer will allow the Contractor to patch or seal joints that will not seal with cold water putty, expandable foam, or an equivalent.

Place joints in form lining sections or between adjacent form panels following the same horizontal line. Place horizontal joints on columns of a unit to the same level. Align joints in form lining vertically and horizontally.

On forms for concrete faces exposed to view, drill holes for form bolts through sheathing or form lining without splintering the face of the form in contact with the concrete. If using both sides of sheathing, avoid splintering on both faces.

Use form lining in accordance with 2401.3B.1.e, "Form Lining," for formed surfaces. The Department will not require use of form lining for buried surfaces or surfaces hidden from view in the completed Structure, except as shown on the Plans.

If using recessed rustication strips to divide a concrete surface into panels as shown on the Plans, set rustications to cover the joints in the form lining. Concrete panels with a rubbed surface finish or a special surface finish do not require form lining joints to be covered by rustication strips.

B.4 Falsework Requirements

Support falsework on piling, on ledge rock, on parts of the Structure, or on temporary footings.

Do not weld on stress-carrying steel members of the Bridge Superstructure except as specified in 2402, "Steel Bridge Construction."

Welded or bolted splices in main load carrying steel members shall meet the requirements of 2402, "Steel Bridge Construction," and 2471, "Structural Metals."

Drive falsework piling to a bearing capacity and penetration that will adequately support the superimposed loads without settlement as shown in the falsework Plans.

Use temporary footings to support falsework in accordance with the following:

(1) Submit geotechnical borings, testing, analysis, and calculations, including soil bearing capacity, anticipated settlement, and sliding resistance, for proposed footings showing that detrimental settlement will not occur under maximum construction loads and conditions anticipated at the site.
(2) Falsework loads must be spread to an area required to meet allowable soil bearing pressure.
(3) Protect footings from undermining, freezing, or being overspread with water.
(4) Use when approved in writing by the Engineer, otherwise support with pilings.

Cut off falsework piling in a bent to provide uniform bearing for the pile cap. Securely fasten caps to the pile heads or posts. Securely brace each falsework bent with timber or steel of adequate size as shown on the falsework Plans. Securely brace the bents to adjacent bents.

Provide falsework for Superstructures in widths greater than the overall width of the Superstructure to brace side forms to the falsework.

On Bridges with separate Roadways, support the form and falsework supports for each Roadway slab with beams or girders under that Roadway.

Locate primary supports for concrete slab spans and the bottom slab for concrete box girders no greater than 2 feet from the construction joints in the slabs.

Provide falsework for slab overhangs for steel beam spans capable of resisting torsional stresses. Use knee bracing, cross bracing, struts, ties, or other methods approved by the Engineer to prevent pronounced deflections caused by stresses. Bracing is particularly critical when slab overhangs are greater than the beam depth.

B.5 Removal of Falsework

Do not release falsework supporting concrete Structures and concrete members until the completion of the curing period in accordance with 2401.3G, “Concrete Curing and Protection,” plus one Calendar Day of drying out time. Release falsework supporting post tensioned structures after stressing the post tensioning tendons as described in the Specifications and shown on the Plans.

Do not place loads beyond those included in 2401.3G.6.e, “Protection from Premature Loading,” on concrete members until completion of curing and after the release of falsework, unless otherwise approved by the Engineer.

Determine adequate strength for the complete Structure using the last concrete cast affected by the release of falsework.

Loosen supporting falsework to allow the concrete to uniformly and gradually take the stresses due to its own weight.

Do not apply live loads to the Superstructure at any point while falsework is partially loosened on any part of the Bridge.

Remove falsework piles located within the Roadbed to an elevation of at least 4 feet below the Subgrade adjacent to the pile. Remove falsework piles located in a stream or lake bed and within the limits of low water to the elevation matching the surface of the stream or lake bed. In established navigation channels, remove falsework to an elevation of at least 2 feet below the surface of the channel bottom. Remove all other piles to an elevation of at least 2 feet below ground elevation.

Remove falsework supports used for the top slab of concrete box girder spans and steel box girder spans.

Remove temporary footings.

Backfill and compact open excavations resulting from the removal of falsework in accordance with 2451, “Structure Excavations and Backfills,” at no additional cost to the Department.

B.6 Form Construction

Provide forms meeting the following requirements and characteristics:

(1) Designed and constructed to safely resist the pressure of fluid concrete under vibration and of other loads Incidental to the construction operations
(2) Constructed and erected mortar tight so that the finished concrete conforms to the dimensions and contours shown on the Plans, and so that undulations and waves on exposed finished concrete surfaces do not exceed the maximum shown in the *Bridge Construction Manual*, Falsework and Form section
(3) Set true to the designated lines shown on the Plans
(4) Rigidly maintained until the concrete has sufficiently hardened to allow removal of forms per 2401.3B.8, “Removal of Forms”

For vertical construction joints in a concrete unit with a rubbed surface finish, locate joints in form sections to allow the removal of the major part of the forms to allow the initial rubbed surface finish on the cast portion.

Construct vertical forms that will permit removal independent from overhead falsework.

Place sheathing lumber horizontally unless otherwise approved by the Engineer.

Construct splices in wales so the wale remains effective continuously for its entire length. Stagger splices in each member of a double wale at least one stud space.

The Contractor may leave openings in the forms to clean out extraneous matter or to facilitate the placement of concrete if the Engineer approves the number and location of openings. Construct closures for openings to ensure a tight fit flush with the adjoining surfaces.

Unless the Plans show otherwise, use chamfer strips with 3/4 inch sides to form chamfered corners where exposed intersecting concrete surfaces meet at angles no greater than 90 degrees. The Department will not require chamfered corners at the corners of beam stools under decks with mortar tight joints. If the Contract does not require joint edging, use similar moldings with 1/2 inch sides at joints exposed to view. Fasten moldings at intervals no greater than 6 inches.

Set chamfer strips at the tops of pier caps supported on falsework in a manner that will allow adjustment to true Bridge seat elevation after the placement of the bulk of the cap concrete.

The Contractor may provide forms for keyways at construction joints in concrete constructed with Nominal lumber dimensions and with side bevels no greater than 1:10.

Provide forms for open joints capable of removal without damaging the joint after the removal of the form.

Before setting grade elevations for curbs, Sidewalks, medians, and railings, free the concrete box girder spans and concrete slab spans from temporary supports.

Do not drive nails into the hardened concrete to fasten forms for Roadway faces of curbs, Sidewalks, and medians. Use braces and struts to maintain proper line and batter for Roadway curb face, Sidewalk, and median forms, if these are cast separately from the slab. Do not use internal spreaders. Do not install bolts and pins set or drill into the slab for the formwork more than 1 1/2 inches below the slab surface. Install all hardware into the slab surface without spalling or damaging the concrete. Remove all hardware from slab and fill the holes flush with non-shrink grout listed on the *Approved/Qualified Products List*.

If constructing a Bridge with a horizontal curve as shown on the Plans, construct the forms for edges of slab, curbs, copings, medians, and railings to that degree of curvature within a tolerance of 1/8 inch in 10 feet.

B.7 Treatment of Forms

Before placing reinforcement, treat the contact faces of forms with a form coating material in accordance with 3902, “Form Coating Material.” Apply the form coating at the rate recommended by the manufacturer.

Protect form lining treated before erection from accumulations of dust and dirt.

Use water to wet faces of forms that contact concrete immediately before placement of concrete.

B.8 Removal of Forms

Do not remove forms until provisions are in place for continuous curing in accordance with 2401.3G, "Concrete Curing and Protection."

Remove forms and form ties carefully to prevent spalling or marring of the concrete surface and to avoid breaking off concrete corners.

The Contractor may remove forms for the Roadway face of curbs, Sidewalks, and medians when the concrete can retain its shape and if weather conditions allow the start of the specified concrete finish per 2401.3F.2.d, “Curb, Sidewalk, and Median Finish,” immediately after removing the forms.

Remove column and wall forms before releasing the falsework supports from concrete supported by the column or wall.

Do not remove forms for rustication, fluting strips, and drain recesses at the same time as the face forms. Leave rustication, fluting strips, and drain recesses forms in place until it is possible to remove these items without spalling, chipping, or marring of concrete corners or edges.

Remove forms for the webs of concrete box girder spans and provide the web concrete with an ordinary surface finish before setting the forms for the top slab in place at that location.

Remove interior forms in concrete box girder spans. Remove deck forms on the interior of steel box girder spans. Clear loose Material from the inside of the concrete box girders and steel box girders, and sweep the box clean.

B.9 Reuse of Forms

The Contractor may reuse forms and form liners if they are sufficiently rigid so that the undulation of the concrete surface does not exceed 1/8 inch when checked with a 5.0 foot straightedge or template. If the form lining between supports show conspicuous permanent set, remove the form lining and correct before reuse.

Plug or cover open holes in sheathing. Plug open holes in form lining flush with the lining. Repair blemishes on the form lining surface to a smooth and even surface. Clean adhering concrete and extraneous matter from form surfaces in contact with concrete before reuse.

C Placement of Concrete – General Requirements

Complete the placement of forms, falsework, bracing, and reinforcement bars for the entire concrete cast and have concrete placement and finishing Equipment and curing Material on site before placing the concrete.

Notify the Engineer at least 24 hours in advance of the casting of concrete to allow the Engineer to inspect forms, reinforcement bars, Materials, and Equipment. Do not place concrete until the Engineer inspects and approves the Work.

Perform mixing, placing, and finishing of concrete under adequate lighting conditions.

Transport and place concrete without segregating the batch Materials. Place concrete in or near its final position without displacing the reinforcement while completely enveloping the reinforcement in the concrete.

Keep Equipment for transporting, placing, and finishing concrete free of foreign matter and coatings of hardened concrete. Waste the water used for cleaning Equipment outside of the forms per environmental regulations and Specifications.

Clean forms and reinforcement bars and remove debris inside the forms before placing concrete.

Place concrete under water only when used for a cofferdam seal and as shown in the Special Provisions.

When placing concrete on or against earth and porous rock foundations, moisten the surfaces before placing concrete.

Footings cast in solid rock will not require side forms.

Place concrete between required or permissible joints as shown on the Plans in a continuous operation. If a breakdown in the concrete placement operation occurs and the concrete placed to that point sets so that re-vibration is not possible, cover the surface of the concrete with an approved bonding agent or mortar, or install a construction joint, as accepted by the Engineer before placing fresh concrete against it.

Place concrete at a rate that does not exceed fluid pressure for which forms were designed. Stop casting operations at signs of overstress or excessive deflection.

Except for seals, deposit and compact concrete in continuous horizontal Layers no greater than 1 foot thick. In columns and thin walls, the Contractor may increase the thickness to no greater than 3 feet. Place and compact concrete before the concrete in the preceding Layer takes its initial set. Place Layers of concrete within 1 hour of placing the next Layer of concrete at the same point, unless otherwise approved by the Engineer.

Do not drop concrete from a height greater than 4 feet unless confined in a vertical down spout or other approved type of pipe or unless the Engineer approves another placement method. Use as many down spouts as needed to place concrete at a horizontal level. The Contractor may use inclined pipes, belts, or chutes to discharge concrete into the hopper of the downspout if the Contractor provides approved means of preventing segregation.

Place concrete buckets as close as practical to the point of deposit before discharging concrete. Discharge concrete at a rate that does not displace reinforcement bars, forms, supports or any embedded items. Do not discharge excess concrete in a pile for re-handling.

Remove laitance and foreign matter if it accumulates on the inside of the forms.

Do not mix dried or hardened concrete accumulations with fresh concrete. As the concrete rises in the forms, keep the form surfaces and reinforcement bars free of concrete spatters that may harden and become part of the mix. Remove dried concrete and dust accumulations on the form surfaces and reinforcement bars above construction joints before placing the next concrete Lift. Do not damage the form surfaces, reinforcement bar coating, or the steel-to-concrete bond when removing excess concrete.

Work the coarse Aggregate away from the forms. Force the concrete under and around the reinforcement bars without displacing the bars.

If casting a wall or column greater than 5 feet tall integrally with a beam, strut, or slab, allow from 30 minutes to 90 minutes, as determined by the Engineer, to elapse between placement of the concrete to the level of the bottom of the beam, strut, or slab and placement of the concrete above this level.

For caps supported by more than one column, cast columns uniformly and allow from 30 minutes to 90 minutes to elapse, as determined by the Engineer, before placing the cap.

Clean set concrete of loose Material, laitance, and dirt before placing fresh concrete against it. Sand or water blast Superstructure concrete to clean the set concrete. Avoid damage to coating on reinforcement bars. Before placing the fresh concrete, draw the forms for the fresh concrete tight against the set concrete. Keep the contact surfaces of the set concrete wet until depositing the fresh concrete.

If the Engineer determines that shock waves from pile driving, blasting, or other operations will damage the concrete, complete these operations before placing concrete or suspend these operations until the concrete gains adequate strength per 2401.3G, “Concrete Curing and Protection.”

Do not support runways for concrete transportation by the forms unless approved by the Engineer.

Remove the span falsework and obtain an acceptable Bridge Slab cure before placing concrete barriers.

D Compaction of Concrete

Compact concrete, except for cofferdam seals, using mechanical vibration applied internally. Operate vibrators at a frequency of at least 4,500 impulses per minute. Compact each batch of concrete immediately after placement.

Apply vibrators at points no farther apart than twice the radius of the vibrator’s visibly effective range. Manipulate the vibrators to Work the concrete around reinforcement and imbedded fixtures and into the corners and angles of the forms. Use spading to supplement vibration to produce smooth surfaces and dense concrete along form surfaces and in corners and locations unreachable by vibrators.

Apply vibration at the point of deposit of freshly deposited concrete. Vibrate long enough to compact the concrete but not so long as to cause segregation and localized areas of grout. Insert and withdraw vibrators in a vertical orientation. Extend vibrators into previously placed concrete of columns, web walls, or other multiple Layer placements.

Do not apply vibration to, or apply vibration directly on reinforcement bars to sections of concrete that has hardened to the degree that the concrete ceases to be plastic under vibration. Do not use vibrators to make concrete flow in the forms; this action will cause segregation.

Use non-metallic vibrator head for compaction of concrete around epoxy-coated components per 2472.3C.3, “Special Requirements for Coated Bars.”

E Joint Construction

Perform joint construction as shown on the Plans and in accordance with the following:

E.1 Transverse Construction Joints

Make grooves or saw cuts 3/8 inch wide by 1 inch deep in accordance with the following unless otherwise shown in the Plans or directed by the Engineer:

(1) At transverse construction joints in the Bridge Slab unless otherwise directed by the Engineer
(2) To the full width of the Roadway between gutter lines
(3) Directly over the construction joint before placement of curb forms

E.2 Weakened Plane Joints

Use a grooving tool or a removable insert when casting the slab to extend and form a weakened plane under Sidewalks and at other slab locations where a saw cut is not possible. Place the insert or groove to cut the fresh concrete on a straight line to a depth of 1 inch. When using an insert, coat with oil or grease before placement. Withdraw the insert when the concrete has set enough to retain the groove shape with the insert removed.

Locate the weakened plane to fall vertically below the Sidewalk, curb, or median joint at that location. On skewed Bridges with exterior girders or beams under curbs, Sidewalks, or medians that are normal to the longitudinal axis of the Bridge, extend the weakened plane using a removable insert. Place the insert as a continuation of the line to be cut, extending to the centerline of the exterior girders or beams.

Outward from the centerline of the exterior girders or beams, place the weakened plane common to the joint placed in the curb, Sidewalk, or median. Form a vertical 1/2 inch V-shape in the edge of the slab at the end of the weakened plane at that location.

E.3 Open or Filled Joints

Form the distance between faces of open joints with removable inserts, headers, or templates to provide the opening shown on the Plans for the temperature range prevailing at the time of concrete placement. Refer to the tabulation shown on the Plans or shop drawings for the required openings at various temperatures. The temperatures listed represent the temperature anticipated when the slab is cast. Joints may widen due to concrete shrinkage.

After placing the Bridge Slab adjacent to an elastomeric seal expansion joint, and after curing and drying the concrete, the Engineer will measure the constructed joint openings. The Engineer may reject openings that deviate from the size shown on the Plans by greater than 3/16 inch as unacceptable Work in accordance with 1512, “Unacceptable and Unauthorized Work.” The Department will also consider offsets at joints between segments as unacceptable Work.

The Contractor may use preformed joint filler to form vertical joints. When using cork joint filler to form a vertical joint, anchor with copper nails 2 1/2 inches long at 20 inch centers. Where the Contract requires chamfered corners at joints created by using preformed material, trim the preformed filler back to the inside of the vee formed by the chamfer strip.

E.4 Expansion Joint Devices

Provide, assemble, and install Bridge Slab expansion joint devices as shown on the Plans and in accordance with 2473, “Expansion Joint Devices.”

F Finish of Concrete

F.1 General

Surface finish concrete that is properly set, and only during weather conditions, or with weather protection, accepted by the Engineer.

F.2 Formed Surfaces

F.2.a Ordinary Surface Finish

Provide ordinary surface finish on formed surfaces of concrete Structures. If applying special surface finishes to conventionally formed concrete surfaces, sand or water blast the surface before ordinary surface finishing to break the surface film and to remove laitance, form release agent, dirt, and other foreign matter that might adversely affect adhesion of special surface finishes.

Immediately after removing the forms, examine the concrete surfaces for defects. Remove and repair concrete with porosity, honey comb, or segregated Materials. The Engineer will approve the time, method, and Materials used to make concrete repairs. Repair small areas with mortar as specified for surface cavities. The Engineer may require formed surfaces to repair large areas. The repairs may require a bonding agent, mechanical bonds, or both. Cure repair work as approved by the

Engineer. The Engineer may reject concrete sections with extensive, irreparable defects as unacceptable Work in accordance with 1512, "Unacceptable and Unauthorized Work."

Remove fins and projections from exposed surfaces and from surfaces that will be waterproofed.

Clean, saturate with water, and fill with mortar surface cavities produced by form ties. Clean, saturate with water, and fill with mortar surface cavities on exposed surfaces with a diameter of at least 3/8 inch. The Department defines "exposed surfaces," as surfaces exposed to view in the completed Structure, above low water, and above the final ground line. At unexposed surface locations or areas where the Engineer determines repairs will not affect the appearance of the completed Structure, clean and fill cavities caused by removing falsework, brackets, form ties, or hanger rods with a silicone caulk listed on the *Approved/Qualified Products List* for "Moisture Cured Polymeric Joint Sealer."

Use mortar consisting of three parts standard Portland cement, six parts mortar sand, and water to fill surface cavities. Use enough water to produce a mortar consistency as dry as possible to use effectively. Mix the mortar 1 hour before use.

Provide a latex or acrylic-based bonding agent listed on the *Approved/Qualified Products List* for special surface finish. Mix the bonding agent into the mortar used for ordinary surface finishing on areas that will receive a special surface finish. Add the bonding agent to the mixing water at a ratio of one part bonding agent to three parts water.

Fill the cavities with mortar. Compact the cavities in place, point, and trim flush with the concrete surface. On exposed surfaces, remove mortar stains or streaks outside the area of the filled cavity.

After completing the concrete Work, remove visible streaks, stains, and blemishes from the surface if the Special Provisions do not show additional surface finishing on an exposed surface. Perform additional surface finishing on an exposed surface for which the Contract that requires only ordinary surface finish when adjoining form lining sheets present sharply contrasting colors or textures. Provide sack rubbed surface finish as a corrective measure if the surface appearance remains sharply contrasting after the completion of the ordinary surface finish.

If applying the ordinary surface finish before the completion of the curing period, minimize interruption to the curing when performing the finishing.

F.2.b Sack Rubbed Surface Finish

In areas with numerous surface voids on an exposed surface, the Contractor may use sack rubbed finish to fill the smaller voids in lieu of the method described under ordinary surface finish. Fill form tie holes and other cavities of at least 3/8 inch in accordance with 2401.3F.2.a, "Ordinary Surface Finish."

Grind or sandblast the concrete surface to remove blemishes, discolorations, and thin mortar films covering surface voids.

After the completion of the Structure, and when further construction will not produce blemishes and discolorations on the surface, perform the following operations:

(1) Saturate the surface with water and, beginning at the top, use a rubber float to apply a mortar mixture to fill the voids. Mix the mortar using the following requirements:

(a) One part standard Portland cement
(b) One part mortar sand
(c) Contains sufficient water to produce a moderately thick paste that will remain in place when applied; rewet the concrete surface if it dries before applying the mortar paste

(2) After the mortar sets in the voids, but before it completely dries, rub the floated surface using a burlap sack filled with a dry mix of mortar to remove mortar in excess of what was needed to fill the voids. The Engineer will accept equally effective means of removing the excess mortar.
(3) Produce a completed surface meeting the following requirements and characteristics:

(a) Free of blemishes, discolorations, and surface voids
(b) Uniform in texture and appearance, except for the difference in texture between filled voids and the remainder of the surface

Correct surfaces not meeting the requirements of this section.

F.2.c Special Surface Finish

This Work consists of the preparation of the concrete surfaces, cleaning the surfaces, furnishing and applying a single component SSF II finish on Structure surfaces required by the Contract.

Submit and follow the approved Quality Control Plan to produce a surface uniform in texture and appearance. Final approval of appearance will be made by the Engineer.

Use only one Department-approved product to apply a concrete coating to the entire Structure that meets the need for aesthetics and chloride protection as listed on the *Approved/Qualified Products List* for special surface finish II coatings.

Supply a SSF II product that meets the requirements of 3501, "Basic Requirements for Paints." Provide a color drawdown sample on a Leneta chart per *ASTM D2805, Standard Test Method for Hiding Power of Paints by Reflectometry*, to the Engineer. The Engineer will provide the drawdown sample to the Materials Engineer for color verification prior to the SSF II being applied. The Department requires an acceptable initial drawdown sample prior to beginning any Work because color testing is the initial control for the quality of the product.

The Engineer will randomly take liquid samples of SSF II in the field at the rates and sample sizes that are shown in the *Schedule of Materials Control*. The Engineer will provide the samples to the Materials Engineer for drawdown readings. The Engineer will sample an entire unopened, manufacturer sealed container if the Engineer determines there is a need.

Deliver SSF II product to the job site in manufacturer sealed containers bearing the manufacturer’s original labels. Assure SSF II containers remain sealed and are maintained at a temperature above 40°F and less than 100°F and not in direct sunlight until ready to be mixed and sampled. Do not use product that is older than its shelf-life.

F.2.c(1) Contractor Qualifications and Documentation

At least 20 Calendar Days before starting SSF II application submit a Project specific Quality Control Plan (QCP) meeting the requirements of Table 2401.3-1 to the Engineer for acceptance.

In appendices of the QCP include:

(1) Training materials and documentation showing that the SSF II manufacturer's technical representative trained the applicators
(2) Contractor's Quality Control (QC) personnel to apply the SSF II coating system used on this Project
(3) Include the method by which the QC person will monitor and document the wet film measurements taken to assure proper coating mils are being maintained utilizing *ASTM D4414, Standard Practice for Measurement of Wet Film Thickness by Notch Gages*
(4) The drawdown sample and the Materials Engineer's letter accepting the initial color

The Department's Quality Assurance Inspector (QAI) will take wet-film readings and review Contractor QCP documentation as necessary to assure the Contractor is in compliance with the Specifications. Supply wet film notched gauges to the QAI as needed.

Provide written documentation of the observed and document results of the requirements in Table 2401.3-1 to the QAI or to the Engineer within 5 Working Days from when each SSF II application shift was completed and all testing results in their entirety at the completion of the job. All SSF II QCP results are required to be submitted to the Engineer, prior to receiving either partial or full payment for SSF II application. The QAI or the Engineer will reject the coating system or reduce payment if the Contractor did not adhere to the QCP or provided inadequate documentation of adherence to the QCP.

Table 2401.3-1
Concrete Coating Inspection Requirements

	Requirements	Frequency/Extent
General	Date, time, and location on Structure	Beginning of each shift or location
	Ambient temperature	Beginning of Work and then every 4 hours
	Dew point and humidity	Beginning of Work and then every 4 hours
	Concrete Surface temperature to be coated with SSF II	Beginning of Work and then every 4 hours
	Wet Film Thickness (WFT) per *ASTM D4414** immediately following the application of the coating (WFT using a wet film thickness gauge provided by the manufacturer of the SSF II product)	Determine and report the mean and range of the readings every 1/2 hour of application time or more as defined by the Engineer (if out of compliance take a reading every 10 minutes until in compliance)
	Visual inspection	100 percent
Surface Preparation Prior to Coating	2401.3F.2, “Formed Surfaces,” and/or 2401.3F.2.b, “Sack Rubbed Surface Finish.” Pre-clean (grind, sand blast, water blast, vapor blast)	Each component to receive an ordinary surface finish coating. Visually inspect 100 percent of concrete area that will receive SSF II and ensure that all applied release agents, curing compounds, dirt, grease, and other deleterious contaminants are completely removed
	2401.3F.3, “Un-Formed Surfaces” Pre-clean (water wash if necessary)	Visually inspect 100 percent for cleanliness
Finish Coat: (Premixed Single Coat System)	Batch/Lot number	Every container
	Verification of surface cleanliness	Examine visually within 1 hour before application
	Temperature of mixed product	Just before application
	Complete mixing of all components in the shipping container	Examine visually every container (no residual components left in container)
	Coating evaluation and repair	Visual, 100 percent
	Recoat time	As recommended by the manufacturer
	Coating system final evaluation and repair	Visual, 100 percent

* *ASTM D4414, Measurement of Wet Film Thickness by Notch Gauges*

F.2.c(2) Application Requirements

Do not start any SSF II coating application until the Engineer has written confirmation from the Department’s Laboratory Director that the product complies with initial color requirements.

Cure concrete as required by 2401.3G, “Concrete Curing and Protection,” and the SSF II manufacturer prior to applying the surface coating. Prepare concrete that is older than 24 hours by power washing with potable water using a minimum of 3500 psi. Remove all efflorescence, flaking coatings, oil, curing compounds, release agents and other deleterious contaminants from the concrete surface prior to the application of the coating. Curing compound and release agent must be completely removed and may require additional means beyond 3500 psi pressure washing, grinding, or blasting as approved by the Engineer.

SSF II may be applied to "un-cured" or "damp" concrete surface per the manufacturer's recommendations provided surface does not show liquid water droplets or pooling.

(1) Department's preferred method: begin SSF II finishing operations only when it is possible to perform the Work continuously from beginning to completion on any one Structure element

(2) Department's alternative method: if continuous SSF II application cannot be accomplished then select coverage zones that will not produce an obvious start/stop delineation line

(3) For cooler times of the year concrete surface finishing operations cannot start when the temperature of the substrate, coating, or ambient air temperature is outside the manufacturer's recommended range. If no recommendation is given, use a minimum of at least 40°F and rising ambient air temperature. Suspend surface finishing operations if the ambient air temperature falls to 45°F and is dropping. Avoid application in direct sunlight to minimize a premature dry-out condition

Single-component coatings require the SSF II product to be thoroughly mixed in its original container, then remixed as necessary and as recommended by the manufacturer to keep components in suspension and to incorporate the color pigments. If the SSF II product is shipped in 5 gallon containers, thoroughly mix the contents then completely empty all the contents into a larger container maintaining a minimum of 15 gallons of uniformly mixed product at all times. Equip the large container with an agitator during spraying. Provide an agitator or stirring rod capable of reaching within 2 inches of the bottom of the 15 gallon container to keep the product thoroughly mixed during application.

Supply a manufactured SSF II product that doesn't require thinning. Thinning of SSF II product is not allowed and the Engineer will reject all thinned SSF II product. Any SSF II product thinned and then applied will be required to be completely removed and replaced, at no cost to the Department.

The Engineer will require the complete removal of all SSF II that is adversely affected by moisture within the first 24 hours after SSF II placement. Once all SSF II is removed, recoat concrete with SSF II to original specified requirements referenced above, at no cost to the Department.

Apply one coat of the SSF II mixture by spray application only, using spray Equipment as recommended by the manufacturer. Use the minimum coverage rate of wet mils as defined on the Department APL for applying the Material. The Engineer will reject, require removal, and recoating of concrete with SSF II if runs, sags, excessive build-up, or overlap of texture causes a non-uniform appearance.

Perform surface finishing that produces a uniform color and texture on the cured surface. To prevent a non-uniform appearance "Tiger-Stripping" of the texture limit the overlap of each spray applied pass of the coating. The final SSF II surface finish will not have laps or breaks in continuity. Perform corrective Work on unaccepted finished areas coated with SSF II as directed by the Engineer, at no additional cost to the Department.

Protect non-coated surfaces from overspray. If the Engineer determines that the overspray damage is non-conforming the Engineer will direct that the overspray be removed, at no additional cost to the Department.

F.2.d Curb, Sidewalk, and Median Finish

Provide a surface finish on formed surfaces of medians, delineator curbs, and the Roadway face of curbs and Sidewalks in accordance with the following:

(1) Begin ordinary surface finish operations immediately after removing the forms and Work continuously to completion. As the ordinary surface finish progresses, rub the surface with a cork float or fine Carborundrum stone to produce a paste on the surface and to expose and fill depressions and surface cavities. Float the paste to a smooth surface free of coarse texture, swirls, and ridges. Before the surface sets, brush the surface lightly with a fine bristled brush to remove cement films and produce a uniform surface with a fine grained and sanded texture

(2) Complete the surface finishing of the formed surface within 12 hours after concrete placement

F.2.e Barrier Surface Tolerance

Do not allow horizontal or vertical irregularities greater than 1/4 inch in any 10 foot length of finished concrete barrier. The Engineer may reject surfaces and edges not meeting this tolerance as unacceptable Work in accordance with 1512, "Unacceptable and Unauthorized Work." Remove and replace unacceptable Work as directed by the Engineer. Remove and replace extensive areas (greater than 10 percent of barrier length) with deviations greater than 1/2 inch. If the Engineer does not direct the Contractor to remove and replace unacceptable Work, the Contractor may leave the Work in place with the following price adjustments:

(1) For deviations from 5/16 inch to 1/2 inch, the Department will pay for concrete barrier at 75 percent of the Contract Unit Price

(2) For minor areas (less than or equal to 10 percent of barrier length) with deviations greater than 1/2 inch, the Department will pay for concrete barrier at 50 percent of the Contract Unit Price

F.3 Unformed Surfaces

F.3.a Miscellaneous Unformed Surfaces

Finish unformed upper horizontal and inclined surfaces, except for the surface of Bridge Slabs and the surface at horizontal construction joints, in accordance with the following:

Do not use steel trowels and steel shod floats. Use wood or wood shod templates and strike-offs. Use hand floats and darbies with wood, canvas, rubber, or cork contact surfaces. Use metal edgers that do not form offsets greater than 1/16 inch in the concrete surface. Do not create waves in the concrete surface when edging. In lieu of using an edger, the Contractor may form rounded corners using a cove strip that does not create an offset greater than 1/16 inch with adjacent concrete surfaces.

Place excess concrete in the forms and compact by internal vibration. After a 30 minute delay, strike off and screed the surface with a template forcing the coarse Aggregate below the finished surface leaving the surface slightly above finished elevation to allow for settlement during curing. Repeat the screeding and strike-off operation to obtain the elevation shown on the Plans and contour, except for edging. Waste laitance and excess mortar outside of the forms. After the final strike off and screeding, hand float the surface to correct irregularities and seal surface tears. Immediately after the water sheen leaves the surface, rework the surface to a uniform texture using a float. Tool rounded corners and edges to final radius forcing the coarse Aggregate beneath the finished radius. Float to remove trails left by the edging tools.

Apply final texture and finish to the surface in accordance with the following:

(1) Brush or broom Bridge curbs and Sidewalks and the floor slabs, Ramps, landings, and stair treads for pedestrian Bridges and tunnels in a transverse direction using a fairly stiff bristled brush or broom to produce a surface finish meeting the following requirements and characteristics:

(a) Visibly serrated
(b) Not slippery when wet
(c) Uniform throughout in texture and appearance

(2) Brush the cement film from the surface to provide a uniform, fine grained, sanded texture using a fine bristled brush.

Ensure the finished surface does not vary by greater than 1/8 inch from a 10 foot straightedge laid longitudinally on the surface, with transverse surfaces substantially as shown on the Plans.

F.3.b Bearing Seats

F.3.b(1) Prior to casting bearing seats

Construct the bearing seat forms, at time of form setting, within a 0.01 foot accuracy tolerance. The contractor may elect to build bearing seat forms at a higher elevation with subsequent grinding to come back into elevation tolerance provided no ponding areas result on top of the bearing seat. If bearing seats are built to a higher elevation, increase top concrete cover by the same amount.

Where anchor rod blockouts are incorporated within the forms, the blockouts may be tied individually or with a template rigidly joining a blockout group. All anchor rod blockouts at a given bearing seat comprise a blockout group. The location tolerance for individual blockouts is 1/16 inch within the blockout group. Position the blockout group to enable placement of the bearing assembly within 1/4 inch of the Plan center bearing position. Refer to the Plan and adhere to all requirements of 2472.3C, "Placing, Supporting, and Tying Bar Reinforcement." Survey the center of individual blockouts prior to casting concrete and provide the X and Y coordinate data to the Engineer. Adjust any blockouts that are out of tolerance. Survey final blockout positions and provide the X and Y coordinate data to the Engineer.

F.3.b(2) After meeting the curing requirements as specified for bearing seat concrete

Grind the Bridge seats to produce a level surface area that does not vary by greater than 1/16 inch for steel base plates or by greater than 1/8 inch for elastomeric bearing pads. The level surface area is defined as an area with a boundary 2 inches outside the bearing contact area on all sides. Grind surfaces outside the level surface area to prevent ponding. Adjust the level surface area if any of the tolerances are exceeded.

After grinding the level surface area, field-survey bearing seats at center of bearing and provide an electronic copy of the X and Y coordinates and elevations to the Engineer.

When anchor rod blockouts are cast into the bearing seat, survey the center of each blockout position and provide the information to the Engineer.

F.3.b(3) Adjustments to Leveled Bearing Seats

Prior to adjusting any level surface areas or bearing seats, submit the proposed method, Material specifications, and required adjustment for each bearing seat to the Engineer. The Engineer must accept the correction proposal in writing prior to proceeding with any Bridge seat modifications.

Adjust the level surface area when the differential between adjacent level surface areas deviates by more than:

(1) 1/8 inch for steel framing fabricated by "full assembly" as specified in 2471,"Structural Metals"
(2) 3/8 inch for all other Bridges

The differential between adjacent bearings can be calculated as follows: $\Delta = |(\text{Plan elevation beam A} - \text{survey elevation beam A}) - (\text{Plan elevation beam B} - \text{survey elevation beam B})|$

At a given line of bearing or within the same Substructure, produce bearing seats within the following accuracy:

(1) Seats may be no more than 3/4 inch low from Plan elevation for the lowest seat at a given Substructure
(2) Seats may be no more than 3/8 inch high from Plan elevation for the highest seat at a given Substructure

The Plan elevation in the sections above mean the bearing seat elevation shown in the Bridge Plans adjusted for the actual bearing heights which have been approved by the Engineer.

F.3.c Bridge Slabs

F.3.c(1) General

Before placing concrete for a section of Bridge Slab, and after setting the strike-off rails or guides to correct elevation, check the top reinforcement for vertical position by operating the strike-off on the rails or guides in the presence of the Engineer. Attach a filler strip 1/4 inch thinner than the minimum concrete cover requirements to the bottom of the strike-off during this check to detect reinforcement bars that may encroach on the required clearance.

Place any of the following in a continuous operation proceeding uniformly from edge to edge of the slab or from end to end of the section:

(1) Each Bridge Slab section between joints
(2) Each Bridge Slab section between an end bulk-head and a joint
(3) With no joints specified, the entire slab

If the Contract does not require a specific sequence or direction for casting slab sections, submit Plans for the proposed casting procedures for approval. Before starting construction, obtain the Engineer’s approval for any change to the casting Plans.

If Bridge Sab placement and finishing is performed at night, provide a Well Lighted area to accomplish QC/QA inspections.

If at least two spans of continuous beams or girders support a Bridge Slab section, place concrete at a rate that concrete will remain plastic for at least one-half a span length back of an intermediate support until placement has proceeded to a point one-half of the span length ahead of that support. Provide approved admixtures to retard concrete setting time as required to maintain plasticity.

If simple span girders support a Bridge Slab section or if the Contract requires sequence casting for wide continuous beam Bridge decks, place concrete at a forward rate of at least 20 feet per hour without producing cold joints between partially hardened concrete and the adjacent newly placed concrete.

At least 14 Calendar Days prior to slab placement, provide a slab placement and curing Plan for each Bridge to the Engineer for approval. Include the following information in the placement and curing Plan:

(1) Anticipated concrete delivery rates
(2) Estimated start and finish time
(3) Material, labor and Equipment proposed for placing, finishing, and curing including placement of wet burlap, soaker hose, or other system to maintain the deck in a moist condition during the curing period
(4) Number of Work Bridges proposed for use
(5) Number of people responsible for the various tasks
(6) Bulkheading methods and Materials proposed for use if the Contractor cannot maintain the proposed concrete placement rates

Attend a pre-placement meeting 2-4 Calendar Days before the slab placement to review the information and details provided in the placement and curing Plan. The following project personnel are required to attend the pre-placement meeting:

(1) Contractor, including Superintendent and foremen
(2) Engineer
(3) Concrete supplier
(4) Concrete pump supplier, if requested by the Engineer

F.3.c(2) On-site Adjustments for Bridge Slab Concrete

In addition to the requirements set forth in 2461.3G.4, "Field Adjustments," comply with the following if any adjustments are necessary on site:

(1) Only admixtures originally incorporated into the mix will be allowed with the exception that viscosity modifying admixture (VMA) may be used to adjust slump
(2) A maximum of 1 gallon of water addition per cubic yard of concrete, including the any water necessary to dilute admixtures, may be on site provided that additional water is available to add per the Certificate of Compliance
(3) Mix the load a minimum of 5 minutes or 50 revolutions after any additions

The Engineer will not allow finishing aids or evaporation retarders for use in finishing of the concrete.

F.3.c(3) Trial Bridge Deck Placement for HPC

A minimum of 14 Calendar Days prior to the actual placement of the Bridge Deck Slab concrete, successfully complete a separate trial placement utilizing a minimum of two 10 cubic yard loads.

The Engineer may allow the incorporation of the concrete for trial batches into the Bridge footings, abutments, or end diaphragms. The Contractor may also choose to incorporate the trial batches into residential/commercial construction in the immediate vicinity of the Project. In any case, the Engineer will require mixing, transporting, and placing the concrete using the same methods as the actual placement of the Bridge deck.

If the concrete is incorporated into the permanent Work, the Engineer will test the plastic concrete in accordance with the *Schedule of Materials Control*. The Engineer may require additional trial batches if the concrete delivered to the Project does not comply with the plastic concrete requirements of the Contract.

The Engineer will waive a trial placement, at the Contractor’s request, provided the Contractor submits a history of at least 3 successful Bridge deck placements in the last 5 years using the same mix design and similar pumping or placement configuration.

The concrete mix design, laboratory batching and mixing, and the trial placement are included in Bridge Slab Concrete.

Use the same Materials, same supplier, same supplier's manufacturing plant, and proportions in the permanent Work as in the trial placement. Strength requirements specified for each mix are applicable to the cylinder tests taken during the production Work.

F.3.c(4) Strike-Off of Bridge Slab (Applies to both Bridge Deck Slab and Bridge Structural Slab)

Place the concrete at a rate that ensures the initial strike-off operation is never greater than 10 feet behind the placement operation. Maintain the head of concrete parallel with the initially screeded surface. Leave excess concrete carried in front of the screed on the surface when reaching the head of the concrete. Mix with freshly deposited concrete before compacting. Consolidate any previously consolidated concrete to remove voids, including those caused by footprints or reinforcement deflection.

Strike off and screed the Roadway surface after concrete placement and compaction. When the initial strike-off operation reveals low areas, fill these areas with additional concrete before continuing. Avoid walking in the concrete after the initial pass of the screed. Re-screed to the cross-slope and longitudinal profile as required by the Contract.

Do not Work, smooth, or disturb the concrete surface while bleed water and laitance remain on the surface.

If the use of a power-operated strike-off screed is specified, provide mechanical screeding motion with Equipment moving on flanged or grooved wheels resting on the screed rails. If exterior beams or girders that lie under the Roadway slab support the running rails, the Contractor may finish the area between the rail and the gutter without the use of the power-operated screed. In this area, use suitable guides to determine the required gutter profile and, after plastic shrinkage, straighten and true the area to the required profile and cross-slope. Ensure the screed carries a surplus of concrete in the front during screeding operations. Perform the final screeding to cover as long a section as practicable without stopping.

Remove at least the upper 4 inches of screed rail supports and fill void with concrete. Any supports left in the deck shall be epoxy coated or galvanized.

<u>Bridge Structural Slabs</u>

The Department will not require screed rails for templates used for strike-off and screeding of a Bridge Structural Slab. If using screed rails, use screed rails in accordance with this section.

Securely tie and rigidly support top reinforcement in accordance with 2472.3C, "Placing, Supporting, and Tying Bar Reinforcement." Before placing the concrete, demonstrate that the Equipment and methods proposed for use will not damage or displace reinforcement bars. Provide additional bar support, additional supports for template, or both upon visible deflections of reinforcement.

Demonstrate adjustments for crown breaks as approved by the Engineer. Evenly attach vibrators across template length and provide templates that will automatically shut-off vibration when forward motion stops.

Space template supports to prevent sag in the template. For portions of template supports in contact with reinforcement, provide template supports consisting of round tubes or rods with a smooth, low friction surface. Provide skis at least 5 feet long with a gradual “turn-up” nose sufficient to prevent entrapment in reinforcement. Support transverse reinforcement bars within 6 inches of the location where template support skis will ride.

Provide a manual or powered winch to advance the template. Do not anchor winch cables to reinforcement bars. The Contractor may attach the winch cable to beam shear studs or stirrups.

Spread and level concrete in front of template without causing “float” or overriding. Hand-float the surface of Bridge Structural Slabs only to close up areas of exposed Aggregate.

Bridge Deck Slabs (Bridge slabs without separate concrete wearing course)

Use a self-propelled power-operated strike-off machine to screed the Roadway surface of monolithic Bridge Deck Slabs. Provide a finishing machine consisting of a cylindrical finisher mated with horizontal adjustable augers, both of which are mounted on a transversely moving carriage. Sidewalk surfaces to be separated by a permanent concrete barrier may be screeded with strike off Equipment conforming to 2401.3F.3.c(4), “Strike-off of Bridge Slab (Applies to both Bridge Deck Slab and Bridge Structural Slab),” meeting the finish tolerances for Bridge Deck Slabs.

Use rails, bulk-heads, or the side forms as screed guides for manual strike-off. Use rails as guides for power-operated strike-offs, with provisions for vertical adjustment. Support the screed rails for power-operated screeds on the exterior beams, girders, or webs of the Structure. Provide calculations and obtain the Engineer’s approval if planning to support screed rails on the side forms or on any falsework independent of the Superstructure.

Construct screed rails in a manner that will allow vertical adjustment after concrete is placed on concrete deck girders and concrete slab span Bridges. During concrete placement, check elevations and vertically adjust if necessary.

For full depth monolithic decks, the finishing machine will consist of a cylindrical finisher mated with horizontal adjustable augers, both of which are mounted on a transversely moving carriage unless otherwise approved by the State Bridge Construction Engineer.

A 10 foot Highway straightedge is required for full-depth decks prior to carpet dragging regardless of whether texture planing is specified for the final ride surface. Float slab in accordance with *Bridge Construction Manual* 5-393.358 to ensure the final surface does not vary by greater than 1/8 inch within a 10 foot straightedge laid longitudinally on the final surface. This surface tolerance includes areas near expansion devices and other breaks in the continuity of the Bridge Slab.

If an outside webwall of a box girder is under a Sidewalk or curb, the Contractor may modify the Sidewalk or curb reinforcement to accommodate the running rail system for the power strike-off machine as approved by the Engineer and at no additional cost to the Department.

F.3.c(5) Final Finish Texture

Draw a carpet drag longitudinally along the Bridge Slab before the concrete attains its initial set to obtain a final finish texture. Adjust the carpet drag to produce a texture accepted by the Engineer. Use a carpet drag meeting the following characteristics and requirements:

(1) Mounted on a Work Bridge
(2) A longitudinal length of 3 feet
(3) Width equal to the concrete placed
(4) Artificial grass type
(5) Molded polyethylene pile face
(6) Blade length of from 5/8 inch to 1 inch
(7) Total weight of at least 70 ounces per square yard

In lieu of the carpet drag texturing, the Contractor may use coarse broom texturing as accepted by the Engineer.

Texture the Roadway surface as accepted by the Engineer to produce a final surface serrated, grooved, or roughened greater than that normally produced by conventional brooming. Do not tear out or loosen particles of coarse Aggregate during texturing.

Produce a final surface, including areas near expansion joints, meeting the following requirements:

(1) Free of porous spots and irregularities
(2) Have the required crown
(3) Does not vary by greater than 3/8 inch on a Bridge Structural Slab when checked with a 10 foot straightedge placed longitudinally
(4) Does not vary by greater than 1/8 inch on a Bridge Deck Slab when checked with a 10 foot straightedge placed longitudinally

Immediately following the carpet drag, texture final Roadway surfaces with a metal-tine pattern unless a diamond-ground texture is scheduled for the surface as part of the Contract. Install the transverse texturing (tining) on a slight diagonal, at an angle of approximately 10 degrees to a line perpendicular to the Roadway centerline, produced by using a device meeting the following characteristics and requirements:

(1) Equipped with steel tines from 4 inch to 6 inch long and from 1/12 inch to 1/8 inch thick
(2) Steel tines arranged to obtain randomized grooves from 1/8 inch to 5/16 inch deep
(3) Variable spacing between tines from 5/8 inch to 1 inch

The Contractor may use other texturing Equipment that will produce an equivalent texture as accepted by the Engineer. Do not texture within 1 foot of curbs.

F.3.c(6) Bridge Slab Finish Under Curbs, Concrete Barriers, Sidewalks, and Medians

Float the top surface of the Bridge Slab under curbs, concrete barriers, Sidewalks, and narrow medians producing a rough surface with the coarse Aggregate embedded in mortar. Provide a smooth finished strip 2 inches wide at the edge of the slab and under the Roadway face of curbs, concrete barriers, Sidewalks, and narrow medians.

Choose one of the following alternates to prepare the top surface of the Roadway slab directly under island type medians:

(1) Sandblast or shotblast the slab surface to remove laitance. Apply a cement bonding grout to the concrete consisting of Portland cement mixed with water forming a slurry having the consistency of paint before placing median concrete. Place median concrete on wet bonding grout.

(2) Drill and anchor 1/2 inch diameter epoxy coated reinforcement bars (dowels) into the slab parallel to each median gutterline. Place the dowels 1 foot in from the gutterlines at 2 foot centers. Drill the dowels at least 4 inches into the Roadway slab and projecting 4 inches into the median concrete. Anchor the dowels with an approved epoxy or approved non-shrink grout.

F.3.c(7) Bridge Slab Finish for Bottom Slab Concrete Box Girders

Strike off the top surface of the concrete in the bottom slab of concrete box girders and finish to within a 1/4 inch tolerance when checked with a 10 foot straightedge. The Department will not require additional finishing of this surface.

F.3.c(8) Surface Smoothness Check

After completion of the curing period, the Engineer will check the Bridge Deck Slab surface for trueness, using a 10 foot straightedge for transverse and longitudinal checks. The Engineer will perform at least 2 longitudinal checks in each Traffic Lane and 1 check at each gutter. Sweep the surface clean of debris before the Engineer performs the checks.

Correct surfaces outside of the specified tolerance of a 10 foot straightedge in accordance with 2401.3F.3.c(5), “Final Finish Texture.” Mill high spots. Remove concrete in low spots designated for removal to at least 2 inches below required grade and then recast to the proper grade with an approved product. Restore removed tine texture. The nonconforming areas not satisfactorily corrected are subject to 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

Remove high spots before filling adjacent depressions. If not placing a wearing course, coat areas corrected by surface grinding with a surface sealer listed on the *Approved/Qualified Products List*.

G Concrete Curing and Protection

Cure newly placed concrete by providing protection against the following:

(1) Rapid loss of moisture
(2) Freezing temperatures;
(3) High temperatures
(4) Abrupt temperature changes
(5) Vibration exceeding limits specified in 2401.3G.7, “Protection of New Concrete against Vibration”
(6) Shock waves
(7) Prematurely applied loads

Should any damage result, the Engineer will suspend operations until corrective action is taken and may subject the damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

Perform the following for defective sections as directed by the Engineer:

(1) Remove and replace
(2) Remove to a depth as directed by the Engineer and replace
(3) Cover with an approved concrete sealer/overlay

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

G.1 Minimum Curing Period

For the purpose of the Work in section 2401.3, “Concrete Bridge Construction, Construction Requirements,” the Department defines the "curing period" as the time of maintaining satisfactory moisture and temperature in concrete during the period immediately following placement through the specified duration, so that hydration of the cement may continue until development of the desired properties to a sufficient degree to meet the required service life. In no case, will the concrete surface show evidence of drying which includes surface color changes during the curing period.

Maintain a minimum concrete surface temperature of 40°F or greater during the curing period. If the concrete surface temperature drops below 40°F during the curing period, notify the Engineer and make adjustments to the curing to raise the surface temperature above 40°F as prescribed in the curing Plan. If the concrete surface temperature drops below 40°F during the curing period, add one additional day to the minimum curing period for each day the temperature drops below 40°F. Provide additional protection as required in accordance with 2401.3G.5, "Protection Against Cold Weather."

The Engineer may allow some modification of the requirement for continuous curing without interruption for the purpose of setting wall or column forms on footings, but only when the Contractor protects the concrete from freezing or excessive drying during the interruption period. Resume curing at the earliest opportunity, and cure until completion of the curing period. If using heated enclosures during the curing period, vent heaters and other Equipment operated within the enclosure to prevent the buildup of carbon dioxide.

When the Plans show a permissible construction joint, the Contractor may begin subsequent concrete placement before completion of the curing period, unless otherwise shown on the Plans.

Determine the minimum curing period for a given element in accordance with Table 2401.3-2 and the following:

(1) High-early concrete is not allowed to accelerate strength to aid in earlier form removal
(2) The Contractor may remove forms for curbs, Sidewalks, median barrier, and barriers when the concrete can retain its shape and if weather conditions allow the start of the specified concrete finish per 2401.3F.2.d, "Curb, Sidewalk, and Median Finish," immediately after removing the forms. Other forms are required to remain in place for at least 24 hours after casting the concrete or longer if stripping the forms will damage the concrete or prevent disengaging the form ties, unless otherwise noted in Table 2401.3-2
(3) If forms are removed prior to the completion of the curing period, resume 100 percent curing coverage within 30 minutes for each formed face. The Engineer may consider revisions to the 30 minute requirement for continuous curing based on field conditions, measured evaporation rates, and the submitted curing Plan in accordance with 2401.3G.3, "Curing Plan"
(4) Cracking the forms loose the next day is acceptable so long as the concrete surface remains moist for duration of curing period

Table 2401.3-2
Curing Requirements for Concrete Bridge Elements
For all formed and unformed concrete
(Do not use for Mass Concrete)

Bridge Element	**Minimum Curing Period**	**Minimum Period For Form Cure**	**Minimum Strength Required to Pull Forms, psi**	**Minimum Strength to Apply Loads, percent of Required †**	**Method Allowed to Determine In-place Concrete Strength**
Bridge Superstructures, unless otherwise specified	96 hours	24 hours	2000 ‡	65	Maturity or Control Cylinders
Slab Span Superstructure	7 Calendar Days	8 Calendar Days	See Special Provisions	See special provisions	Maturity or Control Cylinders
Diaphragms and end webs not a part of box girders and cast before the Bridge Slab	72 hours	24 hours	2000 ‡	45	Maturity or Control Cylinders
Pier Caps	72 hours	72 hours	2000 ‡	65	Maturity or Control Cylinders
Retaining Walls	72 hours	12 hours *	Self-supporting	100	Maturity or Control Cylinders
Barriers and Parapets	72 hours	-	Self-supporting	45 ‖	Maturity or Control Cylinders
Sections not included in Superstructures, unless otherwise specified	72 hours	24 hours	2000 ‡	45	Maturity or Control Cylinders
Bridge Slab #	7 Calendar Days	-	-	100 §	Maturity or Control Cylinders
Bridge Slab Underside #	7 Calendar Days	8 Calendar Days	2000	100	-

* When weather conditions require cold weather protection in accordance with 2401.3G.5, "Protection Against Cold Weather," increase form curing to a minimum of 24 hours.
‖ Achieve 4000 psi prior to use as a traffic barrier.
† Applied loads include but are not limited to Equipment, beams, backfilling, or successive concrete placements.
‡ The Engineer will require verification of the minimum strength when air temperatures drop below 40°F during the curing period or when the mix design includes greater than 15 percent cement substitution. The minimum strength requirement does not apply to bulkheads and edge of deck forms.
# See Table 2401.3-4 for Bridge Slab curing method.
§ See 2401.3G.6.e, "Protection from premature loading" for special loading allowances after wet cure and prior to specified strength.

G.2 Acceptable Curing Methods

Cure concrete in accordance with Table 2401.3-3. Use methods necessary to comply with the minimum curing period.

Do not apply membrane curing compound to construction joints, or to concrete surfaces which are planned for bonding to other concrete, waterproofing, applying sealants or special surface finish, except as allowed in accordance with Table 2401.3-3. Ensure steel reinforcement, anchors, waterstops, and similar devices are free of membrane curing compound prior to placing concrete.

Table 2401.3-3
Acceptable Curing Methods
(Do not use for Mass Concrete)

<table>
<tr><th rowspan="2" colspan="2">Element</th><th rowspan="2">Special Surface Finish Required</th><th colspan="2">Membrane Curing Method (2401.3G.2.a, "Membrane Curing Method")</th><th rowspan="2">2401.3G.2.b, "Curing Blanket Method"</th><th rowspan="2">Wet Curing Method (2401.3G. 2.c, "Wet Curing Method")</th><th rowspan="2">2401.3G.2.d, "Formed Curing Method"</th><th rowspan="2">Single Component SSF II Cure Method (2401.3F.2.c, "Special Surface Finish")</th></tr>
<tr><th>3754, "Poly-Alpha Methyl styrene (AMS) Membrane Curing Compound"</th><th>3753, "Type 1-D Membrane Curing Compound"</th></tr>
<tr><td colspan="2">Footing</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>N/A</td></tr>
<tr><td colspan="2">Pier Cap</td><td>Yes</td><td>No</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="2">Pier Column</td><td>Yes</td><td>No</td><td>Yes*</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="2">Abutment, Retaining Wall and Wingwall</td><td>Front Face</td><td>Yes</td><td>No</td><td>Yes*</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Back Face</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>N/A</td></tr>
<tr><td>Concrete Barrier, Parapet, and End Post</td><td>All Faces of Surface</td><td>Yes</td><td>No</td><td>Yes*</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="2">Pier Strut</td><td>Yes</td><td>No</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>No</td></tr>
<tr><td colspan="2">Cast-in-Place Box Culvert</td><td>No</td><td>Yes</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>N/A</td></tr>
<tr><td colspan="2">Sidewalk, Raised Median</td><td>No</td><td>Yes</td><td>No</td><td>Yes</td><td>Yes</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Coping, Edge of Slab</td><td>Yes</td><td>No</td><td>No</td><td>Yes</td><td>Yes</td><td>Yes</td><td>No</td></tr>
<tr><td colspan="2">Bridge Deck Slab or Bridge Deck</td><td>No</td><td colspan="6">Refer to 2401.3G.6, "Concrete Bridge Deck Curing and Protection"</td></tr>
<tr><td colspan="9">* The Engineer will allow the use of curing compounds meeting 3753, "Type 1-D Membrane Curing Compound," provided a letter from the special surface finish manufacturer states the proposed curing compound is compatible with the special surface finish. Remove remaining membrane curing compound that has not completely dissipated from the surface prior to applying special surface finish. Removal will be required by means of sandblasting, grinding, or other approved methods.</td></tr>
</table>

G.2.a Membrane Curing Method

Use membrane curing compound meeting the requirements of 3754, "Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound," or 3753, "Type 1-D

Membrane Curing Compound." Use the same type of curing compound on the entire individual element.

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

Apply the curing compound in accordance with the following:

(1) At a minimum rate of 1 gallon per 150 square feet of surface curing area
(2) Apply curing compound homogeneously to provide a uniform, solid, white, opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper). If using a Department approved curing compound with a non-white base color, apply the compound to provide a uniform, solid, opaque consistency meeting the intent of the requirement in this section
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by respraying
(4) If the Engineer determines that the initial or corrective spraying results in unsatisfactory curing, the Engineer may require the Contractor to use an alternate curing method, at no additional cost to the Department

Use an airless spraying machine that complies with the following:

(1) A recirculating bypass system that provides for continuous agitation of the reservoir Material
(2) Separate filters for the hose and nozzle
(3) Multiple or adjustable nozzle system that provides for variable spray patterns

G.2.b Curing Blanket Method

After completion of the finishing operations and without marring the concrete, cover the concrete with pre-wetted burlap or curing blankets. Install in a manner that envelops the exposed concrete and prevents loss of water vapor.

Six mil (minimum) white plastic sheeting over a layer of wet burlap or a wet curing blanket is a method of cure in which the loss of mixing water is minimized due to the tight nature of the cover. Install the envelope in accordance with the following:

(1) Overlap the plastic sheeting or burlap or curing blankets a minimum of 12 inches at the seams to maintain a reasonably air tight seal. Secure the edges of the sheeting by any means satisfactory to the Engineer to provide an air-tight cover
(2) On vertical and overhead surfaces they should be held in this position by wire or rope fasteners. They should be held in position on Roadway and Sidewalk slabs by holding down the burlap or blankets with sand or lumber at the joints and edges
(3) Place burlap or curing blankets in close contact with the concrete and add water as necessary to assure that the concrete surface is moist at all times

(4) When using the curing blanket method over areas where reinforcement is exposed use one of the following methods:

(a) Place wet burlap or wet curing blankets in the exposed area, drape plastic over the tops of the reinforcement, and weigh down the plastic adjacent to the exposed areas
(b) Puncture the plastic sheeting and place it directly over the burlap or curing blankets with the reinforcement projecting through the plastic sheeting. Do not allow the burlap or curing blankets to dry out during the curing period

G.2.c Wet Curing Method

Cover the surface of the concrete with pre-wetted burlap as soon as the concrete has hardened sufficiently to prevent marring the surface. Pre-soak the burlap for a minimum of 12 hours prior to placement. Overlap the burlap a minimum of 12 inches. The Engineer will not allow the application of dry burlap and then sprayed down with water as an acceptable wet cure method.

Overlap spray with soaker hoses or sprinklers to keep unformed surfaces continuously wet for the minimum curing period, unless another curing method is used. Use water for curing in accordance with 3906, "Water for Concrete and Mortar."

Limit the amount of water applied to the amount that will keep the concrete wet without running sheets or streams. If the concrete surface shows evidence of erosion by the curing water, the Engineer will immediately suspend the spraying or fogging. Remedy the conditions causing erosion or switch to another cure method that does not involve continuous wet cure.

If the National Weather Service forecast for the construction area predicts air temperatures to fall below 32°F within the next 24 hours, suspend conventional wet curing and switch to another acceptable curing method in accordance with 2401.3G.5"Protection Against Cold Weather."

G.2.d Formed Curing Method

When forms are left in direct contact with the concrete, other curing methods are not required except for exposed surfaces and for cold weather protection. Use another acceptable curing method if forms are removed prior to completion of the minimum curing period.

G.3 Curing Plan

At least 14 Calendar Days prior to any concrete placement, provide a curing Plan to the Engineer for acceptance, in writing. Submit a separate curing Plan for the Bridge Deck in accordance with section 2401.3F.3.c(1), “General,” and 2401.3G.6, “Concrete Bridge Deck Curing and Protection.” A sample curing plan is available upon request. Include the following information in the curing Plan:

(1) Curing method for each element
(2) Method and frequency for verifying no surface drying is occurring
(3) Quality Control person(s) name(s) for ensuring cure is maintained according to curing Plan
(4) Coverage rate, tint color, and dry film thickness for any membrane curing compounds
(5) Special surface finish manufacturer letter stating conditions for placing special surface finish over any membrane curing compounds products

(6) Method to maintain a minimum concrete surface temperature of 40°F or greater during the curing period. Action plan to restore surface temperature should the temperature drop below 40°F
(7) If cold weather conditions are anticipated during the Project, submit a cold weather protection Plan in accordance with 2401.3G.5, “Protection Against Cold Weather”
(8) If it is anticipated that continuous curing will be interrupted for more than 30 minutes, include a table stating what expected weather conditions at time of form removal and applicable curing requirements are necessary to ensure a maximum evaporation rate of 0.3 pounds per square feet per hour is not exceeded in accordance with Figure 2401.3-1

For each structural element, complete the MnDOT *Concrete Curing Quality Control Form* on the Bridge website. Submit completed forms to the Engineer within 7 Calendar Days of completing the structural element.

Failure to adhere to the Engineer accepted Contractor’s curing Plan or observation of any surface drying during the curing period will result in a curing qualification period as follows:

(1) For the next three concrete placements, of similar construction the forms are to remain in place for the minimum curing period
(2) Once curing period is complete, demonstrate the curing Plan procedures in the presence of the Engineer prior to reinstating the curing Plan on new Work

G.4 Protection Against Rain

Protect the concrete from damage due to rain or snow. Have available, near the site of the Work, Materials for protection of the edges and surface of the concrete. Should any damage result, the Engineer will suspend operations until corrective action is taken and may subject the rain or snow damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." Do not start concrete placement when it is raining or snowing.

G.5 Protection Against Cold Weather

Protect the concrete in accordance with the Engineer accepted cold weather protection Plan during the following periods:

(1) October 1 to April 15 when working north of the 46th parallel
(2) October 15 to April 15 when working south of the 46th parallel

The Engineer will not permit the membrane curing method during the dates specified herein.

The Engineer will base anticipated concrete placement and curing temperatures on weather forecasts or on typical temperature data for the time of year at the location of the Structure.

Preheat the forms, in-place concrete, reinforcement bars, and items including the top flanges of beams to a minimum of 40°F when the temperatures of these surface areas are below freezing before placing concrete. Do not apply flames directly to concrete or steel.

Provide insulated forms, insulation, or heating and housing facilities to maintain a concrete surface temperature of between 60°F and 120°F during the curing period. The Engineer may allow the concrete surface temperature of between 50°F and 120°F for concrete with strengths equal to or greater than 75 percent of the required compressive strength but not less than 4,000 psi.

Protect all exposed concrete surfaces within the heated enclosures from drying and carbonation throughout the curing period by using one of the acceptable curing methods and:

(1) Vent the heated enclosures to prevent the buildup of carbon dioxide
(2) Ensure a reasonably uniform temperature throughout the enclosure

Keep the forms, insulation, and housing enclosure in place until the completion of cold weather protection as defined in 2401.3G, “Concrete Curing and Protection.”

Gradually discontinue the use of cold weather protection so the rate of temperature reduction adjacent to the concrete surfaces does not exceed 20°F during any 12 hour period until the surface temperature reaches the ambient air temperature.

G.5.a Cold Weather Protection Plan

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

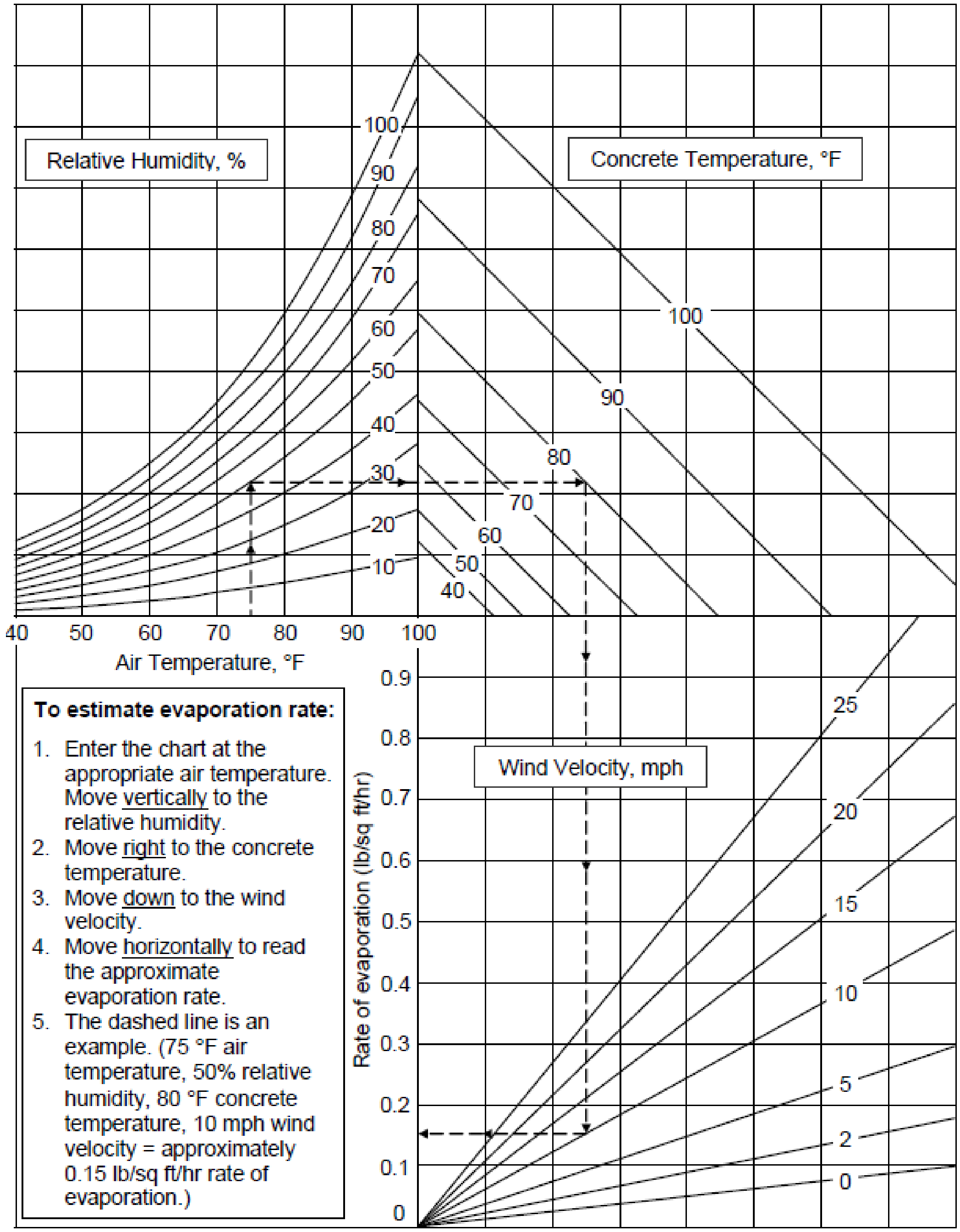
G.6 Concrete Bridge Deck Curing and Protection

G.6.a Prior to Beginning Bridge Deck Concrete Placement

Three hours before the anticipated time of beginning the Bridge deck concrete placement, the Contractor will provide a National Weather Service forecast to the Engineer.

The Engineer will review the forecast with the Contractor to confirm:

(1) There is no forecasted precipitation two hours prior to, during, and up to 2 hours after the placement duration
(2) Less than 30 percent chance of precipitation for the entire placement window
(3) The combination of air temperature, relative humidity, concrete temperature and wind velocity produces an evaporation rate of less than 0.20 pounds per square foot of surface area per hour, according to Figure 2401.3-1



[1] Based on ACI 305 R, "Hot Weathering Concreting"

Figure 2401.3-1

G.6.b Curing Method

The Contractor is fully responsible for curing methods. Cure the concrete Bridge deck in accordance with Table 2401.3-4, unless other methods are approved by the Engineer in writing.

Table 2401.3-4
Required Curing Method Based on Final Bridge Deck Surface

Bridge Deck Type	Final Bridge Deck Surface	Required Curing Method ‖
Bridge Structural Slab curing (3YHPC-S) (3YLCHPC-S) (3Y42-S)	Low Slump Wearing Course	Conventional wet curing after carpet drag
Bridge Deck Slab curing (3YHPC-M) (3YLCHPC-M) (3Y42-M)	Epoxy Chip Seal Wearing Course or Premixed Polymer Wearing Course	Conventional wet curing after carpet drag
	Bridge Deck Planing	Conventional wet curing after carpet drag
	Tined Texturing*	Conventional wet curing after tine texturing. AMS curing compound after wet cure period
	Finished Sidewalk or Trail Portion of Deck (without separate pour above)*	Conventional wet curing after applying transverse broom finish AMS curing compound after wet cure period
* Prevent marring of broomed finish or tined textured surface by careful placement of wet curing. ‖ Apply conventional wet curing to Bridge Slab following the concrete finishing.		

Use conventional wet curing consisting of pre-wetted burlap covered per 3751, “Burlap Curing Blankets,” with 6 mil (minimum) white plastic sheeting per 3756, "Plastic Curing Blankets," and in accordance with the following:

(1) Place the burlap to cover 100 percent of the deck area without visible openings
(2) Place the wet curing within 30 minutes after final strike-off of the concrete surface
(3) Keep the slab surface continuously wet for an initial curing period of at least 7 Calendar Days
(4) Use a Work Bridge to follow the finish machine
(5) Provide an additional center rail on wide Bridges, if necessary

After 96 hours, the Engineer may allow some modification of the requirement for continuous curing without interruption for the purpose of tying barrier reinforcement bars. Restrict the interrupted area to within 2 feet of the barrier. Protect the concrete from freezing or excessive drying during the interruption period. Resume curing at the earliest opportunity, and cure until completion of the curing period.

Where marring of the broomed finish or tined texturing surface finish of Bridge Deck Slabs is a concern, the Engineer may authorize curing as follows:

(1) Apply a membrane curing compound meeting the requirements of 3754, "Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound," using an approved power-operated sprayer in accordance with 2401.3G.2.a, "Membrane Curing Method"
(2) Provide a uniform, solid white, opaque coverage of membrane cure Material on exposed concrete surfaces (equal to a white sheet of

typing paper). This may require use of a Work Bridge to access the center portion of the deck

(3) Place the membrane cure within 30 minutes of concrete placement unless otherwise directed by the Engineer
(4) Provide curing compound for moisture retention until the placement of conventional wet curing
(5) Apply conventional wet curing as soon as walking on the concrete will not produce imprints deeper than 1/16 inch
(6) Keep the deck slab surface continuously wet for an initial curing period of at least 7 Calendar Days
(7) The Engineer will not allow placement of membrane curing compound on any concrete surface that will receive future placement of additional concrete or wearing course on that surface

G.6.c Bridge Superstructure Protection Against Cold Weather

Protect the concrete against cold weather in accordance with 2401.3G.5, "Protection Against Cold Weather," and the following:

Provide imbedded temperature sensors and monitoring devices for Bridge Slabs. Provide a minimum of two sensors and at least one additional sensor per 5,000 square feet of Bridge Slab. Place sensors at locations agreed to by the Engineer.

G.6.c(1) Bridge Slabs, Box Girder Bottom Slabs, and Box Girder Webs

Place and cure concrete in Bridge Slabs, box girder bottom slabs, and box girder webs in accordance with the following:

(1) If the Engineer anticipates air temperatures below 36°F, place concrete only after placing housing needed to heat the pour area and maintain required pour temperatures of at least 60°F.
(2) When the air temperature is greater than 36°F during placement but is anticipated to fall below 34°F during curing, do not place concrete until as much insulation or housing and heating are in as needed to protect the concrete from freezing. The Contractor may install insulation and housing after completion of concrete finishing, as approved in the cold weather protection Plan if the insulation and housing hinders concrete placement.

G.6.d Bridge Deck Slab Dry Out Period

A dry-out period is required for Bridge Deck Slabs cast after October 14 and opened to traffic prior to April 15 of the following year. For 21 Calendar Days after removing the curing Material or until April 15, whichever comes first, heat and provide housing to ensure free air circulation above the concrete surface to dry the concrete and prevent the temperature of the concrete from falling below 40°F.

G.6.e Protection from premature loading

Do not allow vehicles or Equipment on the Bridge Slab until after completion of the curing period and minimum strength requirements of Table 2401.3-2. Reinforcement bar bundles or pallets may be placed on the Bridge Slab after 96 hours provided the loading is not greater than 1,000 pounds per 100 square feet area.

G.6.f Bridge Deck Cold Weather Protection Plan

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

G.7 Protection of New Concrete against Vibration

Do not subject freshly placed concrete to excessive vibration and shock waves during the curing period until it has reached a 2,000 psi minimum compressive strength for structural concrete and lower-strength classes of concrete.

After the first 5 hours from the time the concrete has been placed and consolidated, keep all vibration producing operations at a safe horizontal distance from the freshly placed concrete by following either the primary or alternate method. Plant cast concrete is not subject to these requirements.

G.7.a Primary Method – Prescriptive Safe Distance Method

After the concrete has been placed and consolidated, keep all vibration producing operations at a safe distance from the freshly placed concrete as shown in Table 2401.3-5.

After the concrete has reached the minimum compressive strength specified above, the safe horizontal distance restrictions would no longer apply.

Table 2401.3-5
Safe Horizontal Distance

Minimum Compressive Strength, f'c	Equipment Class L * (Low Vibration)	Equipment Class M ‖ (Medium Vibration)	Equipment Class H † (High Vibration)
< 1,000 psi	10 feet	75 feet	125 feet
1,000 to < 1,400 psi	10 feet	30 feet	50 feet
1,400 to 2,000 psi	10 feet	15 feet	25 feet

* Equipment Class L includes small rubber tire construction Equipment like backhoes under 50,000 pounds, concrete placing Equipment, and legal Highway vehicles if such Equipment travels at speeds of ≤ 5 mph on relatively smooth Roadway surface or ≤ 3 mph on rough Roadway surface (i.e., with potholes).

‖ Equipment Class M includes tracked dozers under 85,000 pounds, track vehicles, trucks (unless excluded above), hand-operated jackhammers, cranes, auger drill rig, caisson drilling, vibratory compacting rollers under 30,000 pounds, and grab hammers.

† Equipment Class H includes pile drivers, vibratory hammers, machine-operated impact tools, pavement breakers, and other large pieces of Equipment.

G.7.b Alternate Method – Monitoring Safe Distance Method

Monitor the vibration producing operations in order to decrease the safe horizontal distance requirements of the Prescriptive Safe Distance method. Monitor all construction operations that produce vibration or shock waves in the vicinity of freshly placed concrete with monitoring Equipment sensitive enough to detect a minimum peak partial velocity (PPV) of 0.01 inches per second. Place monitoring devices on or adjacent to the freshly placed concrete when the measurements are taken. During the time subsequent to the concrete placement, cease all vibration or shock producing operations in the vicinity of the newly placed concrete when monitoring Equipment detects excessive vibration and shock waves defined as exceeding the PPV's in Table 2401.3-6.

After the concrete has reached a minimum compressive strength specified above, the safe horizontal distance restrictions would no longer apply.

Table 2401.3-6
Peak Partial Velocities

Minimum Compressive Strength, f’c	Maximum PPV
< 1,000 psi	0.01 inch per second
1,000 to < 1,400 psi	1.0 inch per second
1,400 to 2,000 psi	2.0 inch per second

H Slipforming of Bridge Barrier

Instead of using conventional forming methods, the Contractor may slipform concrete Bridge barrier in accordance with the following requirements:

H.1 Reinforcement Bars

Do not tack weld reinforcement bars. Use additional reinforcement ties at rebar intersections to maintain the rigidity of the reinforcement bar cage.

Place reinforcement in accordance with 2472, “Metal Reinforcement.”

H.2 Concrete Mix

Use 3S12 concrete mix design for slipformed barrier. The Engineer will reject concrete with a slump greater than 1 1/4 inch.

H.3 Construction Requirements

Perform the following construction requirements:

(1) Meet surface tolerances defined in 2401.3F.2.e, “Barrier Surface Tolerance”
(2) Check the clear distance from the slipform template to the reinforcement bars in the presence of the Engineer. During this check, attach fill strips to the slipformer to detect areas of reinforcement bars that may encroach on the required concrete cover. Perform this check for the full distance of the anticipated subsequent pour area, less any areas of hand-formed barrier
(3) Scrub a thinned bonding grout into the deck surface and adjacent contact points immediately before slipforming barrier. Keep the contact surfaces wet until the fresh concrete is placed on them. Insert rigid plastic extrusion at control joints as per Plan details before placing the curing Materials
(4) If shown on the Plans, saw-cut the top portion of the joint to the full depth within 24 hours of the concrete placement to a width of 3/8 inch
(5) Seal saw-cut joints to a depth of at least 1 inch with a silicone sealer listed on the *Approved/Qualified Products List*
(6) Conventionally form the ends of the barrier with the guardrail plate in place
(7) Conventionally form the barrier sections for a distance of at least 4 feet on each side of areas that the slipform machine cannot access
(8) Maintain the gutter line or barrier face location as shown on the Plans. The Contractor may increase the slab overhang by no greater than 1 inch and batter the outside of the barrier by no greater than 1 inch
(9) Use either chamfer or radii strips at horizontal and vertical edges
(10) Place concrete into the Work within 90 minutes of batching
(11) Manufacturer’s recommended dosage rate listed on the *Approved/Qualified Products List*
(12) Lightly broom in a texture on the barrier surface immediately after passage of the slipformer
(13) Wet cure the barrier by applying conventional wet curing to the barrier immediately following the machine. Use conventional wet curing consisting of pre-wetted burlap covered with separate white plastic sheeting or cover with

pre-wetted poly-coated burlap. Place the burlap to cover 100 percent of the barrier area without visible openings. Place the wet curing within 30 minutes after the machine completes the final strike-off of the concrete surface. Keep the barrier surface continuously wet for an initial curing period of at least 7 Calendar Days

I Joint and Crack Sealing

I.1 Joint Sealing

Place joint sealer Material of the type as shown on the Plans or Special Provisions in accordance with 2301.3N.3, “Joint Sealing.”

Complete concrete curing prior to installation of sealing Materials. A minimum of 14 Calendar Days drying is required prior to application of sealers. Sawcut joints, sandblast, blow clean, and ensure the concrete surfaces are dry at the time the sealer is installed. Perform Work as per manufacturer's recommendations.

Construct preformed joint(s) as detailed in the Plans and in conformance with the following requirements.

(1) Use bituminous felt that complies with *AASHTO M33*, “Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type),”modified to the extent that the load required to compress the test specimen to 50 percent of its thickness before test be not more than 1200 psi
(2) Supply cork complying with 3702, "Preformed Joint Fillers"
(3) Supply polystyrene complying with the following:

Table 2401.3-7
Compressive Strength for Polystyrene Elements*

Type	Compressive Strength (minimum) [5 percent deflection]	Characteristics
A (High Density)	30 psi	Closed Cell Expanded Polystyrene
B (Low Density)	10 psi	Molded Polystyrene
* Test for compressive strength of polystyrene in accordance with *ASTM D1621, Standard Test Method for Compressive Properties of Rigid Cellular Plastics*. Furnish evidence that the Material meets these requirements, if requested by the Engineer.		

Seal construction joints and saw cuts in the deck, curb face, Sidewalk, and median with a concrete joint sealer listed on the *Approved/Qualified Products List* for “Silicone Joint Sealants,” or in accordance with 3723, “Hot-Poured, Elastic Type Joint And Crack Sealer,” or 3725, “Hot-Poured, Extra-Low Modulus, Elastic Type Joint and Crack Sealer.”

I.2 Crack Sealing

The Contractor is fully responsible for crack sealing cracks identified by the Engineer in accordance with 2433, “Structure Renovation.”

2401.4 METHOD OF MEASUREMENT

The Engineer will separately calculate each grade or mix of structural concrete based on the dimensions shown on the Plans.

The Engineer will not deduct for the volumes of concrete displaced by metal reinforcement, structural steel sections, floor drains, conduits, pile headers, chamfer strips with side dimensions no greater than 2 inches, or for variations in camber and deflections as shown on the Plans.

The Engineer will not increase concrete quantity measurements for extra concrete used to secure true conformity of the elevation profile and cross-section in the finished Roadway slab as shown on the Plans.

The Engineer will consider deck thickness as the thickness shown on the Plans as the minimum thickness, unless the Plans show other dimensions.

The Engineer will not include concrete for keyways in quantity computations.

The Engineer will measure median barrier concrete by length based on the end-to-end slab dimensions.

The Engineer will measure concrete barriers by length based on the horizontal length between the outside end faces of barriers.

The Engineer will measure concrete bases for metal railing based on the horizontal lengths between the outside faces of the end posts.

The Department will classify the excavation in accordance with 2451.3B.2, “Types,” and the Engineer will measure the excavation in accordance with 2451.4A, “Structure Excavation,” for cast-in-place Structures.

The Engineer will measure structural concrete by volume based on the dimensions of each element shown in the Plans. The Engineer will not deduct the volume due to rustication, chamfers, or other miscellaneous appurtenances.

The Engineer will measure Bridge Slab structural concrete by volume based on dimensions of the Structure shown in the Plans of the slab.

The Engineer will measure reinforcement bars in conformance with 2472.4A, “Reinforcement Bars.”

The Engineer will measure steel fabric in conformance with 2472.4B, “Welded Wire Reinforcing.”

The Engineer will measure spiral reinforcement in conformance with 2472.4C, “Spiral Reinforcement.”

The Engineer will measure the Bridge Slab by surface area based on the dimensions shown on the Plans. The Engineer will not deduct the surface area of expansion devices or other miscellaneous appurtenances.

The Engineer will measure Sidewalk concrete by area based on the end-to-end Bridge dimension along the centerline of the Sidewalk and the overall width of the Sidewalk block.

The Engineer will measure raised median concrete by area based on the end-to-end slab dimension and overall width of the median.

2401.5 BASIS OF PAYMENT

The Contract Unit Price for structural concrete of each grade mix includes the cost of constructing the Bridge Structure complete in place, except for costs with a separate Contract Unit Price as shown on the Plans.

If the Contractor elects to pour the concrete end diaphragms with the Bridge Slab, using the same concrete mix for the diaphragms as used for the slab, the Department will pay the Contract bid price for end diaphragm concrete.

The Contract pound prices for reinforcement bars, steel fabric, and spiral reinforcement includes the costs of providing, fabricating, delivering, and placing the metal reinforcement.

The Department will pay for structure excavation, soil bearing tests, and backfill Materials in accordance with 2451.5, “Structure Excavations and Backfills, Basis of Payment.”

The Department Contract Unit Price for the relevant concrete Bridge construction Contract Item includes the cost of providing and placing joint sealer, crack sealer, and special surface finish.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Concrete Bridge Construction. The amounts of these adjustments are deemed reasonable.

A.1 JMF Acceptance

The Department may assess a monetary deduction for the quantity of Bridge deck concrete represented by the JMF working range failure of 2401.2K.8, “Job Mix Formula,” from the failing test to the next passing test, at a minimum rate of $500.00 or $5.00 per cubic yard, whichever is greater.

A.2 Concrete Curing and Protection

The Department may apply a monetary deduction for defective concrete sections in accordance with 1503, "Conformity with Contract Documents." as directed by the Engineer.

Failure to place the wet curing on Bridge Structural Slabs and Bridge Deck Slabs within 30 minutes after final strike-off of the concrete surface will constitute a Department monetary deduction of $500 for every 5 minute period, or any portion thereof, after the initial time period until the wet curing is approved by the Engineer, the Department may assess the deduction more than once.

If the Contractor fails to meet the requirements of 2401.3G.6.b, “Curing Method.” the Department may apply a monetary deduction for the concrete item in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

A.3 Special Surface Finish

For any batch/lot that does not test in compliance with 3501, “Basic Requirements for Paint,” the Department may apply monetary deduction. Since the Contract does not contain a separate Contract Unit Price for SSF II, the Department may apply monetary deductions per the following Table 2401.5-1. The square foot measurement is calculated by the surface area of concrete element to which the non-compliant Material is placed.

Table 2401.5-1
Deviation of Sample Color from Accepted Standard

Deviation	Monetary Deduction
Δ E ≤ 3	No monetary deduction for SSF II Materials placed as approved by the Engineer.
Δ E > 3 to 4	$0.15 per square foot of failing batch/lot Material placed.
Δ E > 4 to 5	$0.25 per square foot of failing batch/lot Material placed.
Δ E > 5 to 6	$0.40 per square foot of failing batch/lot Material placed.
Δ E > 6	The Department will not apply monetary deduction. Recoat the failing surface with smooth textured SSF II product in the color specified, at no cost to the Department until Δ E ≤ 3.

B Schedule

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

Item No.	Item	Unit
2401.503	Type ___ Barrier Concrete (Mix No.)	linear foot
2401.503	___ Median Barrier Concrete (Mix No.)	linear foot
2401.507	Structure Excavation Class ___	cubic yard
2401.507	Structural Concrete (Mix No.)	cubic yard
2401.507	Bridge Slab Concrete (Mix No.)	cubic yard
2401.508	Reinforcement Bars ___	pound
2401.508	Spiral Reinforcement	pound
2401.508	Steel Fabric ___	pound
2401.518	Bridge Slab Concrete (Mix No.)	square foot
2401.518	Sidewalk Concrete (Mix No.)	square foot
2401.518	Raised Median Concrete (Mix No.)	square foot
2401.518	Structural Median Concrete (Mix No.)	square foot

2402 STEEL BRIDGE CONSTRUCTION

2402.1 DESCRIPTION

This Work consists of the erection of those portions of Bridges and Structures that are made of structural steel and miscellaneous metals.

2402.2 MATERIALS

A Structural Metals **2471**

B Expansion Joints **2473**

C High Load Multi-rotational Bearings **2474**

D Metal Railings **2475**

E Anchor Rods **3385**

F High Strength Bolts, Direct Tension Indicators, and Pin Bolts **3391**

G Elastomeric Bearing Pads **3741**

2402.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Structural Steel Components of Concrete Bridges.. 2472

A.2 Steel Piling 2452

A.3 Assembly

Assemble Bridge components in accordance with the match markings and erection Plans using procedures outlined in the Contract. If the Contract does not specify assembly procedures, assemble in accordance with recognized practices.

B Handling and Storage of Materials

B.1 Structural Steel

Store girders and beams in an upright position. Keep Materials clean, dry, and in a properly drained area. Cover and shelter members that will be stored for greater than 3 months and provide for air circulation around the members.

B.2 High Strength Fasteners

Fasteners include, but are not limited to, bolts, nuts, washers, and direct tension indicator (DTI) washers.

Before fasteners are delivered to the Bridge site, provide documentation of rotational capacity (ROCAP) testing in accordance with *ASTM F3125, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Annex A2, Rotational Capacity Test*. The fasteners must be received in packages that match the fastener assembly combination as tested. If documentation of ROCAP testing is not received; then perform this testing in the field prior to installation.

Store fasteners in sealed, waterproof containers. Locate the containers in an enclosed Structure that is protected from the elements. Submit a fastener storage Plan to the Engineer at least 14 Calendar Days prior to delivery of fasteners to the jobsite. In the Plan identify where fasteners will be stored, how fastener condition will be quality controlled, and what measures will be used to prevent corrosion.

Notify the Engineer when shipments of fasteners arrive on the jobsite.

For any Work shift, remove from storage only the number of fasteners required for that shift. At the end of the Work day, return fasteners not installed to storage as defined above.

Prior to installation, ensure that the fastener condition has not changed due to weathering, mixture of tested assembly lots, or other reasons. In the event that changes have occurred, the Engineer will require re-qualification using ROCAP testing in the field for a minimum of three fastener assemblies of each combination to be used in permanent bolting.

C Straightening Bent Materials

Straighten plates, angles, and other shapes using methods that will not fracture or damage the metal. Do not heat the metal unless allowed by the Engineer, in conjunction with the Structural Metals Engineer. If allowed and before performing any straightening operations, submit a straightening procedure to the Engineer for review and approval by the Structural Metals Engineer. Do not heat metal to temperatures greater than 1,200°F.

After heating and straightening, allow the metal to slowly cool before inspecting for evidence of fracture or other damage. Repair galvanized and metallized coating in accordance with 2471, "Structural Metals."

D Temporary Works

All Plans, Specifications, and calculations submitted under the provisions of this section must be prepared by a Professional Engineer, checked by a second Professional Engineer for completeness and accuracy, and certified by one of the aforementioned Professional Engineers licensed in the State of Minnesota.

D.1 Falsework

At least 42 Calendar Days before starting construction of the structural steel erection falsework, provide the Engineer with three copies of the detailed Plans and Specifications and two copies of the associated calculations for the proposed system to construct the falsework. Design the falsework to meet the requirements of *AASHTO Guide Design Specifications for Bridge Temporary Works* and *AASHTO Standard Specifications for Highway Bridges*. Ensure the documents include details to allow the construction of the proposed system by reference to the Plans and Specifications only.

Provide calculations to verify the adequacy of any adjacent Structures that will be affected by surcharges from proposed falsework.

D.1.a Falsework Plans

Provide the following in the falsework Plans, as a minimum:

(1) Show the design criteria on the first sheet of the Plans
(2) The size of load-supporting members and transverse and longitudinal bracing
(3) Connection details for load-supporting members
(4) Design-controlling dimensions, including the following:

(a) Beam length and spacing
(b) Post location and spacing
(c) Overall height of falsework bents
(d) Vertical distance between connectors in diagonal bracing
(e) Other dimensions critical to the design

(5) The location and method used to adjust falsework to final grade as specified in the Plan
(6) Falsework elevations, adjusted to account for the "as-fabricated" geometry

D.1.b Timber

Provide timber meeting the following requirements for falsework piles or members;

(1) Sound wood
(2) Straight
(3) Good condition

Provide straight steel members of adequate strength for the intended use.

D.1.c Use of Falsework

Do not erect the structural steel until meeting the following requirements:

(1) Provide the Engineer with Plans and Specifications meeting the above requirements
(2) The Professional Engineer certifying the falsework Plans and Specifications has inspected the falsework after erection and has provided written certification to the Engineer stating the as-constructed falsework is approved for use
(3) Provide the Engineer with X and Y coordinates and elevation of all centerline of bearing for girder supports on falsework

D.2 Formwork

Except for attachment of screed rail support pipes, do not weld on primary stress-carrying members of the Bridge structure to fasten appurtenances not shown on the Plans or on the approved detail drawings. The Contractor may weld screed rail support pipes to the top flange with 1/4 inch longitudinal fillet welds no greater than 2 inches long. Do not weld in the negative moment area, as shown on the Plans as “Area A,” of the top flange of primary stress-carrying members of the Bridge Structure.

Prepare the base metal and weld during ambient weather conditions in accordance with 2471.3G, “Structural Welding.”

E Erection

Provide a bolting Plan in accordance with 2402.3G.2.c, “Installation” for all structural steel erection.

E.1 Analysis and Plans

If the Plans show active public access (vehicular, railroad, trails, navigable waters, etc.) beneath the Structure before the complete erection of the beams and transverse members (e.g. diaphragms, cross-frames, lateral bracing) in a span, submit an erection Plan, Specifications, and calculations to the Engineer detailing the temporary works required to maintain structural adequacy and stability of the Bridge system for each step of the erection Plan. Perform design in accordance with *AASHTO LRFD Bridge Design Specifications*, AASHTO *LRFD Bridge Construction Specifications*, and *AASHTO Guide Design Specifications for Bridge Temporary Works*.

All Plans, Specifications, and calculations must be prepared and certified by the Contractor’s Erection Engineer. The Contractor’s Erection Engineer must be a Professional Engineer licensed in the State of Minnesota. All documents included in the submittal must be checked by a second Professional Engineer for completeness and accuracy.

Use struts, bracing, tie cables, and other devices used for temporary restraint of a size and strength capable of withstanding the stresses developed. Erect and brace at least two adjacent beams or girders, including transverse members, in any one span before suspending operations for the day.

Adjust falsework to the "as-fabricated" geometry, which takes into account the shop blocking and any vertical tolerances used in the fabrication assembly.

Maintain the falsework in place until the Erection Engineer approves the release of falsework supports. Remove falsework in accordance with 2401, “Concrete Bridge Construction.”

E.1.a Plan Requirements

Provide the following in the erection Plans, as a minimum:

(1) Plan of Work area
(2) Erection sequence

(3) Delivery location
(4) Crane information
(5) Lifting weights with center of gravity locations
(6) Rigging or lifting device details
(7) Special procedures
(8) Bearing blocking and tie-down details
(9) Load restrictions
(10) The required bolt tension and the numbers of bolts to install in the permanent connections of the transverse members to stabilize the beam
(11) The required bolt tension and the numbers of bolts to install in the permanent connections of the girder splices if the requirements of 2402.3F.2, “Assembly,” will be modified

E.1.b Calculation Requirements

Provide the following in the erection calculations, as a minimum, for each stage of the proposed erection sequence:

(1) Summary of loads and load combinations, including temporary loads
(2) Girder and system stability
(3) Structural adequacy of girders
(4) Stresses due to rigging or lifting devices
(5) Girder reactions
(6) Girder displacements
(7) Center of gravity for girder pick locations
(8) The required bolt tension and the numbers of bolts to install in the permanent connections of the transverse members to stabilize the beam
(9) Verification of the adequacy of adjacent Structures that will be impacted by surcharges due to cranes

E.2 Preparation

Refer to 2401.3F.3.b, "Bearing Seats," for bearing seat tolerances and corrections. Any corrections must be completed prior to setting the bearing assemblies. Provide survey of X and Y coordinates and elevations at centerline of each bearing prior to setting the bearing assemblies.

Immediately before assembly, remove temporary protective coatings from pins and pin holes, and clean the contact surfaces at connections of foreign matter. Clean the contact area between pins and bushings to bare metal for pin holes provided with bronze bushings before assembling.

When required by the bearing supplier, make correction for temperature and rotation.

Paint surfaces inaccessible after erection as required before fit-up.

F Field Fit-Up

F.1 Stability and Safety

Erect structural steel members in a manner that will provide safety to the workers, Inspectors, the public, and without damaging the steel members. Temporarily anchor, brace, and stabilize primary members, such as beams and girders, as erected to prevent sliding, tipping, buckling, or other movement, before placing transverse members.

F.2 Assembly

For the purposes of the Work specified in section 2402, “Steel Bridge Construction,” a primary member is defined as any member that carries the primary stresses of the Structure. Beams and girders are primary members unless otherwise noted. When the Contract requires full assembly for fabrication, transverse members are also considered primary members.

For purposes of this provision, bolt types are defined as follows:

(1) Permanent bolts are placed prior to placing the concrete deck and fully tensioned per 2402.3G, "Connections." These bolts are used to maintain both final geometry and strength of the connection throughout the service life of the Bridge.

(2) Erection bolts are used to hold connecting members in "snug tight" contact and in correct position during bolting operations in conjunction with erection pins. These bolts must be the same diameter as the permanent bolts.

(3) Installation bolts are used to hold the pieces of the connection prior to installing erection pins and cannot be used in the permanent connection.

Permanent bolts may be used as erection bolts provided they remain in a condition matching the as-manufactured condition and have not been previously tensioned. *ASTM F3125 Grade A325, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated*, bolts may be retightened in the original location once, provided the bolt shows no evidence of permanent elongation, and a nut can easily be spun up to the shank of the bolt.

Use erection washers with erection bolts. Do not use erection pins larger than the diameter of the hole or smaller than the hole diameter minus 0.030 inches. For connections with oversized holes, use pins or tapered spud wrenches to align the connection. Do not use any type of bolt to establish the alignment of the connection.

Pins are considered effective for load transfer and geometry control, and erection bolts for maintaining tight steel.

For the purposed of the Work specified in section 2402, “Steel Bridge Construction,” snug tight is defined as the effort required to bring all plies of the connection together in firm contact. Snug bolts working from the interior of the connection to the free edges; this step will require a minimum of two passes over every bolt to ensure firm contact. The term "snug tight" is interchangeable with the field term of "tight steel.” Prior to beginning permanent bolting, use enough bolts tightened to a snug tight condition to bring all plies of the connection together in firm contact.

Use the following pinning and bolting sequence on primary stress-carrying members, for establishing the "assembled connection":

(1) Install a minimum number of installation bolts to hold the pieces of the connection together during pin installation. Tension of installation bolts must not restrict alignment of the connection

(2) Install erection pins in 25 percent of the total number of holes in the connection. Balance the distribution of the pins throughout the connection. With regard to load transfer, a portion of pins may be substituted with erection bolts under the following conditions:

  (a) The Contractor’s Erection Engineer, submits signed calculations to the Engineer demonstrating the connection forces during erection may be sustained by the proposed number of pins or be resisted in slip by prescribed number of tensioned erection bolts

(b) All written comments to the calculations are addressed to the satisfaction of the Engineer

(c) This exception does not eliminate the need for some amount of pins for the purpose of geometry control

(3) Install erection bolts in a minimum of 25 percent of the total number of holes in the connection. Balance the distribution of the bolts throughout the connection. Tighten the erection bolts to a snug tight condition. Shipping bolts and installation bolts are not included in the erection bolt percentage requirement

(4) Where required by the Contractor’s Erection Engineer and authorized by the Engineer, tension erection bolts necessary to sustain connection slip resistance. When live loads are carried during erection, use additional bolts and erection pins to compensate for the additional loads

(5) Remove installation bolts installed in step (1)

Check bearing plates and assemblies for contact before placing the permanent connectors. Correct deviations from full bearing between parts, or between the Bridge seat and the bearing plates as approved by the Engineer. Readjust transverse members or splice plates, if required to correct deviations. For extreme deviations, the Engineer may direct re-cambering or other re-fabrication procedures. The Contractor may use properly shaped and sized fills or shims to correct minor deviations as approved by the Engineer.

Make adjustments to erected sections to meet the following requirements at all support points (both permanent and temporary):

(1) Maximum deviation from as-fabricated horizontal alignment is ±1/8 inch x (total length along the girder, in feet, between supports)/10. Shift the spans if required to correct for alignment, skew, and proper anchorage and expansion device locations

(2) Maximum deviation from as-fabricated camber (elevation) is – 0 inch, + 1/4 inch x (total length, in feet, from the nearest support)/10. Modify camber and field splice plan elevations to account for as-built bearing seat elevation as necessary

F.3 Permanent Bolting

Permanent bolt girder splices prior to releasing girders from any type of temporary support (i.e. cranes, shoring towers, blocking, etc.) unless allowed by the Contractor’s Erection Engineer Plan prepared in accordance with 2402.3E, “Erection.”

Permanent bolting of transverse members will vary during the erection of steel Structures. The timing of this Activity is affected by the Structure type, how it was fabricated, and the means and methods utilized during erection. Fabrication utilizes either "line assembly" or "full assembly" practices to position, locate, and build structural bolted connections. The erection Plan must clearly define when permanent bolting can occur for each connection in the steel Structure.

Permanent bolting of the transverse members will be authorized after the Contractor meets the erection tolerances and has addressed all written comments by the Engineer.

Proceed with permanent bolting as follows:

(1) Install permanent connectors in open connection holes and snug tighten
(2) Tension the permanent connectors in accordance with 2402.3G, "Connections"
(3) Tension bolts systematically working from the interior of the connection to the free edges, in a manner that will minimize relaxation of previously tightened bolts
(3) Tension fasteners by holding the head of the bolt and turning the nut
(4) Remove pins and any erection bolts not qualified as permanent connectors individually. After removal of an erection pin or erection bolt, replace with a permanent connector and tension before continuing

Where DTI's are used, perform Quality Control on permanent bolt tensioning before presenting to the Engineer for final inspection.

Perform permanent connector tensioning within 10 Calendar Days after initial installation as exposure to the elements affects their rotational capacity test characteristics. Removed and re-lubricated permanent connectors that have been installed for more than 10 Calendar Days or if exposure has affected the rotational capacity test characteristics of the assembly. New ROCAP tests must be performed on each lot combination of re-lubricated bolt assemblies.

F.3.a Line Assembly

For the purpose of the Work specified in 2402.3F, "Field Fit-Up," the Department defines "Line Assembly" as the method by which the Structure was fabricated building the Structure one girder line at a time. It identifies that the Structure has had the girder splices drilled with standard size holes in a "no load" condition. It also identifies that secondary transverse members are connected with oversize holes and have not been subject to preassembly.

When the Contract requires Line Assembly, do not start permanent bolting of transverse members until:

(1) For simple spans: two adjacent lines are installed
(2) For continuous spans: girder lines are supported by three points of bearing and girder field splices are completed on both lines in the adjacent span(s)
(3) See Figure 2402.3-1 below for conceptual illustration of requirements prior to permanent bolting. Permanent bolting of transverse members outside of the area defined for allowable bolting is not allowed until the completion of the next span

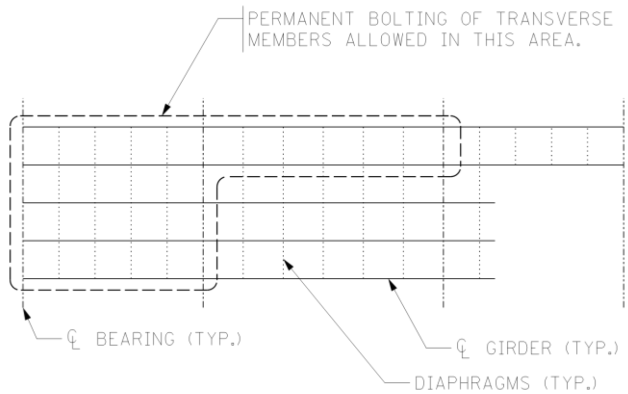


Figure 2402.3-1

Plan view showing framing fabricated in Line Assembly and erection requirements prior to permanent bolting (without temporary falsework)

F.3.b Full Assembly

For the purpose of the Work specified in 2402.3F, Field Fit-Up," the Department defines "Full Assembly" as the method by which the Structure was fabricated. It identifies that the Structure has had the girder splices and transverse members drilled with standard size holes in a "no load" assembled condition. Field erection practices are required to erect the steel in a manner consistent with how it was fabricated and not induce secondary stresses.

When the Contract requires Full Assembly, do not start permanent bolting of transverse members until:

(1) For simple spans, girder lines for the entire span have been erected
(2) For continuous spans, girder lines are supported by at least three points of bearing, girders lines for the entire span are erected, and field splices are completed in the span(s) immediately adjacent to the span in question
(3) See Figure 2402.3-2 below for conceptual illustration of requirements prior to permanent bolting without the use of shoring towers

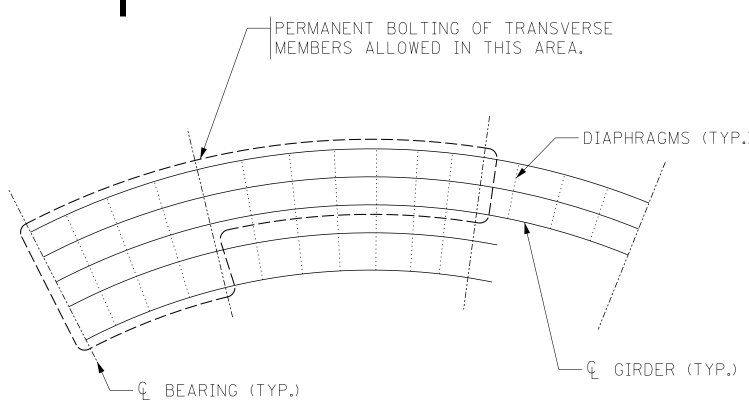


Figure 2402.3-2

Plan view showing framing fabricated in Full Assembly and erection requirements prior to Permanent Bolting (without temporary falsework)

F.3.c With Temporary Falsework (Shoring Towers)

An exception to the requirements in 2402.3F.3.a, "Line Assembly," and 2402.3F.3.b, "Full Assembly," is allowed where shoring towers are used without interruption to correct alignment, camber, grade, and skew. Shoring towers that are fully supporting the members in the as-fabricated, no-load position allow permanent bolting before all girders in the span are erected. For this exception, permanent bolting may begin when both girder lines are supported at three support points and field splices are completed on both lines of the adjacent span(s). Temporary shoring is an eligible point of bearing for erection purposes.

See Figure 2402.3-3 below for conceptual illustration of requirements prior to permanent bolting with the use of shoring towers.

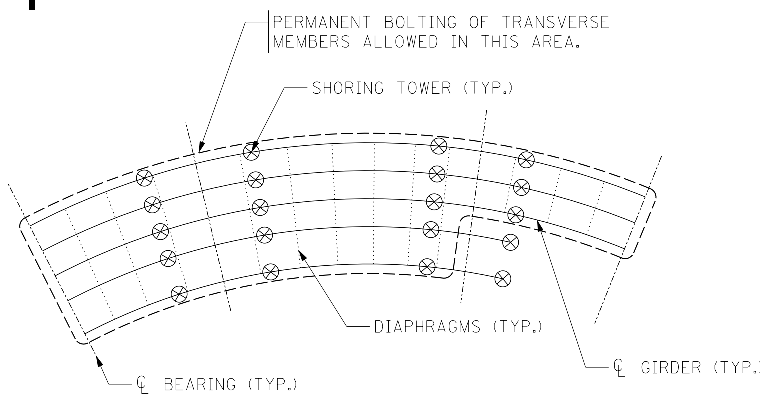


Figure 2402.3-3
Plan view showing framing fabricated in Full or Line Assembly and erection requirements prior to permanent bolting (with temporary falsework)

F.3.d Ground Splices

The Engineer may allow permanent bolting of field splices in beams or girders on the ground before Full Assembly of adjacent spans, provided the beams to be spliced are positioned on firmly supported blocking that replicates the as-fabricated geometry.

Pin ground spliced beams with at least 25 percent pins and 25 percent snug tight bolts and present to the Engineer before permanent bolting. Fully tension and inspect primary member connections that are made up on the ground before erection prior to any lifting operation.

F.4 Pin Assemblies

Before assembling pins, coat pins and pinholes, including pinholes with bronze bushings, with a “bridge grease” as listed on the *Approved/Qualified Products List*.

Draw pin nuts tight, except for pin nuts with cotter keys. Upset the exposed thread at the face of the nut by center punching to prevent back off. If tightening pin nuts with cotter keys ensure the cotter key can be freely inserted and the pin is free to turn without binding under the Lomas nut.

F.5 Construction Elevations

After all permanent connections have been tensioned and inspected in accordance with 2402.3G.2.d, "Inspection," take elevations at top of beams under steel dead load only deflections. Take elevations at five foot increments along the centerline of the beam starting at each centerline of bearing and proceeding up station. Restart five foot increment at each centerline of bearing for continuous spans.

Allow for total dead load deflections as shown in the Plan to enable building forms to the correct grade and specified slab thickness. Provide a copy of the elevations to the Engineer.

For long, multiple span, continuous Bridges, the Contractor may request in writing to take elevations prior to tensioning and inspection of all permanent connections. Provide the Engineer with the following items:

(1) Certified Plans and Specifications for the erection sequence
(2) Calculations to verify strength, stability, and deflections at tenth points and field section ends for each stage of the erection sequence
(3) Designer should work with Bridge Engineer to develop any additional deliverables required

G Connections

Connections, including fill plates and shims, must be clean and undamaged so as not to impact the design slip criteria. Do not damage paint and maintain the appropriate thickness to meet compliance for the designed slip coefficient. Unless the Contract requires or the Engineer approves otherwise, provide field connections made with high strength bolts or pin bolts.

G.1 Welded Connections

Weld field connections in accordance with 2471, "Structural Metals."

G.2 Connections Using High Strength Bolts

G.2.a General

Install bolts with heads outward for the webs of fascia girders. Install bolts with heads downward for the flanges of beams and girders spanning Highways, Streets, Roadways, and walkways.

G.2.b Bolted Parts

Ensure the slope of surfaces of bolted parts in contact with the bolt head and nut is no greater than 1:20 with respect to a plane normal to the bolt axis. Assemble bolted parts to fit solidly together. Do not separate bolted parts by gaskets or other interposed compressible Material.

Assemble joint surfaces, including those adjacent to the bolt heads, nuts, or washers, free of the following:

(1) Scale, except tight mill scale
(2) Dirt
(3) Loose scale
(4) Burrs
(5) Other foreign Material
(6) Other defects preventing solid seating of the parts

Ensure contact surfaces of friction-type joints are free of coating Materials such as oil, galvanizing, and rust inhibitors.

G.2.c Installation

G.2.c(1) Bolt Tension

Clean contaminants and corrosion from the threaded portions of bolts and nuts, before installing. Lubricate and dye nuts in accordance with 3391, "Fasteners."

Use the turn-of-nut or direct tension indicator method to verify bolt tension as required by Table 2402.3-1.

If using impact wrenches, provide wrenches capable of performing the required tensioning of each bolt in 10 seconds.

Provide the Engineer with a job-specific fastener installation Plan at least four weeks before the start of steel erection. The Plan will include Pre-Installation Verification (PIV) testing in accordance with the Research Council on Structural Connections (RCSC), *Specification for Structural Joints Using High-Strength Bolts*.

PIV testing requires the use of a calibrated hydraulic load cell (i.e. Skidmore-Wilhelm) in order to verify the following in the field prior to permanent bolting:

(1) Ensuring all parties are familiar with tightening procedures
(2) Ensuring tools and Equipment are capable of performing adequately
(3) Ensuring structural bolting assemblies (including lubrication) are in suitable condition for proper bolting procedure and achieving needed results

For bolts that are too short to utilize a calibrated hydraulic load cell, calibrated DTIs will be used as a load cell. Once the DTIs have been calibrated, test the fastener assembly in a steel plate of similar thickness to that used in the permanent condition. Refer to the Research Council on Structural Connections (RCSC), *Specification for Structural Joints Using High-Strength Bolts* for more detail, except only one calibrated DTI needs to be used in the fastener assembly for each PIV test.

Perform PIV testing on at least three complete fastener assemblies of each combinations of diameter, length, grade, and lot to be used in the Work. PIV testing must be performed no earlier than 14 Calendar Days prior to permanent bolting. The fastener installation Plan will be updated with the results from the PIV testing. The hydraulic load cell must have been calibrated within one year of the date of use in order to be used for PIV testing.

Tension each fastener to provide the minimum bolt tension shown in Table 2402.3-1 after bringing the connection to a snug-tight condition.

Table 2402.3-1
Bolt Tension

Bolt Size, inch	Minimum Tension*, Kips
3/4	28
7/8	39
1	51
1 1/8	56
1 1/4	71
* Equal to the proof load meeting the requirements of the length measurement method in *ASTM F3125, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated*	

Additional ROCAP or PIV tests are required whenever the condition of the fasteners or understanding of bolting crew is in question by the Engineer.

Do not allow permanent bolting until the PIV testing is completed and the fastener installation Plan is accepted by the Engineer in writing.

G.2.c(2) Washers

Provide fasteners with a hardened washer placed under the nut or bolt head being turned during tightening.

Provide high strength bolts with a hardened washer under the bolt head and the nut if used in conjunction with full sized punched holes.

If an outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a smooth beveled washer to compensate for the lack of parallelism.

G.2.c(3) Direct Tension Indicator (DTI) Tightening

When using DTIs to provide the minimum bolt tensions in Table 2402.3-1, install the indicators, including snug tight fit-up, as recommended by the manufacturer except for the following:

(1) Insert a hardened flat washer between the DTI and fastener if bolting through a short-slotted or oversized hole in accordance with 2471.3I.1.a, “Line Assembly”
(2) If installing a DTI under the turned element, use a hardened washer to separate the turned element from the DTI meeting the requirements of *AASHTO LRFD Bridge Construction Specification* 11.5.6.4.7
(3) Provide compressible washer-type indicators meeting the requirements of *ASTM F959, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners*
(4) Inspect DTIs as recommended by the manufacturer, except as modified in 2402.3G.2.d(3), “Inspection Procedure for Direct Tension Indicators (DTI)”

G.2.c(4) Turn-of-Nut Tightening

Match mark all bolts after snug-tightening has been completed. Complete permanent bolting by turning the nut by the amount of rotation specified in this section. Progress with tightening systematically from the interior of the connection to the free edges. Do not rotate the part not turned by the wrench.

For coarse thread heavy hexagon structural bolts and heavy hexagon semi-finished nuts, rotate nuts from snug tight condition in accordance with the following:

(1) If both faces are normal to bolt axis (with or without use of beveled washers), rotate nuts 1/3 turn for bolt lengths no greater than 4 diameters, 1/2 turn for bolt lengths greater than 4 diameters to 8 diameters, and 2/3 turn for bolt lengths greater than 8 diameters to 12 diameters.

(2) If one face is normal and the other is sloped no greater than 1:20 (beveled washers not used), rotate nuts 1/2 turn for bolt lengths no greater than 4 diameters, 2/3 turn for bolt lengths greater than 4 diameters to 8 diameters, and 5/6 turn for bolt lengths greater than 8 diameters to 12 diameters.

(3) If both faces are sloped no greater than 1:20 (beveled washers not used), rotate nuts 2/3 turn for bolt lengths no greater than 4 diameters, 5/6 turn for bolt diameters from 4 diameters to 8 diameters and, 1 turn for bolt lengths from 8 diameters to 12 diameters.

Measure bolt length from the underside of head to extreme end of the bolt. Measure nut rotation as relative to bolt regardless of the element (nut or bolt) being turned. Rotate nuts within the allowable tolerance of 1/6 turn over and zero rotation under the rotation specified in list items (1), (2), and (3) above.

G.2.c(5) Quality Management

Provide a Quality Control Plan for Installation of fastener assemblies at least four weeks before the start of steel erection. Include the following items as a minimum:

(1) Materials tracking process for components of fastener assemblies

(2) Procedure for tracking when permanent bolts were installed and when final tensioning occurred

(3) Record keeping of final tensioning and inspection readings

(4) Develop a snugging and tensioning sequence for each connection detail

(5) Develop a procedure that ensures the Contractor’s Quality Manager staff will verify the fastener installation Plans were followed

G.2.d Inspection

The Engineer will observe the installation and tightening of bolts to determine that the tightening procedure and bolt tensions comply with the requirements in this section. The Engineer will inspect the bolt tension in accordance with the following procedure unless otherwise specified:

G.2.d(1) Calibration of Inspection Wrench

Provide a manual inspection wrench calibrated in accordance with the following:

Test each combination of bolt production lot, nut lot, and washer lot as an assembly. Test 3 assemblies per combination. Individually place bolts of the same grade, size, and condition, as the bolts under inspection in a calibration device (i.e. Skidmore Willhelm) capable of indicating bolt tension. Place a washer under the part turned in tightening each bolt. Provide test bolts in the same length as the bolts used in the Structure.

Tighten each test bolt in the calibration device to an initial condition equal to 15 percent of the specified bolt tension and then to the minimum tension specified for its size in accordance with Table 2402.3-1. Apply the inspecting wrench to the tightened bolt and turn the nut or head 5 degrees, or 1 inch at 12 inch radius in the tightening direction. Measure the torque applied. Average the torque as measured in the tests of 3 bolts and use this "job-inspecting torque" in accordance with 2402.3G.2.d(3) "Inspection Procedure for Direct Tension Indicators (DTI)."

Provide the inspection wrench and the bolt tension-indicating device as specified in this section. Allow the Engineer to witness the prescribed calibration tests.

During calibration in accordance with 2402.3G.2.d(1), "Calibration of Inspection Wrench," ensure the bolt and nut withstand rotation to two times the number of turns as specified in 2402.3G.2.c(4), "Turn-of-Nut Tightening," without showing visible evidence of stripping the threads or failure of the bolt or nut.

G.2.d(2) Inspection Procedure for Calibrated Wrench

At the Engineer' option, either the Engineer or the Contractor in the Engineer's presence may operate the inspecting wrench as follows:

(1) Inspect the tightened bolts in the Structure by applying, in the tightened direction, the inspecting wrench and its job-inspecting torque to a randomly selected 10 percent of the bolts or at least 2 bolts in each connection.

(2) Accept connections as properly tightened if nut or bolt heads do not turn when applying the job-inspecting torque as indicated in item (1) above. If a nut or bolt head turns during the application of job-inspecting torque, apply the job-inspecting torque to all bolts in the connection. Retighten and re-inspect nuts or bolt heads turned by the job-inspecting torque. The Contractor may retighten the bolts in the connection and resubmit the connection for the specified inspection procedure.

G.2.d(3) Inspection Procedure for Direct Tension Indicators (DTI)

Use the gap between the protrusions to indicate the tension in the bolt.

Furnish the Engineer with one feeler gauge per 50 DTIs prior to commencing bolting.

Notify the Engineer after the completion of each Activity:

(1) Initial tightening
(2) Final tensioning
(3) Verification checks

Provide accommodation for the Engineer to check DTIs at any time during or after completion of snug tightening or final tensioning. Department personnel will not be required to accompany the Contractor during tightening.

At the Engineer's option, either the Engineer or the Contractor in the Engineer's presence may operate the tapered leaf thickness (feeler) gauge within the procedures below.

Use the following procedure for inspection of bolting operations with DTIs:

(1) An initial visual inspection of the DTIs after the bolts are snug tight. Remove and replace DTIs with more than 50 percent of the protrusions crushed

(2) Ensure the DTI protrusions are oriented away from the steel member surfaces

(3) After Contractor verification checks, place a feeler gauge into a randomly selected 10 percent of the DTIs and at least 2 DTIs in each connection to inspect the tightened bolts in the Structure. Measure the gap between the washer and the bolt head in the spaces between the protrusions using the 0.005 inch tapered leaf thickness (feeler) gauge. Inspect the DTIs as recommended by the manufacturer with the exception of either:

   (a) A minimum of 1 entry by the feeler gauge shall be satisfied. Do not tighten DTIs beyond crushing of the protrusion.

   (b) The job-specified entries by the feeler gauge as established by an accepted fastener installation Plan per 2402.3G.2.c(1), "Bolt Tension."

(4) If the feeler gauge can be inserted into more than one-half of the spaces between the protrusions of a DTI, retighten the bolt and retest. There is no allowance for DTIs not satisfying the inspection requirements of DTIs as recommended by the manufacturer, except as modified in condition (3) above

(5) If the feeler gauge cannot be inserted into any of the spaces between the protrusions of more than 10 percent of DTI in an individual connection during the inspection, replace the affected bolts until less than 10 percent of all DTIs in the connection satisfy condition (3) above. Bolts satisfying the following conditions do not count towards the 10 percent allowance:

   (a) The bolt is subsequently tightened in the presence of the Engineer

   (b) The bolt shows no evidence of extensive elongation or fully crushing all the protrusions

   (c) The job-specified entries by the feeler gauge as established by an accepted fastener installation Plan per 2402.3G.2.c(1), "Bolt Tension" allows for all entries to be rejected

G.3 Connections Using Pin Bolts

Install pin bolts in accordance with 2402.3G.2.a, “General,” 2402.3G.2.b, “Bolted Parts,” and the following:

Provide a special tool capable of the following to drive the pin bolts:

(1) Partial swaging of the collars to allow for adjustment during erection when pinning and bolting the Work
(2) Producing the required tension in the bolt
(3) Swaging the collar into the annular locking grooves
(4) Forming the collar into the size and shape recommended by the manufacturer before the pin tail breaks

Provide a device capable of indicating the actual bolt tension to test the pin bolts before use. Provide at least 3 typical bolts of each size and length for tests from the supply of bolts used in the Work. Test other bolts during the bolting operation, as directed by the Engineer. Use the same installation tool used for tightening and swaging the bolts for the field connections to apply tension in the bolts during the testing procedures.

Recover the expendable pin tails from the driving tool as the pin tails break from the bolt. Do not allow expendable pin tails from the driving tool to drop and create hazards.

Obtain the Engineer’s approval of the testing and installation procedures for pin bolts.

H Setting Anchor Bolts

Unless the Contract requires otherwise, drill holes for anchor bolts to the diameter and depth shown on the Plans. Accurately set and fix the bolts with Portland cement grout that completely fills the holes. During freezing weather, the Contractor may use other products, as approved by the Engineer, to set and fix the bolts.

Set nuts for anchor bolts as shown on the Plans and provide for clearance where required. Center punch the bolt thread at the face of the nuts to upset the thread and prevent back-off.

Use templates to accurately set anchor bolts at the proper location and elevation that are to be cast in the concrete.

I Bearing Assemblies and Hangers

Plumb rocker bearings and hangers at 45°F. Consider elongation resulting from total load deflection when setting these devices.

J Shear Connectors

Provide shear connections (also referred to as shear studs or stud welded fasteners) in accordance with 3391, “Fasteners.” Install shear connectors at the locations shown in the Plan after the decking falsework has been installed. The surface must be dry and free of excessive rust, mill scale, pits, scale, oil, paint, and other debris. Shear connector welding is not allowed under the following conditions:

(1) The ambient, steel, or shear connector temperatures are below 0°F
(2) The surface of the steel is wet or exposed to falling rain or snow
(3) The arc shields or ferrules show signs of surface moisture or are wet

Install the first two shear connectors at the beginning of each shift in the presence of the Engineer. Where possible, use automatic stud welding Equipment. At other locations, perform manual welding of studs in accordance with *AWS D1.5, Bridge Welding Code*, Chapter 7.

After the weld cools, test bend the test shear connectors to an angle of approximately 30 degrees from the original angle by means of hammer strike or mechanically bending. The installation procedure must be corrected if any of the following conditions are observed:

(1) The full 360 degree flash does not occur for automatic stud welding
(2) The weld zone exhibits failure after test bend
(3) Rupture or cracking occurs in the shear connector after test bend

Shear connectors rejected must be addressed by submitting a Nonconformance Report (NCR) to the Engineer for acceptance prior to completing any repairs. If removal is required, any defects in the steel remaining must be ground flush to the steel surface. Retest at the rate of 2 shear connectors per failure.

In addition to the initial shear connectors, test bend shear connectors at the rate of 1 per 100 shear connectors installed. If the ambient temperature is below 32°F during installation, test bend at the rate of 2 per 100 shear connectors installed.

Leave shear connectors subjected to test bending in the bent position if no failure (as described above) is observed.

K Expansion Joint Devices

Install expansion devices in accordance with the shop drawings. Set the opening width based on the dimension provided in the Plan and the average ambient temperature based on the last 72 hours before placing concrete adjacent to the joint. Remove joint-forming Material from the joint opening.

Extend gland 1 inch minimum above the top of the extrusion. Cut end of gland horizontally as shown in the Figure 2402.3-4.

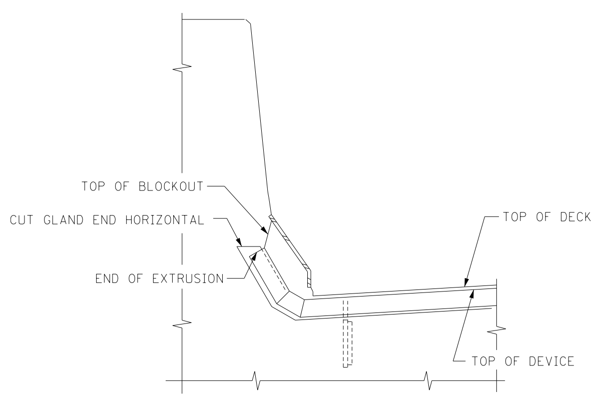


Figure 2402.3-4
Section Through Barrier

Provide a watertight expansion joint installation. Test the watertight quality of the entire length of the installed expansion joint device by filling the joint opening with water, then observe the test for 1 hour. The test may be divided into multiple segments to accommodate change in elevation over the length of the device.

L Field Painting

After completing the erection Work, clean and paint structural metals in accordance with 2478, “Organic Zinc-Rich Paint System,” or 2479, “Inorganic Zinc-Rich Paint System,” whichever is applicable.

2402.4 METHOD OF MEASUREMENT

The Engineer will measure structural metals placed in Bridges or other Structures by weight, length, area, or unit complete in place.

A Weight

The Engineer will calculate the weight of structural steel shapes, structural steel plates, steel sheets, and steel bars based on the net finished dimensions as shown on the Plans using the theoretical density of 490 pounds per cubic feet. The Engineer will not make allowances for the fabrication of girder, cambers, haunches, and sweeps, or for the machining of surfaces. The Engineer will not make deductions for open holes and Incidental bevels or chamfers. The Engineer will increase the summation of the weights of structural steel, exclusive of steel piling, by 1.5 percent to compensate for Incidental metals such as the following:

(1) Permanent fastener assemblies
(2) Shop or field high strength bolts
(3) Field shims
(4) Weld metal deposits
(5) Extra Material used to make weld procedure tests
(6) Shop galvanizing
(7) Metallizing
(8) Overruns, etc. for which the Engineer does not make measurements

The Engineer will calculate the weight of non-Incidental metals, other than steel, using the theoretical densities shown in the AISC *Manual of Steel Construction* using the above measurement limitations, except the Engineer will not measure the weight of bolts, nuts, rivets, and washers used in the fabrication and erection and will not apply a percentage increase to the weight.

B Length

The Engineer will base linear measurement of items not specifically covered herein between the limits as shown on the Plans.

C Complete Unit

The Engineer will include the component parts in the measurement of the complete assembly of a unit.

2402.5 BASIS OF PAYMENT

The Contract Unit Price for the specific structural steel item includes the cost of temporary support and restraint in accordance with 2402.3F, “Field Fit-up.”

The Contract Unit Price for structural metals includes the weight of structural metals in a single total.

The Contract Unit Price for Furnishing structural steel includes the cost of providing and fabricating in accordance with 2471, “Structural Metals”; surface preparation and shop coat painting in accordance with 2478, “Organic Zinc-Rich Paint System,” or 2479, “Inorganic Zinc-Rich Paint System,” unless otherwise required by the Contract; and delivering the Materials to the Project Site.

The Contract Unit Price for Erecting structural metals includes the cost of erecting the structural metals complete in-place and, if the Plans do not include a Contract Pay Item for field coat painting, the cost of field coat painting.

The Contract Unit Price for Structural steel includes the cost of providing and fabricating in accordance with 2471, “Structural Metals”; surface preparation and shop coat painting in accordance with

2478, "Organic Zinc-Rich Paint System," or 2479, "Inorganic Zinc-Rich Paint System," unless otherwise required by the Contract; delivering the Materials to the Project Site, and erecting the Materials.

The Contract Unit Price for Elastomeric bearing pad and Elastomeric bearing assembly includes the cost of testing, providing and installing the pads or assemblies complete in-place.

The Department will pay for steel bridge construction on the basis of the following schedule:

Item No.	Item	Unit
2402.502	Floor Drain Type ___	each
2402.502	Elastomeric Bearing Pad	each
2402.502	Elastomeric Bearing Assembly Type ___	each
2402.502	Bearing Assembly	each
2402.508	Structural Steel ___	pound
2402.508	Furnishing Structural Steel ___	pound
2402.508	Erecting Structural Metals	pound

2403 WOOD BRIDGE CONSTRUCTION

2403.1 DESCRIPTION

This Work consists of constructing wood Bridge Structures, or portions of Bridge Structures made of timber and lumber.

2403.2 MATERIALS

A Structural Wood Components

A.1 Component Grading and Symbol Designations

Provide stress-rated timber and lumber in accordance with 3426, "Structural Wood," for the grade specified.

Provide lumber for laminating meeting the following requirements:

(1) Graded in accordance with 3426, "Structural Wood"
(2) Allowable working stress, base resistance, or both values, as required by the Contract
(3) Meeting the requirements of *ANSI/AITC A190.1*, "Standard for Wood Products – Structural Glued Laminated Timber"

A.2 Timber Piling... 3471

A.3 Other Lumber 3457

B Preservative Treatment

Provide wood treated with preservative in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products," unless otherwise required by the Contract.

C Adhesives

Provide adhesives meeting the requirements for wet-use (waterproof) in accordance with *ANSI/AITC A190.1*, *Standard for Wood Products – Structural Glued Laminated Timber* and *AITC 405*, *Adhesives for Use in Structural Glued Laminated Timber*.

D Dowels

Provide dowels made of hot rolled steel in accordance with 3306, "Low-Carbon Structural Steel," and galvanized in accordance with 3394, "Galvanized Structural Shapes."

E Plank for Laminated Floors

Provide plank strips for laminated floors surfaced on one side to a uniform thickness no greater than 3 inches (S1S). Unless the Plans show otherwise, the Department will not require surfacing to a uniform width.

Provide 50 percent of the strips at least 16 feet long. Use strips at least 6 feet long, except to fill skews. Provide strips in variable lengths to ensure joints on one stringer are no closer than each third strip.

F Railings

Provide timber and lumber for railings free from blemishes that detract from the appearance of the finished work. Surface timber and lumber for railings on four sides (S4S).

G Hardware

Galvanize hardware, including nails, spikes, and wood connectors after fabrication in accordance with 3392, "Galvanized Hardware."

Provide bolts in accordance with 3391.2C, "Bolts for Wood Construction," unless otherwise shown on the Plans.

Provide drift bolts with counter-sunk heads and chisel points, lag screws, and rods in accordance with 3306, "Low-Carbon Structural Steel."

Provide properly proportioned plate washers to develop the full strength of the bolt. Provide round washers with diameters, and square washers with side dimensions, at least 3 1/2 times the diameter of the bolt and with a thickness of at least one-half the diameter of the bolt, unless otherwise shown on the Plans. The Contractor may cut washers for bolts no greater than 1/2 inch in diameter from medium steel plate.

Provide wood connectors of standard manufactured products in the size and type as shown on the Plans.

2403.3 CONSTRUCTION REQUIREMENTS

A Cutting and Framing

Cut, frame, and bore treated wood before treatment.

Drive nails and spikes to set the heads flush with the surface of the wood. The Engineer may reject wood pieces or members with deep or frequent hammer marks in exposed wood surfaces.

B Handling and Storage

Handle, transport, and store wood without damaging portions that will remain in the completed Structure. Do not split or damage the surfaces and edges. Do not puncture the treated surface of treated wood with pointed tools, temporary bolts, or spikes.

C Framing

Accurately cut and frame lumber and timber, true and exact to a close fit to construct the joints with an even bearing over the entire contact surfaces. Do not shim the joints or construct open joints.

C.1 Holes in Untreated Wood

Bore holes in untreated wood with diameters in accordance with the following types of hardware:

Table 2403.3-1
Holes in Untreated Wood

Hardware Type	Bore Hole Diameter
Round driftbolts and dowels	1/16 inch less than the diameter of the bolt or dowel
Square driftbolts or dowels	Equal to the least dimension of the bolt or dowel
Machine bolts	Same diameter as the bolt
Rods	1/16 inch greater than the diameter of the rod
Lag screws	No larger than the body of the screw at the root of the thread

C.2 Holes in Treated Wood

Bore holes in treated wood at least 1/16 inch larger than the holes specified in Table 2402.3-1.

D Field Treatment

Carefully trim and coat the following in treated piles and timbers with a preservative in accordance with 3491, "Preservatives and Preservative Treatment of Wood Products," and meeting the requirements of *AWPA M4*, *Standard for the Care of Preservative-Treated Wood Products*:

(1) Field cuts (except pile cut-offs)
(2) Daps
(3) Field bored holes
(4) Abrasions

Wait at least 2 hours between each application.

For pile cut-offs, treat the tops of treated timber piles used in wood Bridge construction with three applications in accordance with the requirements in this section.

E Piling

Provide timber piling in accordance with 2452, "Piling."

F Sills

Finish concrete pedestals, where required for the support of framed bents, to ensure even load bearing transfer to sills or posts placed on the pedestals. Extend the dowels for anchoring the sills at least 9 inches above the tops of pedestals. Set dowels while casting pedestals.

Provide sills with true and even bearing on piles or pedestals. Drift-bolt sills to the piles using bolts extending into the piles at least 9 inches. Remove earth from around the sills to provide free air circulation.

Use dowels extending at least 6 inches into posts and sills to fasten posts to sills.

G Caps

Place timber caps to obtain an even and uniform bearing over the tops of the supporting posts or piles and to provide an even alignment of their ends. Use driftbolts extending at least 9 inches into posts or piles to secure caps, except wing pile caps. Place the driftbolts in the center of each post or pile.

H Bracing

Fasten bracing to the pile or post and cap using bolts at least 3/4 inch in diameter in tandem with split or tooth ring connectors. Use wire spikes, boat spikes, or spike grid connectors to bolt and spike intermediate intersections as shown on the Plans.

I Stringers and Bridging

Size stringers at bearings. For stringers one panel long, place with knots near the edges in the top portion of the stringers. For stringers two panels long, place with knots near the edges in the compression edges of the stringers and stagger lapped joints over the supports.

Provide outside stringers with butt joints. Provide lapped interior stringers to take bearing over the full width of the floor beam or cap at each end. Toenail or bolt to fasten lapped ends of stringers as required by the Contract.

Accurately frame cross bridging members with bevel cut ends. Place cross bridging members providing full bearing at each end against the sides of stringers. Use two nails at each end to hold each cross bridging member securely. Set the cross bridging before placing the floor. Tightly set and nail the top ends home. Nail the lower ends only enough to hold the bridging in place. After placing the floor and wearing surface, readjust the lower ends of cross bridging, draw tight to the face of the stringers, and fully nail as required by the Contract.

Place block or header bridging before laying the subfloor. Fully nail the blocks at the top and only temporarily nail at the bottom. After placing the entire floor, complete nailing of the bridging. If using bolts or lag screws to fasten block bridging as shown on the Plans, do not final tighten the bolts or lag screws until after placement of the entire floor.

Cut block bridging square and to the accurate length to avoid the need for shims. If end shims are necessary, use zinc or galvanized sheet steel. Use end shims the size of the end of the block, with additional width to allow nailing along one side of block. Use galvanized roofing nails to hold shims in place.

Place cross bridging at the center of each span unless otherwise shown on the Plans.

J Prefabricated Wood Panels

Provide and install nail or glue laminated wood panels for use in Bridge Superstructures in accordance with the following:

J.1 Nail Laminated Panels

Cut individual wood members for use in the panels to the proper length and drill dowel holes. Treat members with preservative in accordance with 3491, “Preservatives and Preservative Treatment of Wood Products.” Fabricate members into panels.

Provide panels fabricated as shown on the Plans and assemble at the fabrication plant before delivery to the Project. Match mark the panels before shipment. Provide panel lengths with a tolerance of 1/8 inch of the dimension shown on the Plans. Install the panels to provide an overall deck width within 1/4 inch of the panel dimension shown on the Plans.

J.2 Glued Laminated Deck Panels

Provide and install glued laminated deck panels as shown on the Plans and meeting the requirements of this section, the *ANSI/AITC A190.1*, “Standard for Wood Products-Structural Glued Laminated Timber,” and *AITC 405*, “Adhesives for Use in Structural Glued Laminated Timber.” Provide shop details to the Engineer. Do not begin fabrication Work until the approval of the shop details by the Engineer in accordance with 2471.3C, “Shop Drawings.”

J.2.a Appearance Grades

Surface finish the panels meeting the requirements of *AITC 110-2001, Standard Appearance Grades for Structural Glued Laminated Timber*, except the Department will not require finishing the Roadway surface of the panels. Place individual planks to achieve the maximum corrugation on the Roadway surface.

J.2.b Dowel Holes

Drill dowel holes 1/16 inch greater in diameter than the dowel and 1/2 inch deeper than necessary to provide the planned dowel projection before the preservative treatment process.

J.2.c Marking and Protection

Match mark the panels before shipment. Do not end seal, surface seal, or wrap the panels.

J.2.d Preservative Treatment

Fabricate glue-laminated desk panels; remove excess glue from all panel surfaces, except on Roadway surfaces, before treating with preservative.

J.2.e Inspection 3491.3

Provide an independent commercial inspection agency's Certificate of Compliance, including the test results, and an approval certification mark on each panel, showing conformance with the requirements of section 2403, "Wood Bridge Construction."

J.2.f Assembly

Verify dowel projection and conformance with dimensions as shown on the Plans at the Project Site before assembly.

K Railings

Frame railings as shown on the Plans. Ensure accurate railing alignment during erection.

L Hardware

Place driftbolts in the Structure with the chisel point at right angles to the grain of the unbored sections of the connected pieces.

Use plate washers for bolts at least 1/2 inch in diameter, unless using bolt heads and nuts that provide an equivalent bearing surface and strength.

Provide wood connectors of the type shown on the Plans. Install the split ring and the shear plate in precut grooves of the dimensions as shown on the Plans or as recommended by the manufacturer. Use pressure Equipment to force the toothed ring and the spike grid into the contact surfaces of the joint. Simultaneously and uniformly imbed connectors of this type at a joint. Install the claw plate using a combination of precut grooving and pressure Equipment.

2403.4 METHOD OF MEASUREMENT

A Treated or Untreated Wood

The Department will separately measure treated wood and untreated wood by the unit of measure based on Nominal sizes and lengths incorporated in the Structure. The Engineer will not provide allowance for waste except beveled ends.

The Department will measure panels by the number of acceptable units of each type provided and installed, including panel hardware.

B Hardware

The Department will measure hardware by weight if the Contract includes a specific Contract Item for hardware. The Department will include of the cost of nails, dowels, or panel hardware with other relevant Contract Items.

2403.5 BASIS OF PAYMENT

The Department will pay for wood Bridge construction on the basis of the following schedule:

Item No.	Item	Unit
2403.502	Prefab Wood Panels Type ___	each
2403.502	Glued Laminated Deck Panels Type __	each
2403.508	Hardware	pound
2403.522	Untreated Wood	MBM*
2403.522	Treated Wood	MBM*

* 1,000 board-feet measure

2404 CONCRETE WEARING COURSE FOR BRIDGES

2404.1 DESCRIPTION

The Work consists of constructing a Portland cement concrete wearing course on a Bridge Structural Slab or approach panel.

2404.2 MATERIALS

Provide a wearing course made of low slump concrete placed at least 2 inches deep in accordance with the following:

A Low Slump Concrete

Provide low slump concrete in accordance with 2461, "Structural Concrete," and as modified by the following:

A.1 Mix Requirements

Provide 3U17A concrete in accordance with Table 2404.2-1 and the requirements of 2461, "Structural Concrete." Use a Department approved Type A Water-reducing Admixture at the manufacturer's recommended dosage rate to achieve the specified slump.

Table 2404.2-1
Concrete Mix Design Requirements for 3U17A

Mix Number	Maximum W/C Ratio	Water Content (pounds)	Cement Content (pounds)	Fine Aggregate Content (pounds)	Coarse Aggregate Content (No. Pit Number/pounds)†	percent Air Content	Slump Range (inch)	Minimum 28 Calendar Day Compressive Strength (psi)
3U17A*	0.32	270	836	1415 ‖	No. 06002-1369 No. 17001-1374 No. 52003-1364 No. 73006-1411 No. 87002-1385 No. 94009-1540 No. 94035-1530	6.5	1/2-1	5600

* Do not provide 3U17A containing fly ash or slag cement.
‖ Includes assumed 3 percent moisture.
† Meeting CA-70 gradation as shown in Table 3137.2-4 and Class A coarse Aggregate meeting the requirements of 3137.2D.2, "Coarse Aggregate for Bridge Superstructure."

B Bonding Grout

Provide grout consisting of Portland cement mixed with water to form a slurry with the consistency of paint to bond the new concrete to the Bridge Structural Slab. Coat the in-place concrete, including vertical joints, immediately before placing the concrete wearing course.

C Poly-Alpha Methyl styrene (AMS) Membrane Curing Compound 3754

2404.3 CONSTRUCTION REQUIREMENTS

A General

Provide Equipment to proportion, mix, place, and finish the concrete as approved by the Engineer.

Place the concrete wearing course on the Bridge Structural Slab after the slab has cured for at least 7 Calendar Days unless the Contract requires a longer curing period for the Bridge Structural Slab. Place the concrete wearing course on the approach panels after the panels have cured for at least 72 hours.

Mix concrete in accordance with the *Concrete Manual* requirements for the Equipment used. Mix the concrete until uniform in composition and consistency. Provide concrete at a rate allowing the finishing operations to proceed at a steady pace and completion of the final finishing in accordance with 2404.3D, "Concrete Placement and Texturing." Provide placing and finishing Equipment, including adequate hand tools, to place and Work the concrete to the correct level for strike-off.

B Finishing Machine

Use a power-operated finishing machine approved by the Engineer and meeting the following requirements:

(1) Designed for normal operating conditions that provide an elapsed time between depositing the concrete on the Bridge deck and the final screeding no greater than 15 minutes
(2) Capable of obtaining positive machine screeding of the plastic concrete
(3) Contains a screed capable of extending at least 6 inches beyond the edge of a subsequently placed section and capable of overlapping the edge of a previously placed section at least 6 inches
(4) Capable of forward and reverse motion under positive control
(5) Contains screeds capable of being raised to clear the screeded surface when traveling in reverse

Demonstrate the capability of the finishing machine to produce results in accordance with 2404.3D, "Concrete Placement and Texturing," under the Project conditions, unless otherwise directed by the Engineer.

Place rails on the outside of the wearing course area to support the traveling finishing machine. Provide rail anchorages for horizontal and vertical stability. Do not ballistically shoot rail anchorages into concrete that will not be overlaid.

After setting the rails to the grade and elevation shown on the Plans and before placing the concrete, check the clear distance from the bottom of the screed to the top of the prepared concrete surface in the presence of the Inspector. Attach a fill strip or other approved device to the bottom of the screed during this check to detect areas encroaching on the wearing course thickness shown on the Plans. Set sufficient screed rails to perform the clearance check in one continuous run over a distance equal to one complete day's placement. Make corrections as directed by the Engineer to obtain the thickness shown on the Plans.

When necessary, place longitudinal joints at the edge of Traffic Lanes as approved by the Engineer.

C Deck Preparation

Within 48 hours before placing the concrete wearing course, clean the slab surface and shotblast the entire Bridge surface and approaches to be overlaid. Shotblast to remove surface film, laitance, fractured concrete particles, and other Materials that may impede the bond of the concrete wearing course. Remove the steel shot before placing the concrete wearing course.

Control and abate the dust generated by the blasting operation meeting the requirements of MPCA Rule 7011.0150. Submit the proposed Plan for dust abatement to the Engineer at least 14 Calendar Days before starting the Work.

Power sweep the Bridge and approach slabs before blasting. Use the least amount of water necessary to minimize the dust from the sweeping operation.

Provide housing for the blast wheel or blasting nozzles meeting the following requirements and characteristics:

(1) Contains a negative air emission control system that draws the confined air and dust into a filtered collection system
(2) Contains an exhaust system with the capacity for relieving the pressure generated within the housing by the blasting Equipment
(3) Sides and corners flexible at the bottom to allow the bottom of the housing to contact the deck surface during blasting operations

Clean the filter collection system to ensure proper filtration.

Provide a housing and filter collection system constructed, maintained, and operated to eliminate avoidable dust emissions.

After blasting, hand sweep or use a “pickup” type power sweeper equipped with adequate dust storage capacity to sweep the prepared surface. Remove minor debris remaining after the sweeping operation by air blasting. Provide an air supply system with an oil trap placed in the air supply line between the storage tank and the nozzle.

Shotblast, sweep, and clean the Bridge Structural Slab before placing the concrete wearing course. Allow time for the Engineer to inspect the surface during daylight hours.

After shotblasting the surface, the Engineer will perform a visual inspection of the Bridge deck, and locate cracks appearing on the top surface. Furnish only one of the Materials listed on the *Approved/Qualified Product List* of Bridge surface and crack sealers. Fill located cracks with an approved crack sealer following the manufacturer's recommendations, and as otherwise directed by the Engineer. Ensure the sealer is cured prior to preceding pre-wetting of the deck, as required for placement of a low slump concrete wearing course.

Control the application of the crack sealer such that the maximum width of crack sealant does not exceed 3/4 inch. If exceeding the permitted width of 3/4 inch, remove excess by means of surface grinding to prevent debonding of concrete wearing course.

Furnishing and placing the sealer on new structural slabs as specified above is included in the cost of the concrete wearing course. Payment for sealing cracks in existing Bridge Deck Slabs getting a new low slump wearing course as provided for in the Special Provisions.

Within 12 hours of placing the concrete wearing course, use potable water to pre-wet the deck surface to a saturated surface dry condition (not absorbing water from or contributing water to the concrete mixture). Maintain the saturated surface dry condition for at least 6 hours. Do not allow free water on the surface when placing the bonding agent as stated in 2404.2B, “Bonding Grout.”

D Concrete Placement and Texturing

Place and finish concrete at a linear rate, measured parallel to the centerline of the Bridge, of at least 40 feet per hour under normal working conditions. Do not place concrete wearing course placement widths greater than 24 feet, unless otherwise shown in the Special Provisions.

Place joints in the concrete wearing course directly above the original joints constructed in the Bridge Structural Slab and in accordance with 2401.3E, “Joint Construction.” Make saw cuts as soon as the concrete can be cut without raveling the surface and expeditiously to minimize the exposure of the uncured concrete to surface drying. Seal saw cuts with joint sealer in accordance with 3723, “Hot-Poured, Elastic Type Joint and Crack Sealer,” or 3725, “Hot-Poured, Extra-Low Modulus, Elastic Type Joint and Crack Sealer.”

After consolidating, screeding, and floating the concrete, draw a carpet drag longitudinally along the pavement before the concrete attains its initial set. Adjust the carpet drag to produce a texture as approved by the Engineer.

Use artificial grass type carpet drag meeting the following characteristics and requirements: mounted on a Work Bridge, a longitudinal length of 3 feet, width equal to the concrete placed, artificial grass type, molded polyethylene pile face, blade length of from 5/8 inch to 1 inch, total weight of at least 70 ounces per square yard.

In lieu of the carpet drag texturing, the Contractor may use coarse broom texturing as approved by the Engineer.

Immediately following the carpet drag, texture the Bridge Deck Slab surface with a metal-tine pattern. Install the transverse texturing (tining) on a slight diagonal, at an angle of approximately 10 degrees to a line perpendicular to the Roadway centerline, produced by using a device meeting the following characteristics and requirements:

(1) Equipped with steel tines from 4 inches to 6 inches long and from 1/12 inch to 1/8 inch thick
(2) Steel tines arranged to obtain randomized grooves from 1/8 inch to 5/16 inch deep
(3) Variable spacing between tines from 5/8 inch to 1 inch

The Contractor may use other texturing Equipment that will produce an equivalent texture as approved by the Engineer. Do not texture within 1 foot of curbs or gutterlines.

Do not extend tining into areas within 1 foot of a curb or gutterline.

Ensure the final surface does not vary by greater than 1/8 inch within a 10 foot straightedge laid longitudinally on the final surface. This surface tolerance includes areas near expansion devices and other breaks in the continuity of the wearing course.

Remove and replace the surface areas not meeting the tolerances specified above. Alternatively, grind the high spots on the surface areas not meeting the tolerances specified above as directed by the Engineer. The Department defines uncorrected nonconforming areas as unacceptable Work in accordance with 1512, “Unacceptable and Unauthorized Work.”

Place joint sealer Material of the type as shown on the Plans or Special Provisions in accordance with 2301.3N.3, “Joint Sealing.”

If the National Weather Service predicts a daytime temperature of at least 80°F for a scheduled concrete placement, reschedule the placement or begin the concrete placement between midnight and 5:00 a.m. Terminate placements at 5:00 a.m. that are started after midnight, but not completed by 5:00 a.m. if the ambient air temperature is at or above 80°F. If the air temperature is below 80°F at 5:00 a.m., the placement may continue until such time as the temperature reaches 80°F. Do not place concrete wearing course if the air temperature falls below 40°F or if the slab surface shows signs of frosting.

Notify the Engineer at least 24 hours in advance of scheduling a night operation. Provide an area with a minimum of 50 foot candles of light to ensure quality workmanship and adequate inspection. Confirm the adequacy of lighting with a light meter.

Except if heating and housing the concrete, do not place concrete for wearing courses in accordance with any of the following requirements:

(1) Before April 15th
(2) After September 15th, north of the 46th parallel
(3) After October 1st, south of the 46th parallel

The Contractor may place concrete for wearing course before April 15 or after September 15 or October 1 as specified above, if heating and housing the deck and performing the following:

(1) Submit a Plan and proposed time schedule for cold weather protection and maintenance of acceptable curing temperatures to the Engineer. Do not begin Work until the Engineer approves the cold weather protection Plan and all Materials identified in the Plan are on site
(2) Provide the concrete with suitable housing immediately after placement allowing free air circulation above the surface and protecting the concrete against freezing, rain, or snow
(3) Provide pre-heating for the structural slab before concrete placement if necessary. Provide insulation blankets or heating facilities to maintain the curing temperatures in item (4) below
(4) For low slump concrete, maintain the concrete surface or enclosure temperature at 60°F or higher for the first 4 Calendar Days after concrete placement. Do not expose the concrete to temperatures lower than 40°F until at least 26 Calendar Days after the initial 4 Calendar Day period
(5) Do not remove the housing enclosure until fulfilling the cold weather protection needs as approved by the Engineer

E Low Slump Concrete

E.1 Mixer Requirements

Provide mixing Equipment in accordance with 2461, “Structural Concrete,” except use a continuous mixer with metered proportioning capability.

Complete the following:

(1) Notify the Engineer at least 5 Calendar Days before calibration test so that the Engineer is present during the test
(2) Calibrate the mixer on site in the presence of the Engineer
(3) Provide written documentation that the continuous mixer is calibrated before using it on the job
(4) Mix concrete at the job site

E.2 Finishing Machine Requirements

Provide a finishing machine meeting the following requirements and characteristics:

(1) Contains at least one oscillating screed
(2) Designed to consolidate the concrete to 98 percent of rodded density by vibration

Install identical vibrators or pillow blocks with eccentric cams to provide at least one vibrator or source of vibration for each 5 feet of screed length. If only vibrating one screed, vibrate the front screed. Ensure the bottom face of the screed is at least 5 inches wide and contains a turned-up or rounded leading edge to minimize surface tearing. Ensure each screed produces a pressure of at least 75 pounds per square foot of screed area on the bottom face. Provide each screed with positive control of the vertical position, angle of tilt, and shape of the crown. Equip the finishing machine with an adjustable power-operated paddle or auger to strike off concrete in front of the first screed.

E.3 Concrete Placement

Scrub the bonding grout into the deck surface and adjacent contact points at a controlled rate (based on field conditions) to prevent drying before covering with the concrete wearing course.

Mechanically strike off the concrete slightly above final grade before consolidating and screeding to final grade.

Saw the wearing course at transverse and longitudinal joints to a straight, vertical edge. Remove trimmings before placing the adjacent wearing course. Do not operate impact Equipment in the adjacent lane during the first 72 hours after placing the concrete unless otherwise approved in writing by the Engineer. Use thinned bonding grout to seal vertical joints with adjacent in-place concrete surfaces after finishing and texturing to assure the vertical joint is sealed.

E.4 Curing Requirements

Coat the concrete with membrane curing compound in accordance with 3754, “Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound,” within 30 minutes after placing the concrete. Use an airless spraying machine containing the following:

(1) A recirculating bypass system that continuously agitates the reservoir Material
(2) Separate hose and nozzle filters
(3) A multiple or adjustable nozzle system to provide variable spray patterns

Before application, agitate the curing compound in the shipping containers to obtain a homogeneous mixture. Apply the compound to provide a uniform, solid white, opaque coverage equal to a white sheet of paper on exposed concrete surfaces. Respray areas that appear to have a coating that is less than a white sheet of paper. Respray membrane film damaged before the placement of the wet cure.

Apply the membrane curing within 45 minutes after depositing concrete if revibrating the concrete as directed by the Engineer. If the Contractor fails to apply membrane curing in the required time after depositing concrete, the Department will consider this as unacceptable Work in accordance with 1512, “Unacceptable and Unauthorized Work.” Remove and replace concrete in areas not coated with membrane curing compound within the required time at no additional cost to the Department.

As soon as the concrete can be walked on without damage, place wet burlap or curing blankets in accordance with 2401.3G, “Concrete Curing and Protection,” for a minimum of 4 Calendar Days. Maintain burlap in a wet condition for the entire curing period.

After completion of the wearing course curing period, the Engineer will perform a visual inspection of the wearing course, and will locate cracks appearing on the top surface. Furnish only one of the Materials listed on the *Approved/Qualified Products List* of "Bridge surface and crack sealers.” Fill located cracks with an approved crack sealer following the manufacturer's recommendations, and as otherwise directed by the Engineer prior to opening the Bridge to vehicular traffic.

Do not allow vehicular traffic on the concrete wearing course during the 4 Calendar Day curing period. If the daily mean temperatures during the 4 Calendar Day curing period fall below 60°F, provide additional curing time before allowing traffic on the surface as required by the Engineer.

2404.4 METHOD OF MEASUREMENT

The Engineer will measure the Concrete wearing course by surface area based on the dimensions shown on the Plans. The Engineer will not deduct the surface area of expansion devices or other miscellaneous appurtenances.

2404.5 BASIS OF PAYMENT

The Department will pay for Concrete wearing course for Bridges on the basis of the following schedule:

Item No.	Item	Unit
2404.518	Concrete Wearing Course (Mix Design)	square foot

2405 PRESTRESSED CONCRETE BEAMS

2405.1 DESCRIPTION

This Work consists of providing and installing prestressed concrete beams and double Tee-beams for use in Bridge Superstructures.

2405.2 MATERIALS

A Concrete 2462

Provide concrete produced in a central-mix plant in accordance with 2462, “Precast Concrete.” The Contractor may use Type I, Type II, or Type III Portland cement.

Use Mix No. 1W82 or Mix No. 3W82 concrete for prestressed beams.

Use Mix No. 3W82 concrete for double Tee-beams.

B Metal Reinforcement 3301

C Structural Steel 3306

D High-Strength Low-Alloy Structural Steel 3309

E Seven-Wire Strand for Prestressed Concrete 3348

F Structural Steel Pipe 3362

G Galvanized Structural Shapes 3394

2405.3 CONSTRUCTION REQUIREMENTS

Provide beams manufactured from a precast/prestressed concrete plant certified by the PCI or by another organization approved by the Materials Engineer and in accordance with the following:

(1) 2401, "Concrete Bridge Construction"
(2) 2471, "Structural Metals"
(3) 2472, "Metal Reinforcement"
(4) *PCI Manual for Quality Control: Precast and Prestressed Concrete*
(5) 3240, "Precast Concrete Manufacturing"

A General

The Materials Engineer is the Engineer with authority concerning all matters of plant fabrication and inspection prior to delivery of the Materials to the Project. The Engineer has authority concerning all matters of fabrication at the Project Site.

Submit a written notification to the Engineer immediately after placing orders for prestressed concrete beams. Include the name and address of the supplier and the beam manufacturing location.

Notify the Materials Engineer at least 7 Calendar Days before beginning manufacturing operations. If the Contractor casts the beams at the Bridge site, notify the Engineer at least 7 Calendar Days before casting to permit inspection of the forms and reinforcement.

If casting the beams at a plant away from the Bridge site, provide an office in accordance with Table 2031.3-1, Field Office with air conditioning and access to sanitary facilities. The Department will not require laboratory space.

If, on any day, the Department inspects beam casting at a plant away from the Bridge site and less than two beams are cast, the Department will deduct from any monies due or becoming due to the Contractor the total cost of inspection for that day.

Ensure the fabricator's Quality Control office maintains documentation containing the data required by the Specifications and the Materials Engineer. This documentation shall contain test data and measurements taken at times and locations approved by the Engineer, assuring that monitoring, by personnel not directly involved in production, is sufficient to ensure compliance with approved procedures.

If the Materials Engineer's review of fabrication Work discloses that approved procedures are not being followed, the Fabricator shall immediately correct the procedure.

The Materials Engineer will determine what additional testing Work must be done by the fabricator or, if necessary, what part of the Work must be repaired or replaced if fabrication Work is not properly monitored and documented by the fabricator.

Any and all costs of required additional monitoring and testing shall be at the expense of the Contractor with no additional compensation. Provide a PCI Level II Certified Technician on site at the start of fabrication and throughout fabrication of the prestressed beams. Provide PCI Level I Certified

Technicians to perform Quality Control functions. Provide a PCI Level II Certified Technician as a supervisor for the Quality Control staff.

Take precautions to prevent contamination of prestressing steel with oil, dirt, or other deleterious substances and to prevent damage that may result in weakening the prestressing steel that may result in its failure under stress. The Materials Engineer may reject nicked or kinked prestressing steel. Do not allow sparks or pieces of molten metal from welding or burning Equipment to contact the prestressing steel. Do not use prestressing steel as a ground for welding Equipment.

Galvanize all steel inserts or devices that will be within 1 inch of the exposed surface of the finished Structure. Galvanize or coat with zinc-rich primer all other steel inserts or devices included in the beam.

B Forms

Provide forms designed to withstand pressure from concrete, vibration, and impact without distortion. Set and maintain forms mortar tight, free of warp, and on a rigid foundation. Set the side form at right angles to the vertical axis of the beam and with the plane of bearing surfaces flat and true. Set side forms during casting as shown on the Plans. Maintain side forms during casting until the concrete sets. Provide a tight fit without offset for joints in sectional forms.

Set forms for prestressed concrete beams so the dimensions of the beam after prestress transfer will conform to the Plan dimensions in accordance with 2405.3H, “Tolerances.”

Treat the face of the forms in contact with the concrete with form coating Material in accordance with 3902, “Form Coating Material,” before setting the form in position. Clean the forms of accumulations of oil and other substances before use.

Provide beam end blocks as shown on the Plans. The Contractor may increase the length of the end blocks as much as 12 inches to accommodate sectional forms. Provide end blocks of the same length for beams of the same length in any one span.

C Steel Units

Place, support, and tie reinforcement bars for prestressed concrete beams in accordance with 2472, “Metal Reinforcement.”

Cover the reinforcement bars with concrete at least 1 inch thick.

Set sole plates for prestressed beams so that after prestress transfer the sole plate locations match the Plan locations within the tolerance specified for the Plan length of pretensioned beams. Place the sole plates in contact with the bottom form. Maintain position of the sole plates during placement of concrete.

Position floor drains as shown on the Plans. Fasten the floor drains to the forms to ensure that concrete placement does not alter the alignment or location.

Remove loose rust, dirt, oil, and other foreign substances from prestressing tendons before erecting the beam side forms.

The Contractor may construct hold-down devices for deflected strands so that the Contractor can remove the device for a distance of at least 1 inch from the face of the concrete and plug the hole with mortar. Use free-rolling devices (hold-down and hold-up) at all deflection points. The device may rest on the bottom form and remain in-place. If resting the device on the bottom form, galvanize the part in contact with the form for a distance of at least 1 inch from the form.

D Placement of Concrete

Cast the beams in an upright position. Place the concrete in each beam without interruption. Modify the casting procedure if the length of the beams and placement conditions cause a cold joint to form when continuing each Lift full length before placing a subsequent Lift.

Vibrate the concrete in each beam internally, externally, or both to produce uniformly dense concrete. Do not displace enclosures or steel units when vibrating. Internally vibrate in accordance with 2401.3D, "Compaction of Concrete," using a vibrator with a non-metallic vibrating head no greater than 1 1/4 inches in diameter operating at a frequency of at least 100 Hz.

After striking off the top surface of the beams to the required level, Work and hand float the surface to seal open tears in the surface and depress coarse Aggregate. Use transverse brooming to roughen the surface. Provide smooth finish on edges of top flanges as shown in the Plans. Apply a bond breaker shown on the APL to the smooth area after curing.

E Concrete Curing

Cure according to the requirements of 3240, "Precast Concrete Manufacturing."

F Tensioning

F.1 Equipment

Tension prestressing tendons using hydraulic jacks or dynamometers and hydraulic jacks. Equip each jack pump with a hydraulic pressure gauge. Calibrate jacks, gauges, and pumps as a unit under conditions similar to operating conditions. Provide a dated, certified calibration curve for each combination used. Recalibrate Equipment presenting erratic results during tensioning operations.

Ensure the hydraulic pressure gauges can accurately determine the actual stress on the jacks within a tolerance of 2 percent of the total indicated stress during final elongation of the prestressing tendons.

Calibrate the dynamometer used to measure an initial tension. Ensure the dynamometer can accurately determine the initial tension within a tolerance of 5 percent.

F.2 General Procedures

Conduct the tensioning procedure so that it is possible to compare the indicated stress on the tendons based on gauge pressures and the indicated stress based on the corresponding elongation of the tendons at any time during the tensioning operation. If the two indicated stresses, corrected for friction loss, differ by no greater than 5 percent, stress the tendons so the lower of the two indicated stresses equals the required tension in the tendon. Do not tension any tendon to an indicated stress greater than 80 percent of its specified tensile strength at any time. If the indicated stresses differ by greater than 5 percent, stop tensioning operations. Determine the source of the discrepancy and correct it before resuming tensioning operations.

When the tensioning operation includes more than two girders with all deflection points included, demonstrate proper tension at both ends. When tensioning more than four girders with all deflection points included, measure and ensure proper elongation on the interior girders that are more than one girder from an end.

Do not tension prestressing strands in the bundled position with direct contact between adjacent strands. Maintain a clear space of at least 1/4 inch between adjacent strands during tensioning. Depress tensioned strands into a bundled position with contact between adjacent strands after the completion of tensioning.

Record the gauge pressures, indicated stresses, and elongations, and submit the record to the Materials Engineer.

The Contractor may tension strands as a group if the strands in the group are from the same manufacturer and the strands receive the same initial tension. When tensioning, consider initial strand tension no greater than 150 pounds per strand to be zero tension. If the Contract requires an initial tension greater than 150 pounds per strand, use a dynamometer to measure the tension. Add the elongation due to the initial tension to the final elongation measurement.

Tension the deflected strands so that final tension is uniform in all parts of the strand. Provide freely turning rollers to reduce frictional forces at the deflection points.

Correct tension-elongation measurements for losses due to slippage of grips or anchorages, and friction to obtain the prestress force shown on the Plans.

If a temperature differential in the strands at the time of tensioning and at the time of concrete placement exceeds 15°F, consider the change in the final elongation measurements to obtain the required prestress force at the time of casting. Base the change in elongation due to temperature on a 1/8 inch per 100 feet of strand length for each 15°F variation in temperature. Tension prestressing tendons when both the ambient air temperature and prestressing tendon temperature are greater than 32°F and rising.

G Prestress Transfer

Perform the prestress transfer after the control cylinders indicate that the concrete has reached a compressive strength of at least 4,500 psi unless otherwise shown on the Plans. When breaking the controls cylinders, use a testing machine that prints all test data, including time and date, directly to a printer, and initial the printout. Make the prestress transfer when the concrete is still warm and moist.

During the prestress transfer sequence keep the lateral eccentricity of the prestress to a minimum and prevent cracking in the top flange of the beams. The Contractor may perform the prestress transfer by the gradual release of hydraulic jacks, by heating exposed portions of individual strands to failure, or by a combination of these two methods. If heating the individual strands, heat in accordance with the following:

(1) Heat each individual strand simultaneously on the strand at no less than 2 locations along the casting bed. Use a sequence of heating each strand along the bed and a sequence of heating individual strands so that no detrimental damage results

(2) Heat with a low oxygen flame played along the strand for a distance of at least 5 inches. Control the heat to ensure that failure of the first wire in the strand does not occur for at least 5 seconds after the application of heat followed by gradual elongation and failure of the remaining wires

Completely strip the forms from the beams before beginning prestress transfer.

H Tolerances

After prestress transfer, check the dimensions of the prestressed concrete beam to verify that the dimensions match what the Plans show within the tolerances in the *PCI, Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, MNL-116*. Inform the plant Inspector of any measurements not within the tolerance limits.

The Engineer will measure differential camber between adjacent members of the same design with the beams erected in the final position.

The Engineer or the Materials Engineer may reject members that do not meet the dimensions shown on the Plans or the specified tolerances.

I Rejection

The Materials Engineer may reject beams failing to meet the requirements of this section or beams showing any of the following after the removal of forms:

(1) Honeycombing
(2) Stone pockets
(3) Sand streaks
(4) Imperfect mixing and casting

The Materials Engineer will not reject beams showing minor surface cavities or irregularities that do not impair the service value if repaired as approved by the Materials Engineer. Make repairs after the Materials Engineer inspects the irregularities. Use repair Materials and methods approved by the Materials Engineer.

J Marking, Handling, Storage, and Transportation

The Department will allow beams to be moved from the casting bed to a nearby storage area after attaining the minimum compressive strength for prestress transfer. Do not transport or install beams until the beam attains a compressive strength of at least 5,000 psi, as evidenced by control cylinders. When casting off-site, do not ship the beam until it has reached the full design strength shown in the Plans.

Mark each beam with the casting date and piece mark. If casting beams away from the Bridge site, mark each beam with the name or trademark of the manufacturer and the Bridge number. The Materials Engineer will stamp each approved beam with the official mark of the Department before shipment. Complete repairs before the Department stamps the unit. Do not ship beams without the Department stamp of approval. After completing the repair Work, notify the Materials Engineer at least 1 full Business Day before intent to ship. The Engineer will perform a final inspection of units upon delivery.

Ensure markings remain in evidence after erection, but not readily visible in the completed Structure.

Keep prestressed beams in an upright position at all times. Support prestressed beams during storage, lifting, and transportation at two points only. Considering beam stresses and stability, determine the support point locations in accordance with standard PCI methods.

Obtain permits as required by Road authorities.

K Installation

Erect prestressed concrete beams in a manner that will provide safety to the workers, Inspectors, and the public at all times, as well as reasonable assurance against damage to the prestressed members. Prior to the placement of diaphragms, temporarily anchor, brace and stabilize the prestressed beams as they are erected so as to preclude sliding, tipping, buckling, or other movement that may otherwise occur. If active vehicular or railroad traffic will be permitted to travel beneath beams prior to complete erection of all the beams and diaphragms in a span, submit an erection Plan prepared by a Professional Engineer, thoroughly checked by a second Professional Engineer for completeness and accuracy, and certified by one of the aforementioned Professional Engineers licensed in the State of Minnesota which details all temporary Works necessary to brace and stabilize beams. Ensure struts, bracing, tie cables, and other devices used for temporary restraint are of a size and strength that will ensure their adequacy. Arrange the Work schedule so that each beam will be connected to an adjacent beam and at least two adjacent girders will be erected (including diaphragms and bolts fully tightened) and braced and stabilized in any one span before operations are suspended for the day. Install and permanently fasten the prestressed concrete beams as shown on the Plans. Provide intermediate diaphragms for prestressed concrete beams as shown on the Plans.

Provide structural steel shapes and plates for the steel intermediate diaphragm option in accordance with 3306, “Low-Carbon Structural Steel,” or 3309, “High-Strength Low-Alloy Structural Steel.” Galvanize structural steel plates and shapes in accordance with 3394, “Galvanized Structural Shapes.”

Provide fasteners, including washers, for the intermediate steel option in accordance with 3391, “Fasteners.” Provide fasteners meeting the requirements of *ASTM F3125 Grade A325, Type* 1. When used with galvanized structural steel, use *ASTM F3125 Grade A325, Type 3*. Galvanize fasteners for use with galvanized structural steel in accordance with 3392, “Galvanized Hardware.”

Use cast-in-place anchorages to connect the steel intermediate diaphragms to the fascia beams. Provide anchorages capable of providing an ultimate pull-out strength of at least 15 kips per anchorage.

Provide approved plastic or galvanized steel Material to form holes in beam webs to connect bolts for steel intermediate diaphragms.

Ensure threaded rods used to attach prestressed concrete beams to cast-in-place concrete diaphragms are either galvanized per 3392, “Galvanized Hardware” or electroplated in accordance with *ASTM B633, service condition SC4*.

Completely remove or cut off flush within 1/2 inch of concrete surface any uncoated items, such as used for static safety lines, anchors, lifting loops, etc., prior to casting the deck.

Provide an ordinary surface finish to the exterior faces of the precast elements in accordance with 2401, “Concrete Bridge Construction.” Provide a surface finish as per the Special Provisions with the beams in place and in conjunction with the final finish of the remainder of the Structure in accordance with 2401, “Concrete Bridge Construction.”

2405.4 METHOD OF MEASUREMENT

The Engineer will separately measure Prestressed concrete beams Type ___ as individual units regardless of minor variations in Plan details between beams of the same type.

The Engineer will measure Prestressed concrete beams ___ by summation of the individual lengths, out to out, along the centerlines of beams.

The Engineer will measure intermediate diaphragms for prestressed concrete I-beams by length based on the horizontal distance from centerline to centerline of beam along the axis of the diaphragms.

2405.5 BASIS OF PAYMENT

The Contract Unit Price for Prestressed concrete beams includes the costs of manufacturing, transporting, and erecting the beams in the final position, and the cost of temporary bracing in accordance with 2405.3K, “Installation.”

The Contract Unit Price for Prestressed concrete beams includes the cost of constructing the intermediate diaphragms complete-in-place and structural steel or concrete and reinforcement bars as shown on the Plans.

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

Item No.	Item	Unit
2405.502	Prestressed Concrete Beams Type ___	each
2405.502	Prestressed Concrete Double Tee-Beam Type ___	each
2405.503	Diaphragms for Type ___ Prestressed Beams	linear foot
2405.503	Prestressed Concrete Beams ___	linear foot

2406 BRIDGE APPROACH PANELS

2406.1 DESCRIPTION

This Work consists of constructing Bridge approach panels.

2406.2 MATERIALS

A Concrete **2461**

A.1 Mix Designation .... **Mix No. 3S52**

B Reinforcement Bars **3301**

C Curing Materials

C.1 Burlap Curing Blankets **3751**

C.2 Poly Alpha Methyl Styrene (AMS) Membrane Curing Compound **3754**

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

C.4 Plastic Curing Blankets **3756**

D Granular Materials **3149**

E Form Coating Material **3902**

2406.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Excavate, shape, and compact the foundation to a firm, uniform bearing surface in accordance with 2106, "Excavation and Embankment – Compacted Volume Method." Construct Bridge approach panels to the section and grade shown on the Plans.

B Forms

Provide forms made of non-reactive metal, wood, or other material capable of maintaining the concrete until the concrete can retain the molded shape. Provide forms with a height at least equal to the approach panel thickness of the formed concrete as shown in the Plans. Support the forms on the foundation to maintain the line and grade as shown on the Plans.

On curves with a radius of 100 feet or less, use flexible or curved forms of the radius as shown on the Plans.

Before placing the concrete, coat the contact surfaces of all forms with an approved form coating Material in accordance with 3902, "Form Coating Material."

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

C Placing and Finishing Concrete

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

Place the concrete in a manner that will prevent segregation. Consolidate the concrete to fill voids using internal vibration. Strike off the concrete to the grade shown on the Plans, and float the surface smooth.

Provide the same surface texture as the Bridge deck and construct in accordance with 2401, “Concrete Bridge Construction,” or 2404, “Concrete Wearing Course for Bridges.”

Finish edges with a 3/8 inch radius edging tool.

D Joint Construction

Place joints as shown on the Plans.

E Metal Reinforcement

Provide and place metal reinforcement as shown on the Plans and in accordance with 2472, “Metal Reinforcement.”

F Workmanship and Finish

Ensure completed concrete Work is uniform in surface contour and texture and conforms to the lines and grades shown on the Plans. Finish the flow line surface of gutters as necessary to eliminate low spots and avoid entrapment of water.

The Engineer will use a 10 feet straightedge to measure surface tolerance. The Department considers vertical deviations in the surface greater than 3/8 inch and line deviations greater than 1/2 inch from the required location as unacceptable Work in accordance with 1512, “Unacceptable and Unauthorized Work.”

G Concrete Curing and Protection

After completing final finishing operations, cure all exposed concrete surfaces. Use one of the following curing methods:

(1) Place the membrane curing compound conforming to 3754, “Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound,” or 3755, “Linseed Oil Membrane Curing Compound,” within 30 minutes of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2406.3G.1.a, “Membrane Curing Method.” Place the membrane curing compound on the edges within 30 minutes after permanent removal of the forms or curing blanket, unless the Contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets in accordance with 2406.3G.1.b, “Blanket Curing Method,” as soon as practical without marring the surface.

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

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

G.1 Curing Methods

G.1.a Membrane Curing Method

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

G.1.a(1) Application Requirements

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

(1) At a rate of 1 gallon per 150 square feet of surface curing area
(2) Apply homogeneously to provide a uniform, solid, white, opaque coverage on all exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some Department approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform, solid, opaque consistency meeting the intent of the above requirement
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by respraying

G.1.a(2) Equipment Requirements

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

(1) A recirculating bypass system that provides for continuous agitation of the reservoir Material
(2) Separate filters for the hose and nozzle
(3) Multiple or adjustable nozzle system that provides for variable spray patterns

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

G.1.b Blanket Curing Method

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

G.2 Protection Against Rain

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

G.3 Protection Against Cold Weather

If the National Weather Service forecast for the construction area predicts air temperatures of 34°F or less within the next 24 hours and the Contractor wishes to place concrete, submit a cold weather protection Plan in accordance with 2406.3G.3.a, “Cold Weather Protection Plan.”

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

G.3.a Cold Weather Protection Plan

Submit a written cold weather protection Plan to the Engineer for approval. The Plan shall include a proposed time schedule for concrete placement and curing, and Plans for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer approves the Contractor's cold weather protection Plan.

H Backfill Construction and Opening Bridge Approach Panels to Traffic

Cast the control specimens in accordance with 2461.3G.5, “Concrete Strength.” Cure the control specimens in the same manner and under the same conditions as the Bridge approach panel represented. The Engineer will test the control specimens in accordance with 2461.3G.5, “Concrete Strength.”

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Resume vibratory and backfilling operations after the concrete has reached a minimum compressive strength of 2,000 psi or a flexural strength of 250 psi.

The Contractor may use hand-operated concrete consolidation Equipment and walk behind vibratory plate compactors 24 hours after placing the concrete, and other Equipment as approved by the Engineer, in conjunction with the Concrete Engineer. The Contractor may also use rollers in “static” mode and fine grading machines.

As soon as possible after the curing is complete and without subjecting the concrete Work to damaging stresses, perform the backfill or embankment construction to the elevations shown on the Plans. If the Contract does require a specific backfill Material, use suitable grading Materials from the excavations in accordance with 2106, “Excavation and Embankment – Compacted Volume Method.” Place and compact the backfill Material in accordance with 2106, “Excavation and Embankment – Compacted Volume Method.”

Dispose of surplus excavated Materials in accordance with 2106, “Excavation and Embankment – Compacted Volume Method.”

Do not open a Bridge approach panel to general public traffic or operate paving or other heavy Equipment on it for 7 Calendar Days, or until the concrete has reached a minimum flexural strength of 500 psi, or minimum compressive strength of 3,000 psi; whichever occurs first.

Perform operations on new Bridge approach panels as approved by the Engineer and in accordance with the following:

(1) When moving on and off the Bridge approach panel, construct a ramp to prevent damage to the pavement slab.

(2) Protect the concrete surface and joints from damage due to heavy loads or Equipment in accordance with 1513, “Restrictions on Movement and Storage of Heavy Loads and Equipment.” Sweep the Bridge approach panel surface free of debris prior to placing the protective Material or tracked Equipment onto the slab.

(3) Operate Equipment on the Bridge approach panel without causing damage. Do not operate the Equipment wheels or tracks within 4 inches of the Bridge approach panel edge.

(4) When hauling Aggregate and other Materials across newly constructed joints, keep the surface free of debris by sweeping or other method as approved by the Engineer to prevent spalling of the joints.

If damage results from any of these operations, the Engineer will suspend all operations until the Contractor takes corrective action and the Engineer approves of a new method. The Engineer may subject damaged concrete to 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

I E8 Expansion Joint Seal

Select E8 expansion joint Material from the *Approved/Qualified Products List*.

Install E8 expansion joint Material in accordance with the manufacturer's recommendations and as shown on the Plans.

2406.4 METHOD OF MEASUREMENT

If the Contract contains a Contract Item (or Contract Items) for the construction of Bridge approach panels, the Engineer will measure their construction as complete-in-place items. The Engineer will measure the total area of all panels of the same basic design. If the Contract does not contain this Contract Item, the Engineer will measure their construction under the relevant Contract Items provided for pavement construction.

The Engineer will measure the length of expansion joints along the joint line as shown on the Plans.

2406.5 BASIS OF PAYMENT

The cost of the following is included in the Contract Unit Price for Bridge approach panels:

(1) Providing and placing concrete, steel, drainage system, and polyethylene sheeting
(2) Constructing the integrant curb, terminal headers, and concrete sills
(3) Protecting and curing the concrete
(4) Other Incidental Work not specifically included for payment under other Contract Items

The cost of constructing the joints complete in-place as shown on the Plans, including the providing and placing of all Materials such as filler, and sealer Material is included in the Contract Unit Price for Expansion joints, Design E8.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Bridge Approach Panels. The amounts of these adjustments are deemed reasonable.

A.1 Workmanship and Finish

If the Engineer does not direct the removal and replacement of the unacceptable Work, the Contractor may leave the Work in-place and the Engineer will calculate a monetary deduction of up to 50 percent of the Contract Unit Price for the unacceptable Work.

A.2 Concrete Curing and Protection

Failure to properly cure and protect the concrete in accordance with 2406.3G, "Concrete Curing and Protection," will result in the Engineer calculating a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the Contract does not contain a separate Contract Item for Structural concrete, the Department may apply a monetary deduction of $50.00 per cubic yard or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

B Schedule

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

Item No.	Item	Unit
2406.503	Expansion Joints; Design E8	linear foot
2406.504	Bridge Approach Panels	square yard

2411 MINOR CONCRETE STRUCTURES

2411.1 DESCRIPTION

This Work consists of constructing concrete Structures of miscellaneous types and varied designs, with or without metal reinforcement, and including box Culverts, retaining walls, Culvert headwalls, open flumes, and other cast-in-place items.

2411.2 MATERIALS

A Concrete **2461**

Provide mix designations as shown on the Plans.

B Reinforcement Bars **3301**

C Welded Wire Reinforcing **3303**

D Preformed Joint Fillers **3702**

E Geosynthetic Materials **3733**

2411.3 CONSTRUCTION REQUIREMENTS

Construct minor concrete Structures in accordance with 2401.3, “Construction Requirements,” and the following:

A General

The Department considers the Structure locations shown in the Plans as approximate only. The Engineer will establish the exact locations in the field. Each Structure shall conform to the planned design, but the Engineer may change the dimensions to fit on-site conditions. Do not order Materials until the Engineer establishes the exact locations and dimensions.

Construct box Culverts in accordance with the standard box Culvert Plans pertaining to construction joints, reinforcement bar splicing, and computation of quantities except as modified by the following:

(1) Stagger transverse construction joints at least 4 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 60 feet long, the Department will allow additional splices at no additional cost to the Department

(3) The Engineer will calculate pay quantities for concrete and reinforcement bars using the formulas as shown on the box Culvert Plans. The Engineer will adjust the formula quantities to account for additional Materials due to design modifications made by the Engineer or to provide for a completed Structure in accordance with the Plans and Special Provisions

Dispose of excavated Materials not needed for backfilling excavations in accordance with 2106.3E, “Excavating Operations,” at no additional cost to the Department.

B Falsework and Forms

Use form lining on vertical faces exposed to view in the completed Work. If required by the Special Provisions, provide detailed falsework or forming Plans.

C Concrete Curing and Protection

Provide curing protection for concrete Structures in accordance with 2401.3G, “Concrete Curing and Protection.”

D Geotextile Fabrics

Provide and install geotextile as shown on the Plans.

2411.4 METHOD OF MEASUREMENT

The Engineer will measure structural concrete using the dimensions as shown on the Plans. The Engineer will separately measure each grade or mix of concrete. The Engineer will not make allowances for quantities in excess of the minimum dimensions shown on the Plans and will not make deductions for volumes displaced by metal reinforcement, chamfer strips, or other Incidentals.

The Engineer will measure metal reinforcement in accordance with 2472.4A, “Reinforcement Bars.” If the Contractor provides additional splices in the reinforcement bars, the Engineer will not include the additional bar for these splices in the pay quantity.

If the Contract requires separate items for Structure excavation or granular backfill Material, the Engineer will measure quantities in accordance with 2451, “Structure Excavations and Backfills,” only for Structures with estimated quantities as shown on the Plans.

2411.5 BASIS OF PAYMENT

The Contract Unit Price for each grade or mix of structural concrete includes the costs of constructing the Structures complete and in-place. The Department will pay separately for metal reinforcement, Structure excavation, and backfill Materials if the Contract contains specific Unit Prices for these items.

The Contract Unit Price for concrete ____ of each type includes the costs of constructing the Structures complete and in-place. If the Contract contains a Unit Price for a surface area, the Department will pay separately for concrete in accordance with 2461.5, “Basis of Payment.”

The Contract Unit Prices for other applicable Contract Items include the cost of providing and installing geotextile fabric.

The Department will pay separately for Structure excavation and special backfill Materials only when the Contract contains Unit Prices for volume and the Plans show an estimated quantity for specific Structures. The Department will not provide separate payment for Structure excavation and special backfill Materials if the Contract contains Unit Prices for Structures by individual unit.

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

Item No.	Item	Unit
2411.502	Concrete ____	each
2411.504	Concrete ____	square yard
2411.507	Structural Concrete (Mix No.)	cubic yard
2411.507	Structure Excavation Class ___	cubic yard
2411.507	Granular Backfill (*)	cubic yard
2411.507	Aggregate Backfill (*)	cubic yard
2411.508	Reinforcement Bars (___)	pound

* Specify the basis of measure (LV or CV) after the item name. See 2451.4B, "Granular Materials."

2412 PRECAST CONCRETE BOX CULVERTS

2412.1 DESCRIPTION

This Work consists of installing precast concrete box Culverts.

2412.2 MATERIALS

A Concrete **2461**

B Reinforcement Bars **3301**

C Welded Wire Reinforcing **3303**

D Granular Materials **3149**

E Geotextile Type 3 .... **3733**

F Precast Concrete Box Culverts **3238**

2412.3 CONSTRUCTION REQUIREMENTS

Construct precast concrete box Culverts in accordance with 2411, "Minor Concrete Structures," 2451, "Structure Excavations and Backfills," and 3236, "Reinforced Concrete Pipe," and the following:

A Foundations

Prepare foundations in accordance with 2451.3C, "Foundation Preparations," except provide granular bedding in accordance with 3149.2F, "Granular Bedding," and at least 24 inches thick. Use a template to shape the bedding to a flat base. Use a mechanical hand compactor to compact the bedding adjacent to the bottom corner radii.

B Laying Precast Concrete Box Culvert

Lay precast concrete box Culvert sections with the groove end of each section up-grade. Tightly join the sections. Use concrete pipe ties meeting the requirements of *Standard Plate 3145* to tie individual sections together. Seal the joint on all four sides of the box Culvert with an approved product, as listed on the *Approved/Qualified Products List* under "Preformed Mastics," per the manufacturer's instructions. Place a strip of 3733, "Geosynthetic Materials," geotextile type 3 Material at least 24 inches wide centered over the top and sides of the joint. Use a minimum 12 inch lap between cut sections of the fabric. Clean the concrete to remove dirt by using a brush before applying the adhesive and fabric. Securely bond the fabric to the Culvert by applying adhesive to the Culvert or fabric for the full perimeter of the installed fabric. Prevent displacement of the geotextile Material during backfilling operations.

Join the box sections so that when laid on the granular bedding, they form a smooth, uniform line of sections. Do not adjust the grade by exerting force on the box section with excavating Equipment or by lifting and dropping the box section. If the box section is not on the correct grade, unjoin the sections, correct the grade and rejoin the sections.

Prevent construction Equipment loads greater than the loads used in the design to be transferred to the box section before, during, or after fill placement, either directly or through the fill.

Use precast concrete plugs to plug lifting holes in the top surface. If lifting holes are located in the sidewall, completely fill the holes with mortar meeting 3107 “Masonry Mortar,” or cover the hole with bolts, nuts and washers meeting 3392, “Galvanized Hardware,” and large enough to completely cover both ends. After plugging, seal and cover lifting holes with an approved product, as listed on the *Approved/Qualified Products List* under “Mastic,” or mortar.

2412.4 METHOD OF MEASUREMENT

A Culvert Excavation

If the Contract contains separate Pay Items for Culvert excavation, the Engineer will classify and measure excavation for concrete box Culverts in accordance with 2451.4A, “Structure Excavation.”

B Precast Concrete Box Culverts

The Engineer will measure precast concrete box Culverts by length. The Engineer will determine the length by adding the Nominal laying lengths of the individual sections incorporated into each Structure. The Engineer will take separate measurements for each Contract Pay Item size.

The Engineer will measure transition sections between two different box Culvert sizes as the larger or more costly size, except for special sections designated for measurement as each.

C End Sections and Other Appurtenant Items

The Engineer will separately measure end sections and other appurtenant items such as flap gates and other specially identified units, having Contract pay units described as “each,” by the number of complete units of each type and size incorporated into the box Culvert structures.

The Engineer will measure cast-in-place concrete Work, other than end sections and Culvert extensions, in accordance with 2411, “Minor Concrete Structures.”

D Granular Materials

The Engineer will not separately measure granular bedding for concrete box Culverts.

If the Contract includes Contract Pay Items for special backfill or bedding, the Engineer will measure special backfill or bedding for precast concrete box culverts in accordance with 2451.4B, “Granular Materials.”

2412.5 BASIS OF PAYMENT

The Contract Unit Price for Precast concrete box culvert and Precast concrete box culvert end section will include the cost of providing and installing Culverts and end sections, excavations, lintel beams, drop-wall, foundation preparation, granular bedding Material, and backfill, unless the Contract includes separate Contract Pay Items for the Work. The Department will include the cost of cast-in-place concrete Work for extending an existing box Culvert with the adjacent precast box culvert. The Department will include the cost of the 6 inch granular bedding for Precast concrete box Culverts with the relevant Contract Pay Items for precast concrete box Culverts.

The Department will pay for Precast concrete box Culverts on the basis of the following schedule:

Item No.	Item	Unit
2412.502	___ x ___ Precast Concrete Box Culvert End Section	each
2412.503	___ x ___ Precast Concrete Box Culvert	linear foot

2433 STRUCTURE RENOVATION

2433.1 DESCRIPTION

This Work consists of widening, rebuilding, crack sealing, or restoring Structures, including removal as shown on the Plans and in the Special Provisions.

2433.2 MATERIALS - BLANK

2433.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Explosives

Do not use explosives to remove any portion of a Structure being widened or reconstructed. The Contractor may use explosives to remove Material not directly connected to the remaining Structure as approved in writing by the Engineer and in accordance with 1711, "Use of Explosives."

A.2 Field Measurements

Consider the dimensions of the old Structure as shown on the Plans as approximate. Before making shop drawings and before manufacturing, take measurements of the old Structure to ensure proper joining of the old and new Work. Ensure elevations taken from existing Plans are adjusted to elevation datum used for construction. Provide the measurements to the Engineer. Show field measurements on the shop drawings.

B Removal and Disposal Requirements

Remove and dispose of Materials encountered in the renovation of existing Structures in accordance with 2442, "Removal of Existing Bridges," meeting the requirements of the MnDOT Regulated Material Management-Building Demolition/Relocation website and the following:

Stabilize peeling lead paint by coating with a lead paint encasement product listed on the *Approved/Qualified Products List* to prevent the peeling paint from flaking during demolition, or scrape and contain the peeling paint. If encasing, apply 16 mils of paint. If applying paint on a Bridge over water, attach a diaper apron or other containment method if necessary to prevent drips of paint from contaminating the water.

Remove old concrete or stone masonry within the limits shown on the Plans and without damaging the remaining Structure. Make saw cuts at least 1 inch deep on faces exposed to view to produce a straight line between new and old concrete.

Cut keyways into the concrete that remains in place without damaging the remainder of the Structure as shown on the Plans.

Do not impair the supporting capacity of the foundation soil and do not damage the remaining Structure if removing piling located within the new footing area.

If old piles interfere with the planned spacing of new piles, drive the old piling to determine bearing capacity and suitability for use in the new construction, as directed by the Engineer. Unless otherwise required by the Contract, the Department will pay for extra pile driving as Extra Work in accordance with 1402, "Contract Revisions."

B.1 Remove Slab

Remove and dispose of delaminated or unsound concrete Bridge deck surfaces and other areas of the Superstructure identified for partial removal in the Plans and by the Engineer, in accordance with the Plans and the following:

After traffic control has been established, the Engineer will sound the deck and identify removal locations by defining the areas for repair. Remove only that portion of the deck that has been defined for repair by the Engineer.

Restrict removal to methods which, in the Engineer's judgment, will not damage the Structure.

Restrictions for the power Equipment:

(1) Perform removal with power Equipment which has previously demonstrated satisfactory performance on the type of Work for which it is to be used. If permitted by the Engineer, use newly developed power Equipment on a performance basis, but discontinue such usage if so directed by the Engineer.
(2) Do not use jackhammers heavier than a Nominal 30 pound class for removal above the top Layer of reinforcement; except that the Engineer may permit the use of up to a Nominal 60 pound hammer by individual operators on a performance basis, but discontinue such usage if the Engineer determines that the heavier hammers are creating additional delamination, or that they are not being used with proper discretion.
(3) Pointed bits for jackhammers are not permitted except in areas where full depth removal is specifically defined by the Engineer.
(4) Do not use jackhammers heavier than a Nominal 15 pound class for removal below the top Layer of reinforcing bars unless full depth removal is specifically defined by the Engineer.

Ensure that the edges of all removal areas are near vertical and clean immediately before placing the concrete patching mix.

After removal operations are completed, clean the removal area of all remaining loose concrete by sandblasting. Clean exposed reinforcing bars by sandblasting to remove loose rust. Tightly adherent rust and mill scale may remain on the surface. Remove spent sand and debris.

Follow provisions of 1717, "Air, Land, and Water Pollution," as supplemented by Special Provisions, referring to MPCA Rule 7011.0150 as it relates to sandblasting and or concrete removal operations.

Leave all deck reinforcement steel in place as it was before concrete removal, unless otherwise directed by the Engineer. Replace all reinforcement bars damaged by Contractor's operations, as directed by the Engineer, unless the Engineer deems that the bars can be salvaged. The Engineer may deem bars that are damaged by Contractor's operations as salvageable. Where salvageable, propose methods to the Engineer to restore bars to as near the original condition as possible or replace affected portions of bars. All costs incurred for replacement or salvage is included in the applicable remove concrete pay item. All costs for damaged reinforcement are at no cost to the Department.

Do not perform removal in any area until the perimeters for removal in that area have been defined by the Engineer for that type of removal.

Dispose of all Materials removed in accordance with 2104.3C, "Removal Operations."

C Concrete Construction

Perform concrete construction in accordance with 2401, "Concrete Bridge Construction," and the following:

(1) Place and secure bolt anchors and other fasteners as specified in the Special Provisions and in accordance with the manufacturer's installation recommendations
(2) If no surface finishing of old concrete is shown on the Plans, provide a surface finish for at least 2 feet of the adjoining portion of the old concrete to blend the finish of the new with the old Work
(3) Unless otherwise shown on the Plans, drill holes and install bolt anchorages to the size and depth in accordance with the manufacturer's recommendations

C.1 Bridge Deck Crack Sealing Process

Perform crack sealing on new or existing Bridge deck surfaces in accordance with the following process:

(1) Perform deck cleaning and crack mapping in accordance with 2433.3C.2, "Deck Cleaning and Mapping Cracks."
(2) High crack density is defined as those Roadway surfaces on Bridge where crack mapping 72 square feet of representative area results in 20 linear feet. All other Bridge Roadway, Sidewalk, trail, median, and approach panel surfaces will be considered Low crack density.
(3) Seal Low crack density Surfaces in accordance with 2433.3C.3, "Seal Cracks with Epoxy by Chase Method."
(4) Seal High crack density surfaces in accordance with 2433.3C.5, "Methyl Methacrylate (MMA) Flood Seal."
(5) Where a concrete wearing course is present on concrete approach panels the crack sealing treatment may be evaluated separately under the same procedure as defined in 2433.3C.2, "Deck Cleaning and Mapping Cracks."
(6) If a silane application is scheduled in Contract Work, apply silane prior to sealing cracks according to 2433.3C.3, "Seal Cracks with Epoxy by Chase Method" and after any sealing in 2433.3C.5, "Methyl Methacrylate (MMA) Flood Seal."

C.2 Deck Cleaning and Mapping Cracks

This Work consists of cleaning the Bridge deck and Sidewalk for evaluation of crack density in advance of the crack sealing operations. Any grinding or Bridge deck planing should occur in advance of this phase. Where tining is the surface texture on new Bridge surfaces, AMS curing compound may be present. Crack sealing will not require removal of the curing compound for cracks less than 0.017 inches wide unless treating surfaces that are more than 1 year old.

The Contractor is required to:

(1) Remove all dirt, loose Aggregate and other deleterious Materials on Bridge deck, approach panels, Bridge joints, and Sidewalks. Bridge joint cleaning may require hand-operated Equipment such as blowers and power washers to thoroughly clean. Dispose of any loose Material removed from swept and cleaned areas in accordance with 2104.3C.3, "Concrete and Masonry Structures"

(2) Produce a 1 foot grid on the deck surface for mapping cracks at Engineer selected locations as detailed below
(3) Provide 2 crack comparator gages, per Bridge, conforming to standard crack widths of *ACI 224R-01*, "Control of Cracking in Concrete Structures"
(4) Prepare and submit crack mapping records for a minimum of two 12-foot by 6-foot areas documenting crack pattern and density
(5) Summarize measured crack data in 2 designated areas per Bridge to the Engineer. Based on observed crack density, a sealing treatment per Contract requirements will be authorized by the Engineer

The Engineer will locate 2 areas to represent the general cracking condition of the deck after cleaning at locations so that a 72 square foot area is located in a 12 foot longitudinal by 6 foot transverse area near midspan; and a 72 square foot area 6 foot in width located between 24-feet and 12-feet from center of a pier (if multiple spans).

The above locations are general guidelines and actual locations will be selected by the Engineer, but in all cases will be in a Traffic Lane to capture crack density.

Power wash representative areas. During the deck drying process produce a 1 foot grid at the designated locations.

Record crack frequency and the crack size range according to Table 2433.3-1.

Table 2433.3-1
Crack Width Ranges and Color Designations

Crack Classification	Crack Width	Pen Color
A1	< 0.010 inch	Black
A2	0.010 inch – 0.016 inch	Red
B1	0.017 inch – 0.024 inch	Green
B2	> 0.025 inch	Blue

Record mapping on grid-lined engineering paper demarked with 1 inch squares and 1/10 inch increments, where 1 inch paper Scale represents 1 foot measurement on Bridge deck surface. Record with clarity the general crack path in the appropriate color from Table 2433.3-1. Map cracks with an accuracy of ± 6 inches for path and using the largest portion of the crack width as the size. Re-evaluate crack size on Bridge deck every 2 feet when mapping and determine corresponding color of pen for recording. A sample crack map will be furnished on request.

Compute length of cracks in each crack classification category to the nearest 1/10 of a foot. Sum the length of cracks. Present crack mapping records and crack lengths to the Engineer at least 2 Business Days prior to performing any Bridge deck sealing. The Engineer will review the length of cracks based on interpretation of the submitted crack maps. Follow the 2433.3C.1, "Bridge Deck Crack Sealing Process," for determination of sealing method.

Where varying crack levels exist within a 200-foot or longer Bridge, crack evaluation may be performed at 50-foot intervals to substantiate a switch in crack sealing treatments.

C.3 Seal Cracks with Epoxy by Chase Method
This Specification covers crack sealing to:

(1) Structural slabs that will receive a concrete wearing course
(2) Bridge Deck Slabs (monolithic decks) with Low crack density in conformance with 2433.3C.1,"Bridge Deck Crack Sealing Process

(3) Concrete wearing course with Low crack density in conformance with 2433.3C.1,"Bridge Deck Crack Sealing Process

Seal all cracks 0.010 inches and larger. Cracks smaller than 0.010 inches, as measured at the crack's widest segment, on finished Roadway surfaces and Sidewalks will not require sealing.

When applied on finished concrete Roadway surfaces, apply epoxy in a width not exceeding 2 inches.

When applied on a structural slab which is to receive a concrete wearing course, apply epoxy in a cured width not exceeding 1 inch.

Furnish only one of the Materials listed on the *Approved/Qualified Products List*, "Bridge Surface and Crack Sealers." A product may be selected from either the "High Elongation Epoxy Crack Sealers" or "High Strength Epoxy Crack Sealers" categories. Apply in accordance with the requirements listed on the *Approved/Qualified Products List*, except that when applied under a concrete wearing course only 1 application pass is required.

C.4 Surface Preparation and Application

C.4.a When applied on final concrete surface including existing surfaces

Do not apply crack sealants to concrete surfaces less than 21 Calendar Days old except on new decks immediately prior to opening to traffic. No greater than 21 Calendar Days prior to application:

(1) Perform a visual inspection of the Roadway surface, and Sidewalk where applicable. Locate and mark all cracks appearing on the top surface visible from 5 feet above deck surface, and as directed by the Engineer

(2) Within 1 1/2 inches of the cracks, sandblast, shotblast, vapor blast, or waterblast to remove curing compound and other contaminants that would impede the adhesion of the sealant. Provide shielding as necessary to prevent dust or debris from striking vehicular traffic. Collect all debris and other Material removed from the surface and cracks, and dispose of it in accordance with applicable federal, state, and local regulations

(3) Air dry a wet deck for a minimum of 24 hours before applying the sealer

(4) Immediately before applying the sealer direct a 125 psi air blast, from a compressor unit with a minimum pressure of 365 cubic feet per minute, over the cracks to be sealed to remove dust and debris. Provide shielding as necessary to prevent dust or debris from striking vehicular traffic. Use a suitable oil trap between the air supply and nozzle. Use *ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air*, to ensure the compressed air is oil and moisture free.

Have the Engineer approve the prepared surface prior to applying the sealer.

Seal the entire length of all cracks 0.010 inches or greater in width as measured at its widest segment.

Protect all expansion joints and prevent the crack sealant from contacting the strip seal glands. Protect all striping and traffic markings from marring sealant application, and reduction in reflective properties. Replace any striping and traffic markings that are marred by sealant, at no cost to the Department.

Fill cracks with an approved crack sealer following the manufacturer's recommendations, and as otherwise directed by the Engineer. Where traffic is to be placed on crack sealer before curing is complete, broadcast to refusal oven dried 30 grit or similar sand into wet, uncured resin. Clear and remove unbonded sand or grit. Remove excess sand that causes concern for traction or braking from Bridge deck, including deck joints, as directed by the Engineer.

C.4.b When applied to structural slab prior to placing new wearing course

Locate all cracks after shotblasting or other abrasive surface preparation completed for a concrete wearing course appearing on the top surface, and as directed by the Engineer. Fill all located cracks with an approved crack sealer following the manufacturer's recommendations, and as otherwise directed by the Engineer. Ensure the sealer is cured prior to preceding pre-wetting of the deck, as required for placement of a low slump concrete wearing course.

Control the application of the crack sealer such that the maximum width of crack sealant does not exceed 1 inch. If exceeding the permitted width of 1 inch, remove excess by means of surface grinding to prevent debonding of concrete wearing course. Air dry a wet deck for a minimum of 24 hours before applying the sealer. Have the Engineer accept the prepared surface prior to applying the sealer.

C.4.c Application Weather Limitations

Do not apply sealer Materials during wet weather conditions or if adverse weather conditions are anticipated within 3 hours of the completion of sealer application.

Provide forecast from the National Weather Service website to the Engineer 3 hours before placement. The Engineer will review the forecast for the following:

(1) No forecasted precipitation 2 hours prior to the scheduled placement duration, nor up to 2 hours after the anticipated completion of the placement.
(2) Less than 30 percent chance of precipitation for the entire placement window.

Do not mix or apply any of these products at temperatures lower or higher than those specified in their product literature. Apply the crack seal at the coolest time of the day within these limitations.

C.5 Methyl Methacrylate (MMA) Flood Seal

This Work consists of furnishing and applying a protective MMA sealer, as authorized by the Engineer. Do not apply crack sealants to concrete surfaces less than 21 Calendar Days old unless otherwise ready to open to traffic.

Prior to MMA flood seal application, seal cracks greater than 0.040 inches with approved epoxy in conformance with 2433.3C.3, “Seal Cracks with Epoxy by Chase Method.”

Prior to the MMA flood sealant application, prefill cracks 0.024 inch to 0.040 inches wide with same sealer as used in flood seal or a pre-promoted version of the sealer. Where sealant soaks-in/withdraws from top of crack, place fine grade abrasive sand (20/40 abrasive) in crack and reapply MMA sealant to seal to top of crack. When sealant has not retreated after gel time, the crack is considered prefilled. Do not fill crack with sand beyond top of concrete surface.

Apply an approved MMA to Bridge deck between gutterlines. At least 14 Calendar Days before the start of the Work, provide the Engineer with the sealer manufacturer's written instructions for application and use.

C.5.a Materials

C.5.a(1) Epoxy

Furnish only one of the Materials listed on the *Approved/Qualified Products List* for Bridge Products, "Bridge Surface and Crack Sealers." A product may be selected from either the "High Elongation Epoxy Crack Sealers" or "High Strength Epoxy Crack Sealers" categories. Apply in accordance with the requirements listed on the *Approved/Qualified Products List* for Bridge Products, except that when applied under a concrete wearing course only one application pass is required.

C.5.a(2) MMA Sealant

Furnish only one of the Materials on *the Approved/Qualified Products List* for Bridge Products, “Bridge Surface and Crack Sealers,” or "Methacrylate Resin Crack Sealers."

C.5.a(3) Broadcast Sand

Provide a commercial quality dry blast sand with 95 percent passing the No. 8 Sieve and 95 percent retained on the No. 20 Sieve.

C.5.a(4) Fine Grade Sand

Provide fine grade abrasive sand for (20/40 abrasive) prefilling large cracks unable to be prefilled with sealant alone.

Submit sand Material data to the Engineer for review and address all written comments. Submit storage and use Plan to the Engineer documenting procedures for maintaining dry sand and within gradation requirements above.

C.5.b Surface Preparation

Clean all areas to be sealed by removing dirt, dust, oil, grease, curing compounds, laitance, or other contaminants that would prevent adhesion and crack penetration of the sealant. Where AMS curing compound is present on the Roadway surface, shotblast the areas to be sealed.

Collect all debris and other Material removed from the surface and cracks and dispose of it in 2104.3D, “Disposal of Materials and Debris.”

Perform a visual inspection of the Roadway surface. Locate and mark all cracks greater than 0.024 inches appearing on the top for prefilling.

Immediately before applying the sealer direct a 125 psi air blast, from a compressor unit with a minimum pressure of 365 cubic feet per minute, over the entire surface to remove all dust and debris paying special attention to carefully clean all deck cracks. Use a suitable oil trap between the air supply and nozzle. Use *ASTM D4285 Standard Test Method for Indicating Oil or Water in Compressed Air,* to ensure the compressed air is oil and moisture free.

Provide shielding as necessary to prevent dust or debris from striking vehicular traffic.

Air dry a wet deck for a minimum of 72 hours before applying the sealer.

Have the Engineer accept the prepared surface prior to applying the sealer.

C.5.c Sealant Manufacturer Support

A technical representative from the sealer manufacturer must be present during the first Project application on a Contract. The need for the manufacturer’s representative may be waived if the Contractor provides evidence and reference contracts for Work involving at least 5 Bridges treated with the same products and within the last two years. Contractor experience record in no way relieves the Contractor from applying in accordance with this Specification and as recommended by the manufacturer.

Prior to application of the sealant, hold a meeting with the manufacturer's representative and the Engineer to discuss all necessary safety precautions and application considerations. The manufacturer’s representative must be available to answer all safety and installation questions.

C.5.d Weather Limitations

Do not apply sealer Materials during wet weather conditions or if adverse weather conditions are anticipated within 12 hours of the completion of sealer application. Provide a forecast from the National Weather Service website to the Engineer 3 hours before placement. The Engineer will review the forecast for the following:

(1) No forecasted precipitation 2 hours prior to the scheduled placement duration, nor up to 12 hours after the anticipated completion of the placement.
(2) Less than 30 percent chance of precipitation for the entire placement window.

Do not mix or apply any of these products at temperatures lower or higher than those specified in their product literature. Apply the crack seal at the coolest time of the day within these limitations.

C.5.e MMA Flood Seal Application

Do not apply crack sealants to concrete surfaces less than 21 Calendar Days old unless getting ready to open to traffic. Application by spray methods will not be permitted during windy conditions, if the Engineer predicts unsatisfactory results.

Do not thin or alter the MMA crack sealer unless specifically required in the manufacturer's instructions.

Mix the sealer before and during its use as recommended by the manufacturer. Distribute the sealant as a flood coat in a gravity-fed process by broom, roller, or with a spray bar near the surface so the spray pattern and coverage rates are reasonably uniform to the satisfaction of the Engineer. Apply the sealant at a minimum rate of 90 square feet per gallon unless a lower dosage is recommended by the manufacture in writing and accepted by the Engineer.

Protect all expansion joints and prevent the crack sealant from contacting the strip seal glands. Protect all striping and traffic markings from marring, sealant application, and reduction in reflective properties. Replace any striping and traffic markings that are marred by sealant, at no cost to the Department.

Prior to completion of gel time of the flood seal (within 15 minutes) and before broadcasting sand, broom uncured sealant in the direction of tining or deck grooves to promote maintenance of the deck texture for traction.

Broadcast sand to refusal into uncured resin to create traction and absorb sealant that is not penetrating into cracks. Broadcast approved sand into the wet, uncured resin no sooner than 20 minutes after applying resin but within gel time of product. Apply approved sand at a minimum rate of 250 pounds per 1000 square feet.

Allow the sealant to dry/cure according to the manufacturer's instructions. Do not allow vehicular traffic onto the treated areas until the sealer has dried/cured and the treated surfaces provide safe skid resistance and traction. Remove non-adhered sand from Bridge deck and joints by power sweeping the deck and vacuuming the joints. Traffic or Equipment will be allowed on the sealed deck after the Engineer has determined:

(1) The treated deck surface is tack-free and non-oily
(2) The sand cover adheres and resists brushing by hand
(3) Excess sand and absorbent Material has been removed
(4) No sealant Material will be tracked beyond limits of treatment by traffic

D Reinforcement Steel

Place reinforcement steel in accordance with 2472, “Metal Reinforcement,” and the following:

(1) Unless otherwise shown on the Plans or the Special Provisions, do not cut reinforcement bars that extend through the cut line closer than 40 bar diameters to the cut line
(2) If any reinforcement bar loses more than 10 percent of its section due to damage from the removal of old concrete, install an approved bolt anchor or clamp capable of developing the strength of the damaged bar, at no additional cost to the Department and as directed by the Engineer

E Structural Steel Construction

Provide structural steel manufactured in accordance with 2471, “Structural Metals.” Erect structural steel in accordance with 2402, “Steel Bridge Construction,” and the following:

(1) If practicable, subpunch holes for field connections between new and old steel in the shop. Ream the holes to proper size in the field after assembly. If making the holes for these connections in the field, clamp the parts together and drill the holes using the holes in the old steel as a template. Do not use a flame-cutting torch to make the holes
(2) Clean rust, scale, and foreign matter from the tops of existing steel stringers and floor beams in contact with new timber or concrete, and coat with primer in accordance with 2478, “Organic Zinc-Rich Paint System,” or as directed by the Engineer. Allow the paint to dry for at least 24 hours
(3) Clean foreign matter from the contact surfaces of old steel and coat with the designated primer paint in accordance with 2478, “Organic Zinc-Rich Paint System,” before permanently connecting to the new steel

F Masonry Construction

Construct masonry as shown on the Plans.

Make connections to old stone masonry at the old mortar joints. Step the joints to old stone masonry as directed by the Engineer.

Clean mortar and loose or fractured Material from old stone masonry at the joint before placing the new masonry. Immediately before placing new concrete or stone masonry, wet the surface of the old masonry.

G Timber Construction

Perform timber construction in accordance with 2403, “Wood Bridge Construction,” and the following:

(1) Use new nails, spikes, and hardware throughout the Work
(2) Before placing either new or old timber on the Structure, clean the contact surfaces of the timber
(3) Apply at least two coats of copper naphthenate or another compatible preservative Material meeting the requirements of *AWPA M4* to contact surfaces, except treat new treated timber and designated old Structure parts with oil paint. Allow each application of preservative to dry for at least 2 hours before applying the next coat

2433.4 METHOD OF MEASUREMENT

A Structure Removals

The Engineer will measure Structure removals by lump sum.

B Item Removals

The Engineer will measure removal of specified items by the unit of measure for the Contract Item as shown on the Plans and in accordance with the following:

B.1 Lump Sum

The Engineer will measure item removals by lump sum, including the entire item as required by the Contract or as approved by the Engineer.

B.2 Mass

The Engineer will measure removal of Structural steel by weight in accordance with 2402.4A, “Weight.”

B.3 Length

The Engineer will measure the length of item removals longitudinally along the center of the unit and within the limits shown on the Plans or approved by the Engineer.

B.4 Area

The Engineer will measure item removal by area on the basis of actual width and length measurements and within the limits shown on the Plans or as approved by the Engineer.

B.5 Volume

The Engineer will measure item removal by volume, except for timber, on the basis of actual dimensions of the unit as removed. The Engineer will measure timber based on Nominal sizes and actual lengths.

B.6 Each

The Engineer will measure item removal by each complete item removed for the required Work.

C Deck Cleaning and Mapping

Deck cleaning and mapping will be measured to the nearest square foot only for existing Bridge Roadway surfaces, and Sidewalk where applicable, where surfaces are cleaned for crack sealing operations in accordance with 2433.3C.2, "Deck Cleaning and Mapping Cracks." Bridge surfaces, Sidewalk surfaces, and Roadway surfaces constructed within the same Contract are not eligible for measurement.

D Seal Cracks by Chase Method with Epoxy

Sealing cracks in the deck surface will be measured by volume in gallons of epoxy sealer applied to the cracks that have been designated by the Engineer to be sealed. Cracks sealed by the Contractor that have not been designated by the Engineer will not be measured for payment. Cracks that have been sealed at a width greater than 2 inches will be measured and the pay quantity will be reduced at a pro-rated rate using the ratio of 1 gallon for every 450 linear feet of cracks that were sealed in excess of 2 inches wide.

E MMA Flood Seal Cracks

Measurement will be made to the nearest square foot of concrete area sealed by MMA flood seal as designated by the Engineer. Prefilled cracks immediately ahead of flood sealing will be compensated by addition of 0.002 square feet of MMA flood seal per gallon used in prefilling cracks with MMA sealant.

F Anchorages

The Engineer will separately measure Anchorages of each type shown on the Plans by the number of units complete in place.

G Placing Used Materials

The Engineer will separately measure the placement of used Materials by the unit of measure for the Contract Item as shown on the Plans and in accordance with place used items.

2433.5 BASIS OF PAYMENT

The Contract Unit Price for deck removal includes the cost of cleaning and painting all steel formerly in contact with the deck where paint is not tightly adhered and sound, unless otherwise shown on the Plans. Sound paint is defined as primer meeting 2478, "Organic Zinc-Rich Paint System," DFT requirements that remains tightly adhered after scraping with a dull putty knife.

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

Item No.	Item	Unit
2433.501	Structure Removals	lump sum
2433.501	Place Used*	lump sum
2433.501	Remove*	lump sum
2433.502	Remove*	each
2433.502	Place Used*	each
2433.502	Anchorages Type___	each
2433.503	Remove*	linear foot
2433.503	Place Used*	linear foot
2433.506	Seal Cracks with Epoxy by Chase Method	gallon
2433.507	Remove*	cubic yard
2433.508	Place Used*	pound
2433.508	Remove*	pound
2433.518	Remove*	square foot
2433.518	Deck Cleaning and Mapping	square foot
2433.518	MMA Flood Seal	square foot
2433.522	Place Used*	MBM ‖

* Specify item name
‖ 1000 board feet measure

2442 REMOVAL OF EXISTING BRIDGES

2442.1 DESCRIPTION

This Work consists of removing and disposing of existing Bridges.

2442.2 MATERIALS

Use explosives for the removal of existing Bridges in accordance with 1711, “Use of Explosives,” and as approved by the Engineer.

2442.3 CONSTRUCTION REQUIREMENTS

A General

The Department will not require salvage of Material during bridge removal, unless otherwise shown on the Plans or as required by the Special Provisions. Remove Material, not required for salvage for the Department, using methods that will not damage salvaged members.

Place salvaged Material in stockpiles at locations as directed by the Engineer. If the Contract requires delivery of salvaged Material to a storage yard or other designated location, place salvaged Material on dunnage or sound wooden pallets. Dispose of Material not required for salvage in accordance with 2104.3C, “Removal Operations,” and 2104.3D, “Disposal of Materials and Debris.”

Completely remove all portions of existing Bridge to bottom of footing or to an elevation shown in the Contract. Completely remove piling and obstructions that interfere with the new Structure.

Fill pits or trenches resulting from the removal operations with Material meeting 1103, “Definitions: Select Grading Material,” as approved by the Engineer. Place backfill above water level in Layers no greater than 1 foot thick. Compact each Layer in accordance with the methods in 2106.3G.2, “Quality Compaction.”

If removing a Bridge from a location not on the site of the new Structure, excavate and dispose of the embankments adjoining the abutments as directed by the Engineer and in accordance with the following:

(1) To slopes conforming to the natural ground surface
(2) To a 1:2 (Vertical:Horizontal) slope beginning at the intersection of the front face of the abutment and continuing until intersecting with the natural ground surface

Do not constrict the stream channel except as required by the Contract or as approved by the Engineer.

If removing part of an existing concrete pavement, remove the pavement to an existing joint or cut the pavement on a straight line at right angles to the centerline of the Road. If cutting, use a saw to cut the top surface at least 1 inch deep without damaging the pavement remaining in place. During excavation, prevent undermining or disturbing the foundation Material under pavement remaining in place.

B Structural Steel

Dismantle salvaged structural steel in sections, individual members, or parts as shown on the Plans or as directed by the Engineer. Unless otherwise required by the Contract, remove structural steel in the reverse sequence of the original erection. Remove structural steel without damaging any structural members. Only cut field driven rivets. Use pilot nuts to draw pins.

Match mark members with valve-action opaque paint markers in accordance with a diagram provided by the Department. Similarly mark pins, pin nuts, loose plates, and ring fills to indicate proper location. Securely wire or bolt loose parts to adjacent members, or pack loose parts in properly identified boxes.

Coat pins, pin-holes, and machined surfaces with a lubricant listed on *the Approved/Qualified Products List*.

Remove rivets with a pneumatic chipping tool. Do not use torches unless specifically required by the Contract.

Stockpile structural steel on suitable skids. Arrange dissimilar parts in separate piles. Stack structural steel to avoid damage to the members.

C Timber

Remove timber and lumber with minimal breakage or splitting. Remove nails, spikes, fastenings, and hardware from timber and lumber. Clean timber of dirt and all other foreign matter except paint and bituminous surfacing Material.

2442.4 METHOD OF MEASUREMENT

The Engineer will measure each total Bridge removal and will not separately measure salvage Material types or salvage portions of Work for each Bridge removed.

2442.5 BASIS OF PAYMENT

The Contract Unit Price for Remove existing Bridge includes the cost to remove and dispose of the Structure within the removal limits designated in the Contract.

The Department will pay for the removal of existing Bridges or Material salvage on the basis of the following schedule:

Item No.	Item	Unit
2442.501	Remove Existing Bridge	lump sum
2442.501	Salvage and Haul Material (Bridge)	lump sum

2451 STRUCTURE EXCAVATIONS AND BACKFILLS

2451.1 DESCRIPTION

This Work consists of excavating, preparing foundations, placing, and compacting backfill for Bridges and Structures per 1103, "Definitions," either cast-in-place or prefabricated. This Work also consists of constructing and removing cofferdams, making soil bearing tests, and the disposing of surplus excavated Materials.

The Department considers the following as cast-in-place Structures: Bridge Substructures, concrete box Culvert extensions, concrete retaining walls, footings for structural plate arches, 3 sided concrete boxes, concrete arches, and high mast light foundations.

The Department considers the following as prefabricated Structures: precast concrete, prefabricated metal, or thermo plastic Structures including concrete box Culverts, pipe Culverts and sewers, cattle passes, and Subsurface drains.

2451.2 MATERIALS

A Granular Material 3149

B Select Grading Material

Unsuitable Materials include those Materials not meeting 1103, "Definitions: Select Grading Material," and additional Materials deemed unsuitable by the Engineer.

Provide Materials for special backfill, bedding, drain, or filter purposes as shown on the Plans.

2451.3 CONSTRUCTION REQUIREMENTS

A General Requirements

Prepare foundations to the elevations and grades shown on the Plans. Use temporary construction to place Structures or Substructures in open excavations under dry conditions.

A.1 Site Preparations

Clear and grub in accordance with 2101, "Clearing and Grubbing." Clear and grub the entire area bounded by straight lines between the Structure extremities. If constructing Bridges, extend clearing and grubbing operations to the Right-of-way between the Bridge extremities. Remove tree branches that overhang the Structure and inhibit its function.

Perform preliminary embankment construction in accordance with 2106, "Excavation and Embankment – Compacted Volume Method."

A.2 Elevations and Dimensions

The Engineer may make adjustments, in writing, to the approximate elevations and dimensions of footings as shown on the Plans.

The Engineer may make adjustments to the approximate location and orientation of box Culverts and pipe Structures as shown on the Plans.

A.3 Temporary Construction

Perform temporary construction Work to avoid unnecessary hazards or disruption to the permanent Work at no additional cost to the Department. Temporary construction may include sheeting, shoring, bulkheads, dikes, channels, drainage pipes, sluiceways, cofferdams, warning signs, and fencing as necessary.

Obtain the Engineer's approval of detailed construction Plans and methods before starting temporary construction Work.

A.3.a Cofferdams

Construct cofferdams of sufficient size to allow pumping, and provide waterways outside of the forms. Include provisions to allow lowering the foundation elevation to 3 feet below the level shown on the Plans.

Do not place cofferdam bracing against concrete forms or the Structure. The Contractor may extend steel bracing through poured concrete located below the final ground elevation. Do not box out braces or struts unless otherwise approved by the Engineer in writing.

Remove cofferdams located within Roadbed embankments when no longer needed, to at least 4 feet below the Subgrade elevation. Remove cofferdams located in streams or lakes to the bottom of the stream or lakebed. Remove cofferdams located in established navigation channels to an elevation at least 2 feet below the established bottom of the channel. Remove other cofferdams to an elevation at least 2 feet below grade.

A.3.b Concrete Foundation Seal

If the Plans do not show a concrete seal, the Contractor may install a concrete seal within a cofferdam, if accepted by the Engineer. Perform the concrete seal construction, including necessary excavation, at no additional cost to the Department. Submit written notice to the Engineer indicating the planned seal thickness, sources of Materials, mix design, and method of concrete placement for approval by the Engineer.

Place the entire seal below the foundation elevation for the Substructure shown on the Plans in accordance with 2401.3C, "Placement of Concrete – General Requirements."

A.3.c Pumping

While pumping from within foundation enclosures, keep the foundation Materials intact and do not draw water through or over fresh concrete. The Contractor may pump during concrete placement and within 24 hours after concrete placement, if using a pump separated from the Work by a watertight wall or other means that prevent damage to the foundation.

Do not begin pumping to dewater a cofferdam sealed with concrete until the seal has cured in accordance with the following minimum requirements:

(1) Three Calendar Days when the temperature of the water within the cofferdam has been maintained at 70°F or greater;
(2) Four Calendar Days when the temperature of water has been maintained from 45°F to 70°F; or
(3) Five Calendar Days when the temperature of the water within the cofferdam has been no greater than 45°F during the curing period.

A.4 Restoration Work

Restore the surface and general features of the excavation site after completion of the Work to the similar condition as before excavation, to the satisfaction of the Engineer.

A.5 Cold Weather Protection

Place permanent or temporary backfill, or other insulating Material approved by the Engineer, to protect foundation soils against freezing and related heaving actions after casting footings or driving foundation piles. The Department will waive this requirement if the Contractor has only driven the test pile within the foundation at the time of freezing conditions. If frost heaving is evident, drive the test pile further when installing the rest of the foundation piles, as directed by the Engineer.

B Excavating

B.1 General

Perform Structure excavation to allow the erection of forms, temporary construction, and compaction of backfill Materials, unless the Contract requires or the Engineer directs otherwise.

B.2 Types

The Department will classify excavation types in accordance with the following:

(1) Class U: Material within the excavation unclassified by the Material encountered or the conditions of removal.
(2) Class E: Material within the excavation except for Class R Material.
(3) Class R: Ledge rock, boulders, detached rock, or concrete pieces, with a volume of at least 1/2 cubic yard.
(4) Class W: The upper limit of excavation designated by the elevation of low water as shown on the Plans for waterway Bridges.

The Department will consider the volume of removed Structures as a separate Contract Pay Item and will not include the volume of Structure removals within the excavation limits as part of the excavation volume. The Department will include the cost of Structure removals with other relevant Pay Items, unless otherwise required by the Contract.

B.3 Cast-In-Place Structures

The Engineer may reject the Work if water accumulates within the excavation and detrimentally affects the Structure or the stability of the backfill.

Confine excavation in streams or lake beds within caissons or cofferdams. Repair disturbances to streams or lake beds using Materials approved by the Engineer.

Complete necessary areas of excavation within sealed cofferdams before placing items, such as walers, struts, and other framework items, that may restrict the access to the excavation Equipment.

B.3.a Earth Excavations

If placing concrete on natural soil foundation without piling, as shown on the Plans, shape the bottom of the excavation to the dimensions and elevations shown on the Plans. Use vibratory methods to compact the foundation soils in accordance with 2106.3G, Compacting Embankments and Backfills.” Replace unsuitable foundation soils with Material as shown on the Plans and as directed by the Engineer. Replace Materials unnecessarily removed below the foundation elevation at no additional cost to the Department.

Complete excavation before beginning pile driving operations for each unit. After driving the piles, shape the bottom of the excavation to the elevation shown on the Plans. Use granular Materials meeting 3149.2D.1, “Granular Backfill,” to backfill excavations below the established elevation of the foundation at no additional cost to the Department.

B.3.b Rock Excavation

Do not remove Class R and Class W Materials encountered in the excavation, unless the Department classifies the excavation as Class U, until the Engineer measures the pay quantities for Class R and Class WR Materials.

For footing foundations located in solid rock, remove the rock to the elevation as shown on the Plans for the entire area bounded by vertical planes through the neat lines of the footing. If the Plans do not show a footing elevation, remove the rock to an elevation no higher than the established elevation for the bottom of the footing or as directed by the Engineer.

Remove rock without affecting the quality of the foundation.

B.4 Prefabricated Structures

B.4.a Earth Excavations

If the Contract does not contain provisions for foundation preparation, excavate to provide uniform support under the entire Structure, to allow the placement of the Structure to the staked grade and line, and to allow for the installation of backfill Materials.

If the Contract contains provisions for foundation preparation, excavate to provide the foundation thickness shown on the Plans and uniform Structure support.

B.4.b Rock Excavations

Expose, but do not remove Class R and Class WR Materials encountered during Class E or Class WE excavation, until the Engineer measures the pay quantities for Class R and Class WR Materials.

Remove and replace unyielding Materials such as bedrock, boulders, or concrete located within 1 foot of the sides or the bottom of the Structure in accordance with 2451.3D, “Backfilling and Compacting Excavations,” and 2451.3C, “Foundation Preparations,” or as directed by the Plans and Special Provisions.

C Foundation Preparations

Prepare the Structure foundations in accordance with the following, except as modified by the Contract.

Provide temporary construction, pumping, or other means to construct the Structure in a dry excavation at no additional cost to the Department.

C.1 Cast-In-Place Structures

Remove disintegrated Material, loose Material, and thin strata rock from rock foundations. Clean and fill rock seams with concrete, cement mortar, or grout as directed by the Engineer.

If the character of the natural foundation soil is unsuitable, provide additional excavation below the planned footing elevation as directed by the Engineer. The Engineer will direct the limits of the excavation and the placement of special backfill.

C.2 Prefabricated Structures

Remove and replace unsuitable foundation Materials encountered at or below the foundation elevation using suitable replacement Materials as directed by the Engineer. Install the replacement Material in Lifts no greater than 6 inches thick, per 2106, “Excavation and Embankment – Compacted Volume Method.”

Compact granular Materials used for bedding and foundation backfill in accordance with the Plans and 2106, “Excavation and Embankment – Compacted Volume Method.”

D Backfilling and Compacting Excavations

Backfill excavations for Structure construction to the required extent shown on the Plans and at the appropriate time. Uniformly distribute suitable Material meeting 1103 “Definitions: Select Grading Material,” in horizontal Layers throughout the excavation area in seams of no more than 6 inch compacted thickness.

Compact backfill in accordance with 2106, “Excavation and Embankment – Compacted Volume Method.”

If the Contract does not specify special backfill Materials, use Materials meeting 3149.2D.1, “Granular Backfill,” placed within 18 inches of the sides and 12 inches above the top of the Structure. For the remainder of the backfill, use embankment Material meeting 1103, “Definitions: Select Grading Material.” If outside the Roadbed construction, use suitable Material meeting 1103, “Definitions: Select Grading Material,” for the entire backfill.

Do not place backfill Material on a frozen foundation or when the Material may freeze during the placement or compaction Work.

Step the sides of the excavation if steeper than 4:1 and if potential wedging action of the backfill may be detrimental to the Structure. If the Contract does not require specific maximum dimensions for the excavation, the Contractor may enlarge the excavation and flatten the side slopes for convenience of backfill and compaction operations, at no additional cost to the Department.

Maintain the sides of the excavation and prevent voids in the backfill when removing shoring or bracing from the excavation.

E Surplus Materials

Excavated Materials not used for backfill are the property of the Contractor. Dispose of surplus Materials in accordance with the disposal form submitted to and approved by the Engineer.

2451.4 METHOD OF MEASUREMENT

The Engineer will determine quantities of excavation and embankment in accordance with 1901, “Measurement of Quantities,” except as modified by this section. Provide sufficient time for the Engineer to determine quantities.

A Structure Excavation

The Engineer will not adjust (P) designated quantities unless otherwise specified in 1901, “Measurement of Quantities,” or for excavation Materials reclassified by the Engineer.

The Contractor may dispute an excavation quantity. If the Engineer considers the dispute, the Engineer will recalculate the excavation quantity for the entire Structure. If the Contractor completes the excavation before the Engineer directs a change, the Engineer will not make deductions or additions for resulting changes in the excavation volume if no enlargement of the excavation is required.

The Engineer will consider additional quantities determined by recalculation as separate from the Contract Pay Item quantities for Structure excavation for Bridges.

The Engineer will measure rock within the Structure excavation and recalculate the volume for each excavation Pay Item classification considering the quantity of exposed rock measured. The Engineer will proportionately increase or decrease excavation Pay Item quantities based on the measured volume of rock to maintain the planned total excavation quantity.

The Engineer will not adjust low water elevations as shown on the Plans or for safety concerns, working clearances, or stability of soils, regardless of existing conditions.

The Engineer will calculate the volume of Structure excavation in accordance with the following limits except as modified for the type of Structure and unless otherwise required by the Contract:

(1) Vertical planes that encompass the structure, located 1 1/2 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, establishing the beginning of Structure excavation
(3) The bottom of the Structure and its projections

The Department will consider the volume of removed Structures as a separate Contract Pay Item and will not include the volume of Structure removals within the excavation limits as part of the excavation volume. The Department will include the cost of Structure removals with other relevant Pay Items, unless otherwise required by the Contract.

If the Plans include a separate Contract Pay Item for the removal of an existing Structure from the excavation limits of the new Structure, the Engineer will reduce the structural excavation quantity by the measured volume of the existing Structure.

If the Contractor excavates Material to expedite the Work and the Contract includes the Material removal in a different Contract Item or indicates removal by others, the Engineer will not include this Material in the Structure excavation quantities.

A.1 Cast-in-Place Structures

For the horizontal limits of excavation for footings for cast-in-place Structures in ledge rock, the Engineer will use the footing limits as shown on the Plans.

The Engineer will measure excavation for timber pile abutments and timber bents using the limits as shown on the Plans.

A.2 Prefabricated Structures

For foundation construction requiring a greater surface dimension than provided in 2451.4A, “Structure Excavation,” the Engineer will measure the excavation using the greater dimension.

A.2.a Induced Trench

For excavation by the induced trench method performed in accordance with 2501.3F, “Induced Trench Installation,” the Engineer will measure additional excavation required for loose backfill over the Structure in accordance with the following:

(1) Within the planned grading section

(2) Between vertical planes separated by a distance equal to the outside width of the Structure
(3) To a depth equal to the outside height of the Structure

B Granular Materials

The Engineer will measure granular Materials for special backfill, bedding, or filter purposes by loose volume or compacted volume in accordance with 1901, “Measurement of Quantities,” and as required by the Contract.

2451.5 BASIS OF PAYMENT

If the Contract does not contain a Contract Item for clearing or grubbing, the Department will consider clearing and grubbing to be Extra Work in accordance with 1402, “Contract Revisions.”

The Department will pay for preliminary embankment construction in accordance with 2106, “Excavation and Embankment – Compacted Volume Method.”

If the Contract does not include a Contract item for the restoration Work on the surface of the excavation site, the Department will include this cost with other relevant Contract Pay Items.

The Department will pay for cleaning and filling seams in rock foundations as Extra Work in accordance with 1402, “Contract Revisions,” unless otherwise required by the Contract.

The Contract Unit Price for the relevant Structure excavation and backfill Contract Items include the cost of disposing of surplus excavated Materials.

For cast-in-place Structures, if the Plans do not include limits for the excavation of timber pile abutments and timber bents, the Department will include this cost with other relevant Contract Items.

If the Plans do not include a Contract Pay Item for Class R and Class WR excavation, the Department will pay for these Materials if encountered during Class E or Class WE excavation in accordance with Class R at 5 times the Contract Unit Price of Class E or Class WR at 3 times the Contract Unit Price of Class WE.

Unless otherwise modified in the Contract, the Department will pay for the excavation for cast-in-place Structures in accordance with the following:

(1) For additional required excavation depth, the Department will increase the Contract Unit Price by 25 percent for additional excavation to 3 feet below excavation as shown on the Plans. For excavation required to a depth greater than 3 feet below the planned elevation, the Department will pay for this portion of the additional excavation as Extra Work in accordance with 1402, “Contract Revisions,” unless the Department and Contractor agree on a Unit Price increase not exceeding 25 percent.
(2) For additional excavation required by changes in the Structure dimensions, and the Contractor objects to the Contract Unit Price, the Department will pay for the additional excavation as Extra Work in accordance with 1402, “Contract Revisions.”
(3) For disputed Plan Quantities, if the Contractor requests a recalculation of Structure excavation for Bridge Structure, and the recalculation shows an additional quantity, the Department will separately pay for additional Structure excavation for Bridge construction at 50 percent of the Contract Unit Price.

The Contract cubic yard price for Granular backfill and Granular bedding will include the cost of placing and compacting the Materials.

If the Plans do not include a separate Contract Pay Item for Structure excavation, the Department will include this cost with the Contract cubic yard price for Granular backfill and Granular bedding.

If the Plans do not include specific Contract Pay Items, the Department will pay for granular Materials used for bedding, backfill, or filter purposes as shown on the Plans, in accordance with this section, and as directed by the Engineer as Extra work in accordance with 1402, "Contract Revisions."

The Department will pay for structure excavation and backfill in accordance with the following schedule:

Item No.	Item	Unit
2451.507	Structure Excavation Class ___	cubic yard
2451.507	Granular Backfill (*)	cubic yard
2451.507	Aggregate Backfill (*)	cubic yard
2451.507	Granular Bedding (*)	cubic yard
2451.507	Coarse Filter Aggregate (*)	cubic yard
2451.507	Fine Filter Aggregate (*)	cubic yard
2451.507	Fine Aggregate Bedding (*)	cubic yard
2451.507	Coarse Aggregate Bedding (*)	cubic yard
2451.507	Conduit Aggregate Bedding (*)	cubic yard

* Specify (LV) or (CV) in accordance with 2451.4B, "Granular Materials."

2452 PILING

2452.1 DESCRIPTION

This Work consists of providing and driving piling as required by the Contract.

2452.2 MATERIALS

A Timber Piling **3471**

B Preservative Treatment **3491**

C Steel H-Piles **3372**

D Cast-in-place (CIP) Concrete Piles

D.1 CIP Steel Pile Shells **3371**

D.2 Concrete Pile Fill, Mix No. 1P62 .... **2461**

E Reinforcement Bars **3301**

2452.3 CONSTRUCTION REQUIREMENTS

A Delivery and Inspection of Piling

If the Contract requires test piles, provide the number and lengths of piles as shown in the Contract, unless otherwise directed by the Engineer. The Engineer may designate that piles authorized for one unit of a Structure be driven in another unit of the same Structure or any unit of another structure constructed under the same Contract.

If test piles are not specified in the Contract, provide the number and lengths of piles as shown in the Contract.

Before delivery, establish the quality of the Material in steel H-piles and in steel shells for cast-in-place concrete piles. Submit the mill test reports and mill shipping papers in accordance with 3371, "Steel Shells for Concrete Piling," and 3372, "Steel Piling," to the Engineer.

The Contractor may request the Engineer’s written approval to use small quantities (less than 5 percent in a Substructure unit) of piling from the Contractor’s surplus of cut-offs and overruns. Certify the small quantities of piling as remaining quantities of Materials previously submitted with accompanying mill test reports and approved for use on other Projects. The Department will not pay for pile splices used to make up approved piles for the Contractor’s convenience. Splices made for the Contractor’s convenience are not eligible for extra compensation in accordance with 2452.5B, “Piling.”

Do not drive piling before the Engineer accepts the Material on the basis of mill test reports.

The Engineer will visually inspect piling at the site before driving to verify the quality of welds and to determine the piles contain no physical defects that would cause the pile to fail during driving and are capable of performing as intended.

B Handling, Transportation, and Storage

Handle, transport, and store piling without damaging piles intended for use in the completed Structure.

C Equipment for Driving

C.1 Requirements for Pile Hammers

Use pile driving Equipment approved by the Engineer. The Engineer will use the Contractor-provided 2452.3C.1.a, “Driving System Submittal,” as the basis for approval of Equipment. Acceptance of the pile driving Equipment does not relieve the Contractor of the responsibility to properly install the piling. If in the opinion of the Engineer the accepted driving system fails to perform satisfactorily during actual driving, the Engineer reserves the right to revise the driving criteria and/or require change of Equipment.

C.1.a Driving System Submittal

The driving system submittal must be certified by a Professional Engineer, licensed in the State of Minnesota. Allow 10 Business Days for the Department's review. Allow an additional 10 Business Days for the review of any resubmittals. No variations in the driving system will be permitted without the Engineer’s written approval. Submit a revised driving system submittal if the hammers or other driving system components change from those shown in the original approved submittal. Use the same pile hammer to drive test piles and to drive the piles authorized by the Engineer based on the results of the test pile driving. Any variation needs to be authorized by the Engineer.

For the driving system submittal, perform drivability studies as follows for each hammer and pile type:

(1) Model the proposed driving system including hammers, striker plate, hammer cushion, helmet, and pile cushions based on a wave equation analysis

(2) Include in the analysis pile length variation to account for driven length variation, stickup length, and other considerations appropriate to construction requirements. As appropriate, include soil parameter variations to account for geotechnical uncertainties at the Project Site as well as possible range of hammer energy

(3) Use an authorized computer program (GRLWEAP or similar program)

(4) When a follower is used, include:

(a) an analysis of the driving system with the follower
(b) an analysis of the driving system without the follower

Include in the driving system submittal:

(1) Results of the drivability analysis showing that proposed driving systems will install piles to the specified tip elevation or Nominal pile bearing resistance shown on Plans. The system should be adequate to overcome the greatest expected driving resistance or a minimum of 155 percent of the factored design load and account for end of initial driving and restrike conditions, as appropriate. Driving systems must generate sufficient energy to drive the piles with compressive and tensile stresses not more than 90 percent of the yield strength of a steel pile as driven
(2) The Engineer will only accept pile driving Equipment, as determined by the wave equation analysis, capable of operating from 30 blows per foot to 180 blows per foot at the above conditions
(3) Include with relevant ranges when applicable scaled graphs depicting:

    (a) Pile compressive stress versus blows per foot
    (b) Pile tensile stress versus blows per foot
    (c) Nominal driving resistance versus blows per foot for expected typical and range of driving energy

(4) Complete description of:

    (a) Soil parameters used for pile tip and skin, including soil quake and damping coefficients, skin friction distribution, and ratio of shaft resistance to total resistance
    (b) Assumptions made regarding the formation of soil plugs, drilling through the center of open ended steel shells, pre-augering, pre-boring, jetting, use of vibratory or other systems to advance the pile other than impact hammers, and the use of closure plates, shoes, and other tip treatment

(5) List of hammer operation parameters assumed in the analysis, including fuel settings, stroke limitations, and hammer efficiency
(6) Copies of test results from any previous pile load tests, dynamic monitoring, and driving records used in the analyses
(7) Completed Pile and Driving Data Form along with manufacturer's specifications for pile driving system components. Driving system components will be confirmed by the Engineer upon delivery of the hammer to the Project Site
(8) An electronic copy of the WEAP input files
(9) The penetration (blows per foot) as calculated by the *MPF12 Pile Driving Report* at the Nominal pile bearing resistance required for the test piles and at 85 percent of the manufacturer's maximum rated energy for the proposed hammer
(10) When the MnDOT Pile Formula 2012 will be used as field control, the Engineer will only accept pile driving Equipment capable of operating at 180 blows per foot or less at the above conditions

C.2 Pile Driving Caps

Equip the top of the pile with a driving cap in the size and type, as approved by the Engineer, to protect the pile against damage during driving. Use a shock block of the type and size as approved by the Engineer on the upper side of the driving cap, when driving conditions warrant. Provide drive caps and shock blocks as recommended by the pile hammer manufacturer.

C.3 Pile Driver Leads

Provide pile driver leads meeting the following requirements and characteristics:

(1) Capable of holding the pile and the pile hammer in alignment during driving operations
(2) Long enough to preclude the use of punches or chasers
(3) Meeting the requirements of the pile hammer manufacturer

C.4 Water Jets

Provide jets capable of delivering water in the volume and pressure required to freely erode the Material adjacent to the pile. Provide a water source capable of maintaining at least 100 psi of pressure at two jet nozzles, 3/4 inches in diameter.

D Pile Driving

Notify the Engineer at least 24 hours before beginning pile driving operations. The Engineer will reestablish the working points for each Substructure unit after the Contractor completes the excavation for that unit. Stake the pile locations.

Excavate to the bottom of footing elevation as shown on the Plans before driving foundation piles or test piles in any Substructure. During pile driving operations, keep the water level in the excavation below the top of the pile. Do not perform underwater pile driving unless a concrete foundation seal is required to dewater cofferdam.

For each foundation pile, perform continuous pile driving operations unless otherwise directed by the Engineer.

Sharpen timber piles to a square point with dimensions at least 5 inches at the tip. Provide timber piles with blunt ends for soils with SPT blow counts less than 20 as shown in Plan borings or for piles having point bearing on hard stratum.

Do not use punches or chasers for pile driving if the Contract requires a concrete foundation seal in a cofferdam. If driving piles in a cofferdam, provide the extra length of piling to drive the piles to the cutoff elevation, at no additional cost to the Department. Accurately locate and space the piling as shown in the Bridge Plans with tolerances per 2452.3D.4, “Foundation Piles,” 2452.3D.5, “Pile Bents,” and 2452.3F.2, “Pile Bents.”

Provide pile Material and appurtenances capable of withstanding driving to substantial refusal defined in accordance with 2452.3E.1, “Penetration and Bearing, General.” The Department considers failure of piles during pile driving operations to include buckling, bending, kinking, splitting, or rupturing that will impair the strength of the pile or reduce the effectiveness of the energy delivered by the pile hammer, as determined by the Engineer.

If the Engineer determines that the piling Material and appurtenances cannot withstand driving to substantial refusal, discontinue pile driving and correct or change the pile driving operations, Equipment, or Material as approved by the Engineer.

If failure of the pile occurs after the Engineer directs the Contractor to continue driving after obtaining substantial refusal, the Department will pay for the cost of the failure.

D.1 Jetting and Preboring

The Contractor may perform water jetting if needed, or as required by the Contract, to aid in driving displacement type piles. Do not perform jetting in embankments or in areas where the jetting may damage the existing soils. Before reaching a preset depth approved by the Engineer but not less than 5 feet of the final tip elevation, withdraw the jets and drive the piles with the hammer to secure the final penetration. Control and dispose of jet water, as approved by the Engineer.

Perform preboring for displacement type piles driven through embankments if the embankment depth, measured below the bottom of the footing, is greater than 8 feet. Perform preboring through the depth of the embankment. Continue preboring through shallow, dense crust at the surface of the original ground as directed by the Engineer.

Perform preboring through embankments less than 8 feet if the Material may damage the piles during driving, as directed by the Engineer. Perform preboring for displacement type piles if the Material below the bottom of a footing precludes driving to a penetration of 10 feet below the bottom of the footing without damaging the piles, as directed by the Engineer. If the pile does not penetrate greater than 0.03 inches per blow for each 1000 foot pounds of rated energy, the Engineer will consider this, the weight of the ram, and the type and size of the piles to determine the probability of damage.

Make prebored holes of a diameter that will admit the largest cross-sectional diameter of the pile without creating friction between the faces of the pile and the prebored hole.

D.2 Test Piles

Provide test piles as required by the Contract. Drive test piles at the locations shown on the Plans unless otherwise approved or directed by the Engineer.

Place full lengths of test piles in the leads and continuously drive, unless otherwise approved by the Engineer. The Contractor may perform sectional driving if the Engineer determines from the survey sheet or from previous pile driving in the area that the test piles can be driven in sections without the danger of “set-up” during the splicing period.

Assist the Engineer in obtaining data (examples: lay pile in a safe location, marking pile with 10 blow count, attach gauges as instructed) for bearing for the full length of the pile driving. Redrive the test piles as required by the Engineer and in accordance with 2452.3D.8, “Pile Redriving.”

If the Engineer determines that steel test piles have not developed adequate bearing capacity per 2452.3E.1, “Penetration and Bearing, General,” provide additional lengths and splice as directed by the Engineer.

D.3 Static Pile Load Tests

Provide *ASTM D1143M, Axial Static Compressive Load Testing; ASTM D3689, Axial Static Tension Load Testing; ASTM D3966, Lateral Static Load Testing; ASTM D7383, Quasi-Static Load Testing*; O-Cell Load Testing; or similar testing for evaluation of either axial or lateral compressive or tensile load and deformation analysis.

(1) Coordinate test program with Construction, Bridge, and Materials offices
(2) Provide Materials, furnish labor, and conduct the test program as required by the Contract. Install temporary and permanent instrumentation as required by the Contract or as directed by the Engineer
(3) Analyze and report data both in hard-copy format and electronic format in a timely manner
(4) Adjust test program as directed by the Engineer based on conditions encountered in the field

(5) If the test program is used for construction control, provide appropriate analysis and field inspectors' charts, as described in section K, for assessment of the capacity of foundation piling

D.4 Foundation Piles

Guide piles during driving. Complete pile driving with piles having the required batter or plumbness within 1/2 inch per foot, and having a final position within 6 inches of Plan location within the footing area. The Engineer may reject or apply a monetary deduction per 1512, "Unacceptable and Unauthorized Work," for improperly positioned piles, as determined by the Engineer.

If the Engineer determines that some piles in a unit have heaved during the driving of other piles in the unit, redrive the piles as directed by the Engineer to complete the pile driving.

D.5 Pile Bents

The Department defines pile bents as piles meeting the following characteristics and requirements:

(1) Driven in single rows
(2) Capped with timber, steel, or concrete caps
(3) Driven to closer tolerances than for general pile driving, as described below

Guide piles during driving. Complete pile driving with piles having the required batter or plumbness within 1/4 inch per foot, and having a final position within 3 inches of Plan location within the bent. The Contractor is responsible for any increase in pile cap dimensions or reinforcing caused by inaccurately placed piles. The Engineer may reject or apply a monetary deduction for improperly positioned piles, as determined by the Engineer. For timber pile bents, select piles having a uniform diameter.

D.6 Cast-in-Place Concrete Piles

Equip the bottom of each pile with a driving shoe meeting the following requirements:

(1) Welded watertight
(2) Dimensions no greater than 1/4 inch larger than the dimensions of the periphery of the pile shell

Provide pile points, if required by the Contract, at specified locations or as directed by the Engineer. Provide the pile points for cast-in-place concrete piles in lieu of flat driving shoes. Equip the bottom of each shell with a commercially manufactured conical pile point of cast steel welded watertight, as approved by the Engineer. Attach the conical pile point to the pile as recommend by the manufacturer.

Inspect each pile with the Engineer after driving, for depth to the driving shoe and for condition of the shell. Notify the Engineer upon observation of impairment or damage. The Engineer, considering the bearing requirements and driving conditions, will determine the acceptability of the pile. Provide a light for a visual inspection of the full length of pile.

The Department will not require the Contractor to provide reinforcement bars unless otherwise shown on the Plans.

Vibrate concrete in the portion of pile shells containing reinforcement cages.

Do not perform pile driving and other operations that will cause detrimental vibrations near concrete-filled piles until the concrete has been in place for at least 3 Calendar Days. Refer to 2401.3G, "Concrete Curing and Protection," for vibration limits on newly placed concrete.

Do not place concrete for footings and caps until the day after concrete placement for the piles.

Protect concrete in the piles against freezing temperatures for at least 3 Calendar Days after placement. If placing concrete in piles during freezing temperatures, provide 30 percent additional cement to the concrete mix for concrete above 10 feet below the ground line or waterline.

D.7 Steel H Piles

Provide pile tip protection, if required by the Contract, at the specified locations or as directed by the Engineer. Provide H-pile tip protectors, as listed on the *Approved/Qualified Products List* website under, “H-Pile Tip Protection.” Attach the cast steel points to the piles as recommended by the manufacturer.

The Contractor may provide thick wall pipe on a performance basis and meeting the following requirements and characteristics in lieu of steel H piling as approved by the Engineer:

(1) Meeting the requirements of *ASTM A252, Standard Specification for Welded and Seamless Steel Pipe Piles*, Grade 3
(2) Wall thickness of at least 1/2 inch
(3) Tensile properties of at least 110,000 psi
(4) Cross-sectional area at least equal to H piling
(5) Section modulus at least equal to the weakest axis of the H piling
(6) Diameter at least equal to the H pile depth less 3 inches
(7) Driven open ended and filled with granular Material or 1P62 concrete mix

The Engineer will consult with the Bridge Engineer for special welding requirements.

D.8 Pile Redriving

Redrive of test or foundation piles determines the capacity that can be obtained by including pile “set up.” “Set up” is the time-dependent increase in pile resistance.

If the Contract includes a Pay Item for “Pile redrive,” perform pile redrive at the direction of the Engineer a minimum of 24 hours after initial driving unless otherwise required by the Contract. If driving conditions allow, continue to drive test pile to the length shown on the Plans and in accordance with 2452.3E.1, “Penetration and Bearing, General.” Redrive additional foundation piles to verify the bearing capacity as determined and directed by the Engineer.

Do not drive other piles in the same Substructure during the waiting period. Perform redriving with a warm pile hammer. Apply at least 20 blows to a previously driven pile or timber mats to warm the pile hammer before using it for the redrive. When redriving, do not strike each pile with greater than 20 blows. When using MPF12 as field control, mark the penetration of every blow and measure penetration using the average of the first 5 blows in which the hammer has good energy. Do not trim piles to the cut-off elevation shown on the Plans until the Engineer has determined the need for redriving. Do not fill CIP concrete piles in any Substructure unit with concrete until the Engineer determines that the driven piles in the unit meet the required bearing resistance shown on the Plans and the pile shells were trimmed to the cut-off elevation.

Weld extensions to piles authorized and subsequently driven or drive additional piles as directed by the Engineer.

E Penetration and Bearing

E.1 General

The Department calculated the Nominal pile bearing resistances as shown on the Plans using design loadings. The Department will use the Nominal pile bearing resistance as determined by 2452.3E.2, “Determination of Nominal Bearing Resistance,” to establish the minimum criteria for pile acceptance in which the driving resistance is not less than the required Nominal bearing resistance as shown on the Plans. If necessary, drive the foundation piles beyond the resistance shown on the Plans until the piles reach the required penetration as shown on the Plans or until the piles have been driven to the penetration determined by the Engineer and based on the test pile results.

Drive the test pile full length unless substantial refusal is encountered at a lesser penetration. If the test pile has been driven full length and if the test pile has not attained 115 percent of the Nominal resistance for the foundation piles as shown on the Plans, drive the test pile further as directed by the Engineer and in accordance with 2452.3D.2, “Test Piles,” and 2452.4A, “Test Piles.” Perform pile redriving as shown on the Plans with the penetration and time delays in accordance with 2452.3D.8, “Pile Redriving.”

The Engineer will consider that substantial refusal is attained, in accordance with 2452.3D, “Pile Driving,” when the penetration rate equals 0.05 inches per blow.

When the conditions of this section have been met for the test pile, the resulting pile cut-off becomes the property of the Contractor.

E.2 Determination of Nominal Bearing Resistance

The Department bases the required Nominal resistance as shown on the Plans for each field control method. Determine the driven pile Nominal resistance in accordance with the following using the appropriate corresponding field control method as shown on the Plans. Unless the Contract requires otherwise, if more than one field control method is shown on the Plans, determine the method used in accordance with any of the following:

(1) If the Contract includes a “Pile analysis” Contract Item for a Substructure, provide the Pile Driving Analyzer (PDA) for the field control
(2) If the Contract does not include a “Pile analysis” for a Substructure, the Contractor may choose the field control method. The Department will include the cost of the PDA with the relevant Contract Item for piling driven

E.3 MnDOT Pile Formula 2012 (MPF12) Used as Field Control Method

Determine the Nominal pile bearing resistance using the following dynamic formula for CIP concrete piles and steel H piles driven with power-driven hammers:

$$R_n = 20\sqrt{\frac{W \times H}{1000}} \times \log\left(\frac{10}{S}\right)$$

Where:

Rn = Nominal Pile Bearing Resistance in tons

W = Weight of the striking part of the hammer (ram) in pounds (see note below)

H = Height of fall in feet (see note below)

S = Average penetration in inches per blow for the last 10 blows or 20 blows, except if the pile may be damaged by this number of blows.

The MPF12 is not suitable for use in pile driving conditions where the average penetration is greater than 0.5 inches per blow (less than 24 blows per foot). The Contractor shall immediately notify the Engineer if the specified Nominal pile bearing resistance shown in the Plans is obtained with an average penetration greater than 0.5 inches per blow.

The Contractor may choose any of the following options to reduce the average penetration during driving to less than 0.5 inches per blow and achieve the specified Nominal pile bearing resistance shown in the Plans:

(1) Reduce the fuel setting of the hammer for the test piles and foundation piles
(2) Perform redrives on the test piles and 10 percent of the foundation piles at a reduced fuel setting of the hammer. Perform redrives on the foundation piles that had the highest penetration at the end of initial drive or as determined by the Engineer
(3) Continue driving the pile until the average penetration is less than 0.5 inches per blow
(4) Use a qualified smaller hammer

The above options will be performed at no additional cost to the Department, with the exception that additional driven and delivered length will be paid for by the Department up to the estimated length shown in the Plans.

Regardless of the value measured during driving, the value of (S) used in the dynamic formula shall not be less than 0.066 inches per blow (more than 180 blows per foot). If the measured average penetration for the last 10 blows is less than 0.066 inches per blow, use 0.066 in the dynamic formula to determine the bearing resistance.

Note: (W x H) is measured during pile driving and is also commonly referred to as the “energy,” E, hence E = W x H, for single acting power-driven hammers and is measured in foot-pounds. The value of (W x H) used in the dynamic formula shall not exceed 85 percent of the manufacturer’s maximum rated energy for the hammer used.

In addition to the limits stated above, apply the dynamic formula only if:

(1) The hammer has a free fall
(2) The head of the pile is free from damage
(3) The penetration of the pile is at a uniform rate
(4) There is no bounce after the blow. If a bounce occurs, deduct twice the bounce height from H to determine the value of H in the formula

For the requirements of this section, double-acting hammers include hammers utilizing a power source for acceleration of the down-stroke of the ram.

E.4 Pile Driving Analyzer (PDA) Used as Field Control Method

Determine the Nominal pile bearing resistance using the pile driving analyzer and the Case Pile Wave Analysis Program (CAPWAP) in accordance with 2452.3E.4.a, “High-Strain Dynamic Monitoring of Pile Driving.” Use the refined WEAP bearing graph as required in 2452.3E.4.a(3), “Signal Matching and Refined Wave Equation Analysis,” to determine the bearing resistances recorded on the pile driving report. Attach a copy of the bearing graph to the pile driving report. Calculate and record the bearing resistances for informational and comparison purposes on the report in accordance with 2452.3E.3, “MnDOT Pile Formula 2012 (MPF12) Used as Field Control Method.”

E.4.a High-Strain Dynamic Monitoring of Pile Driving

E.4.a(1) Description of Work

Provide and use a Pile Driving Analyzer (PDA) to perform high-strain dynamic monitoring of driven piles meeting the requirements of *ASTM D4945, Standard Test Method for High-Strain Dynamic Testing of Deep Foundations*. Perform the dynamic pile testing on the initial driving and redriving of designated piles as shown in the Plans or directed by the Engineer. Test additional piles or designated piles at additional times as directed by the Engineer.

E.4.a(2) Pile Preparation

Prepare each pile to be tested by marking and attaching instrumentation to the piles. During initial driving of steel shell piles, attach instrumentation after the pile has been placed in the leads. In all circumstances, extra care should be exercised to protect the instrumentation from distress throughout the pile installation. Wireless pile instrumentation may be attached to the pile, if approved by the Engineer, prior to placing the pile in the leads provided that the instrumentation is adequately protected against damage by contact with the leads, abrasion, or shear from the rope, chain, or fabric, used to pick up the pile.

During the test, provide assistance as necessary, e.g. access, tightening gages, resetting or replacing gages, or replacing cables as necessary for the successful conduct of the dynamic monitoring program. Alert the Engineer to any unanticipated or unusual conditions including such items as severed cables, loose gages, or unusual pile, or pile hammer performance.

E.4.a(3) Signal Matching and Refined Wave Equation Analysis

Following dynamic testing of the driven piling, perform a refined wave equation analysis based on driving data obtained from the high-strain dynamic monitoring program using the Case Pile Wave Analysis Program (CAPWAP) or other approved signal matching software. This Work shall be performed by a Professional Engineer, in the State of Minnesota, pre-qualified for Work type 6.5 Deep Foundations, as defined by the *Geotechnical Manual*. Complete the analysis on all piles dynamically tested, or as directed by the Engineer. Furnish PDA and CAPWAP electronic data and summary hardcopy outputs to the Engineer.

After the wave matching analysis is performed, use the GRLWEAP or similar program and the signal matching program (e.g. CAPWAP) data to produce a refined Wave Equation Analysis bearing graph and Inspector’s chart for the basis for pile acceptance. Prepare similar charts if soil set-up and pile re-strikes are being evaluated. Submit the refined WEAP bearing graph and Inspector’s Chart for use in construction control for each Substructure. Use the bearing graph to determine the foundation pile’s Nominal bearing resistance to be recorded on the pile driving report.

Prepare and submit a summary plot of the performance of each pile in the pile group where each pile is plotted on the Inspector’s chart by its observed set and the corresponding stroke of the pile hammer. Adjust this procedure as directed by the Engineer for non-diesel hammers. Any piles not plotting in the acceptable range will be rejected.

E.4.a(4) Deliverables

Provide the results from each dynamic test performed with the PDA and analyzed with the CAPWAP program meeting the following requirements to the Engineer within the time specified:

(1) Results from each high-strain dynamic test performed with the PDA and analyzed with the CAPWAP program. The results are to be transmitted in the form of the electronic raw data files and a hard copy of columnar data produced with the PDIPLOT program or similar. The data shall consist of blow counts, stresses in the pile, pile capacities, hammer energies and hammer strokes for each one-foot depth increment. This information will be used by the Engineer to develop the construction control criteria, authorize pile length, and establish minimum penetration resistance. In addition, provide expert advice regarding the analysis of the PDA and CAPWAP data.

(2) Bearing graphs showing blow count-versus-pile resistance and Inspector's charts depicting stroke-versus-blow count to be used for confirming the Nominal Pile Bearing Resistance of the foundation piles. The graph/charts are to be developed based on the results of the PDA, CAPWAP, and pile load test data where static load tests are conducted as part of the construction control. These graphs/charts are also to be documented in the report listed below. These graphs and charts are required for each foundation group, or as specified in the Contract documents, or as directed for the Engineer. Submit this information both in hard-copy and electronically (Adobe PDF or similar).

(3) A brief report for the piles at each Substructure tested including a summary of the PDA and CAPWAP results; this report will include appropriate information for the evaluation of test data from standard "test" piles as well as Static Load Test (SLT) test piles, Static Load Test reaction piles, and foundation piles.

(4) Supply one or more flash drives (or other electronic storage media) containing data for the piles tested for each Substructure. The data shall be in the form of W01 (PDA file), PIL (PDIPLOT file), and CWW (CAPWAP file) and be properly labeled. The Contractor shall send these electronic files to the Engineer no later than 3 Working Days after dynamic pile tests have been completed at any given Substructure unit.

(5) A final Project report which summarizes the findings from the PDA and the associated CAPWAP computer program, the developed bearing graphs, and the pile load test results.

(6) One or more compact discs (CDs) (or other electronic media) containing data for the complete Project as an

archive copy including information for piles tested, including any pile static load test data. The data from the dynamic tests shall be in the form of W01 (PDA file), PIL (PDIPLOT file) files, and shall be properly labeled. Include the CAPWAP analysis results and CWW (CAPWAP) files. Include reports and electronic copies of bearing graphs and Inspectors charts. Include any preconstruction WEAP analysis data sheets and WEAP submittal information and electronic files modeling the Contractor's hammer system. Include subsequent refined wave equation analysis, and summary plots showing foundation pile performance with respect to the acceptance criteria. Include electronic copies of field notes and other information pertinent to the high-strain dynamic monitoring and any related static load testing (including gage locations, test dates, performance notes, etc.) Transmit this electronic archive to the Engineer within 5 Working Days after completion of the Project dynamic (and or static) pile test program.

E.5 Static Load Test (SLT) Used as Field Control Method

Determine the Nominal pile bearing resistance using the results from the Static Load Test and related analysis from high-strain dynamic monitoring and the Case Pile Wave Analysis Program (CAPWAP) in accordance with 2452.3E.4 , "Pile Driving Analyzer (PDA) Used as Field Control Method." Use the refined WEAP bearing graph as required in 2452.3E.4, "Pile Driving Analyzer (PDA) Used as Field Control Method," to develop the Inspector's chart as the basis for foundation pile acceptance and use the bearing graph to report the bearing resistances, to be recorded on the pile driving report. Attach a copy of the bearing graph to the pile driving report. Calculate and record the bearing resistances for information and comparison purposes on the report in accordance with 2452.3E.3, "MnDOT Pile Formula 2012 (MPF12) Used as Field Control Method." Provide the deliverables as required in 2452.3E.4, "Pile Driving Analyzer (PDA) Used as Field Control Method."

F Pile Cut-off

F.1 Piles

Cut off timber piles at the elevation shown on the Plans within a tolerance from −1 inch to 1/2 inches after cutting off the timber pile, leave the head of the pile with sound, undamaged wood.

Cut off steel piles to within ±1 of the cut-off elevation using an approved method that preserves the shape of the pile at the elevation shown on the Plans.

F.2 Pile Bents

After aligning and bracing the pile bent, cut off the tops of timber piles at the elevation shown on the Plans to provide uniform bearing for the cap without using shims or fills.

Cut off steel piles using an approved method that preserves the shape of the pile at the elevation shown on the Plans to allow concrete forming or framing in brace members.

G Extensions, Splices, and Studs

Make splices for steel H-piles and CIP steel shell piles as shown on the Plans, except make splices for cold rolled fluted steel shells as recommended by the manufacturer and as approved by the Engineer.

Utilize pile welders qualified to *AWS D1.1*, “Structural Welding– Steel.” Provide continuity records log proving performance of the weld process since latest qualification.

Make splices on piles driven in pile bents at points not exposed to view, unless otherwise required by the Engineer. If making splices in pile bents exposed to view as approved by the Engineer, finish the splices by grinding in such a way that the ground surface area blends in smoothly with the contour of the CIP pipe. Verify the complete removal of the defect by visual inspection and the wall thickness shall not be adversely affected. If shear studs are required on the piles, perform the welding in accordance with *AWS D1.5*, *Bridge Welding Code,* Chapter 7.

The Contractor may provide commercial drive-fit splices for CIP piles on a performance basis as approved by the Engineer. Do not use splices in any of the following conditions:

(1) In pile bent-type piers or integral, and semi-integral abutments
(2) Where foundation soils are soft or unstable
(3) In foundations where uplift is anticipated (concrete seals, etc.)
(4) Within 10 feet of the pile cut-off
(5) Where down drag is indicated in the pile load table
(6) Where Pile Driving Analyzer or Static Load Test is specified in Contract as field control method

Commercial made H-pile splicers used solely for aligning two H-pile sections prior to welding them together will not be permitted.

H Coating Steel H-Piles and Steel Pile Shells

H.1 Painted Piles

Provide paint and perform painting in accordance with 2478, “Organic Zinc-Rich Paint System.” Provide CIP steel pile shells painted in accordance with 3371, “Steel Shells for Concrete Piling.”

Paint the outside of steel H-piles and CIP steel pile shells that are not encased in concrete but extending above ground surface or water surface with epoxy zinc-rich primer for the entire length, except for sections below splices at least 2 feet below the final ground surface or low water elevation. Apply the primer preferably before shipping or at least 2 Calendar Days before driving the piles.

After driving, paint the piles with remaining coat(s) on exposed portions above the water level, existing at the time of paint application or above an elevation 6 inches below the final ground surface. Paint the finish coat for piles in Bridges with concrete Superstructures in a color matching the AMS-STD-595A No. 37200 (lusterless aluminum) and paint the finish coat for piles in Bridges with painted steel Superstructures with the topcoat color of the Superstructure. Paint the finish coat for piles in Bridges with unpainted 3309, “High-Strength Low-Alloy Structural Steel,” steel or timber Superstructures in a color matching the AMS-STD-595A No. 10075 (brown) with a semi-gloss finish.

H.2 Galvanized Piles

Provide galvanized steel H-piles and CIP steel pile shells in accordance with 3394, “Galvanized Structural Shapes.” Provide H-piles galvanized in accordance with 3372, “Steel Piling.” Provide CIP steel pile shells galvanized in accordance with 3371, “Steel Shells for Concrete Piling.” Continuously coat steel H-piles and the outside of CIP steel pile shells that are not encased in concrete. Coat the pile from the cut-off elevation to an elevation extending a minimum of 10 feet below the defined ground surface or the bottom of water channel with hot-dipped galvanizing. Do not hot-dip galvanize within 1 foot of a splice. Based on test pile length, if a splice is required, adjust location of splice so that it is not visible after driving is completed.

Protect the galvanizing from abrasion or discoloration beginning immediately after the coating process. The special care shall include, but not be limited to:

(1) Use of nylon slings for handling
(2) Shipping and storing on blocking with isolation from adjacent shells
(3) Carrying in lieu of dragging
(4) Use of timber blocking in leads while pile driving
(5) Prompt washing of concrete leakage

Design forms and falsework for the Substructure in a manner not requiring clamping or welding to any portion of the piling that are exposed after the cap construction is complete.

Repair damaged galvanized areas by the metalizing process described in *AASHTO M 36*, “Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains,” at no additional cost to the Department. Zinc rich paint is not an acceptable repair.

2452.4 METHOD OF MEASUREMENT

A Test Piles

If the Plans show specific Contract Pay Items for test piles, the Engineer will measure the number of test piles provided as required by the Contract and driven as directed by the Engineer. The Engineer will not eliminate test piles from the Contract, unless all piles for the unit are eliminated or unless mutually agreed upon by the Contractor and the Engineer.

If the Plans do not show a specific Contract Pay Item for test piles, the Engineer will include the measurement of test piles with the measurement for piling.

If the Engineer determines that steel H-test piles or steel shells for cast-in-place concrete test piles provided in the lengths required by the Contract do not develop sufficient Nominal pile bearing resistance or do not provide information per 2452.3D.2, “Test Piles,” for ordering foundation piles, splice extensions onto test piles, or deliver longer piles as required by the Engineer.

The Engineer will measure splice extensions onto test piles or longer piles, as required by the Engineer when driving beyond Plan test pile length, in accordance with the relevant Contract Pay Items for piling.

B Piling

The Engineer will measure piling by the length of acceptable piling below cut-off elevation.

No additional payment will be made if the Contractor elects to furnish and drive thicker wall pipe piles than specified.

C Pile Load Tests

The Engineer will measure pile load tests by the number of piles load tested as required by the Contract and as directed by the Engineer.

D Reinforcement Bars

The Engineer will measure reinforcement bars used in cast-in-place concrete piles by weight in accordance with 2472, “Metal Reinforcement.”

E Pile Redriving

The Engineer will measure pile redriving by the number of piles redriven as required by the Contract and as directed by the Engineer. The Engineer will recalculate the estimated Plan Quantity to agree with the actual number of piles redriven at the Project Site, estimated not to exceed 25 percent of the total number of planned piles. The Engineer will consider any pile redriving completed without the direction of Engineer as unauthorized Work and the Department will not compensate the Contractor for that Work.

F Dynamic Monitoring of Pile Driving

The Engineer will measure Pile driving analyzer field control by the number of piles that required the pile driving analysis as required by the Contract. The Engineer will consider initial analysis and redrive analysis on an individual pile as one pile analysis. The Engineer may increase or decrease the number of piles to be dynamically monitored.

If the Contract does not require the Pile driving analyzer field control method, the Contractor may perform the Pile driving analyzer field control method at the Contractor’s option and at no additional cost to the Department.

2452.5 BASIS OF PAYMENT

A Test Piles

The Contract Unit Prices for test pile include the fixed costs of furnishing the pile, applying the driving shoe, driving to full length per 2452.3D, “Pile Driving,” filling with concrete if CIP, coating if required, and performing analysis for hammer qualification submittals. If the Plans do not include a Contract Pay Item for test piles, the Department will include the fixed costs of piling with the relevant Contract Unit Price for mobilization.

The Department will pay for splice extensions onto test piles or longer piles, as required by the Engineer when driving beyond Plan test pile length, with the Contract Pay Items piling.

B Piling

The Department will not pay full Contract Unit Prices, but may make partial payments based on actual cost, for stock lengths of steel H-piles and cast-in-place concrete piles delivered to the Project.

All treated timber piles, untreated timber piles, steel pipe piles, steel H-piles, and concrete piles driven will be paid for by the linear foot. Payment will be made only for the actual number of linear feet of acceptable piling complete in-place as needed for design or as directed by the Engineer.

Splices will be compensated at the rate of 6 times the Contract Unit Price for piling, if the splice was made and only after piling is driven to estimated test pile length for that Substructure and bearing is not achieved. Maximum of 1 splice will be paid per pile. No additional payment will be made for splices made solely for the Contractor’s convenience.

If the quantity of driven piling is less than the estimated Plan Quantity, the Department will pay 50 percent of the cost to re-stock unused piling if the Contractor elects to re-stock piling and provides a paid invoice showing the re-stocking fee not to exceed the difference of estimated pile length in the Plan and actual driven length. Payment for the Department’s portion of the restocking fee will be made as a backsheet item under "Piling, Restock" superseding any claims due from 1907, "Payment for Surplus Material.”

The following costs are included in the cost of the piling: predrilling pilot holes; pile sleeves; maintaining open holes during pile driving; broken, bent, damaged, or misplaced piles; concrete filling or concrete encasement; misplaced pile or corrective location or alignment measures; modifying or replacing pile driving Equipment; redriving piles which have heaved more than 1/4 inch; piles which are damaged during handling or if the Engineer determines that the damage was caused by the Contractor's carelessness or negligence while driving; piles which were not driven in accordance with these Specifications; piles driven with the tops lower than the cut-off elevation; spudding or jetting of piles; cutting, trimming, and coating steel H-pile and cast-in-place concrete piles; providing and attaching driving shoes for pipe piles; all labor, Equipment, and necessary Incidentals; and disposal of all pile cut-offs.

The cost of mobilization and demobilization for pile driving operations is included in the cost of mobilization and demobilization per 2452.5, "Piling, Basis of Payment."

The cost to control sediment in water from jetting operations is included in the cost of piling.

C Pile Load Tests

The Contract each price for Pile load test includes the cost of providing and driving reaction piles at locations that preclude their use in the Structure as foundation piles.

D Pile Redriving

The Contract Unit Price for Pile redriving includes the cost of redriving test piles and foundation piles, and providing and driving additional pile lengths as directed by the Engineer.

E Dynamic Monitoring of Pile Driving

The Contract each price for Pile analysis includes the cost of dynamic testing of a pile during initial driving and redriving, additional time needed in driving operations, labor, consultants, and Equipment.

The Department will include the cost of the actual redrive with the Contract each price for Pile redriving.

The Department will not adjust the Contract each price for increased or decreased Contract quantities for Pile analysis.

F Pile Points

The Contract each price for Pile points includes the cost of providing and attaching the points to the piles.

G Pile Tip Protection

The Contract each price for Pile tip protection includes the cost of providing and attaching the tips to the piles.

H Schedule

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

Item No.	Item	Unit
2452.502	Untreated Timber Test Pile ___ ft long	each
2452.502	Treated Timber Test Pile ___ ft long	each
2452.502	CIP Concrete Test Pile ___ ft long ___"*	each
2452.502	Steel H-Test Pile ___ ft long ___"*	each
2452.502	Pile Load Test Type ___	each
2452.502	Pile Redriving	each
2452.502	Pile Analysis	each
2452.502	Pile Points ___"	each
2452.502	Pile Tip Protection ___"	each
2452.503	Untreated Timber Piling	linear foot
2452.503	Treated Timber Piling	linear foot
2452.503	CIP Concrete Piling___"*	linear foot
2452.503	Steel H-Piling___"*	linear foot
2452.508	Reinforcement Bars	pound

* Nominal size in inches

2461 STRUCTURAL CONCRETE

2461.1 DESCRIPTION

This Work consists of producing, providing, placing, curing, and protecting cast-in-place Portland cement concrete for placement in Structures, pavements, and Incidental construction.

A Definitions

For the purpose of the Work specified in section 2461, "Structural Concrete," the Department defines:

Absorption Factor
Factor used to determine the water contained within the pores of the Aggregate and is held within the particles by capillary force.

Batch water
Water actually batched into the truck by the batcher. Batch water includes potable water and clarified water.

Free moisture
The water that is carried on the surface of the Aggregate that becomes part of the Total water.

Mix design water
The maximum allowable water content for 1 cubic yard of concrete.

Ready-mix Concrete
Either central-mixed concrete proportioned and mixed in a stationary plant and hauled to the point of placement in revolving drum agitator trucks or a truck mixer or truck-mixed concrete proportioned in a stationary plant and fully mixed in truck mixers.

Ready-mix Producer or "Producer"
Party that is producing the concrete for the Contract. It is understood that the Ready-mix Producer is the agent of the Contractor.

Real Time
The actual time during which something takes place.

Temper water
Water added in mixer to adjust slump

Total actual water
The water in the concrete mixture at the time of placement from any source other than the amount absorbed by the Aggregate. It includes all Batch water placed in the mixer, free moisture on the Aggregate, and any water added to the ready-mix truck prior to placement.

Total moisture factor
Factor used to determine total amount of water carried by a given wet Aggregate.

Total water
Batch water added to free moisture. Total water may also include the water used in diluting admixture solutions.

Water/Cement (W/C) Ratio
W/C Ratio is defined as the ratio of the Total water weight to the total cementitious weight, which includes cement and supplementary cementitious Materials.

2461.2 MATERIALS

A Cementitious Materials

Provide cementitious Materials from certified sources listed on the *Approved/Qualified Products List*.

Use Type I, I/II, IS, IL, or IP cement to produce Type 1 non-air-entrained concrete.

Use Type I, I/II, IS, IL, or IP cement and an air-entraining admixture listed on the *Approved/Qualified Products List* to produce Type 3 air-entrained concrete.

Use Type III Portland cement as allowed by the Contract or the Engineer.

A.1 Portland Cement 3101

A.2 Slag Cement 3102

A.3 Blended Hydraulic Cement 3103

A.4 Fly Ash 3115

A.5 Ternary Mixes

Ternary mixes are defined as Portland cement or Type IL and two other supplementary cementitious Materials, Type IT blended cement, or blended cement (excluding Type IT) and one other supplementary cementitious Material.

B Aggregates

Provide Aggregates from sources listed on the MnDOT *Concrete Aggregate Properties* list.

B.1 Fine Aggregate 3126

B.2 Intermediate Aggregate 3131

B.3 Coarse Aggregate 3137

C Water 3906

Provide water from potable sources.

The Concrete Engineer will allow clarified water as a substitution for potable water in accordance with the following:

(1) From the *Approved/Qualified Products List*
(2) In any concrete defined as MnDOT Grades B, F, G, M, P, and R
(3) Up to a maximum of 50.0 percent of total mix water by weight
(4) Provided the clarified water is identified separately on the Certificate of Compliance

D Concrete Admixtures 3113

Provide admixtures from the *Approved/Qualified Products List* for concrete grades shown in Table 2461.2-6 and Table 2461.2-7.

D.1 Allowable Admixtures

Use of any of the following admixtures are at the Contractor's discretion:

(1) Type A, Water-reducing Admixture
(2) Type B, Retarding Admixture
(3) Type D, Water-reducing and Retarding Admixture
(4) Type F, High Range Water-reducing Admixture
(5) Type G, High Range Water-reducing and Retarding Admixture
(6) Type S, Specific Performance Based Admixture

D.2 Use of Accelerating Admixtures

Use of Type C, Accelerating Admixture, and Type E, Water Reducing and Accelerating Admixtures, require approval of the Concrete Engineer, in conjunction with the Engineer, unless otherwise allowed in the Contract.

The Engineer will permit the use of Type C or Type E accelerating admixtures only when the following conditions exist:

(1) The ambient temperature is below 36°F
(2) An Engineer approved cold weather protection Plan is in-place
(3) Cold weather protection Materials are on-site and ready for use

E Concrete Mix Designs

E.1 Classification of Concrete

The Department will classify concrete by mix number to identify type, grade, consistency, and Aggregate size, if any, in accordance with Table 2461.2-1.

Table 2461.2-1
Mix Number Identification

First Digit	Second Digit	Third Digit	Fourth Digit	Additional Digits
Type Designation	Grade Designation	Maximum Slump	Coarse Aggregate Gradation Designation	Additional Digits Allowed or as Specified

E.1.a Type Designation

Provide Type 1 or Type 3 concrete in accordance with Table 2461.2-2:

Table 2461.2-2
Concrete Type Designation

Concrete Type	Target Air Content *
1	2.0 percent
3	6.5 percent ‖
* For concrete mix design purposes only. ‖ Unless otherwise required by 2301, “Concrete Pavement,” or elsewhere in the Contract.	

E.1.b Grade Designation

The Department will designate concrete grade in accordance with Table 2461.2-6 and Table 2461.2-7 using a letter designating the following:

(1) Intended use
(2) Maximum Water/Cement (W/C) Ratio
(3) Maximum cementitious content
(4) Maximum supplementary cementitious substitution (SCM)
(5) Slump range
(6) Minimum 28-Calendar Day compressive strength, f’c
(7) Coarse Aggregate quality in accordance with 3137, “Coarse Aggregate for Portland Cement Concrete”

E.1.c Slump Designation

The Department will designate the slump range as defined by the grade designation in accordance with Table 2461.2-6 and Table 2461.2-7.

E.1.d Coarse Aggregate Gradation Designation

Select the appropriate coarse Aggregate gradation designation in accordance with Table 2461.2-3 based on the intended use and the gradation requirements in 3137, “Coarse Aggregate for Portland Cement Concrete.”

Table 2461.2-3
Coarse Aggregate Gradation Designation

Designation	Coarse Aggregate Gradation
1	2301, “Concrete Pavement” only
2	#67*
3	#7*
4	#89*
7	CA-70
8	CA-80
* Gradation sizes designated per *ASTM C33/C33M*, *Standard Specification for Concrete Aggregates*, Table 3.	

E.1.e Additional Concrete Mix Designation Digits

Specialty concrete mixes require additional concrete digits in accordance with Table 2461.2-6. Use “EX” for exposed Aggregate mixes and “CO” for colored concrete mixes. The Contractor may add additional digits to the right of the required digits in the concrete mix number.

E.2 Concrete Mix Design Requirements

The Engineer determines final acceptance of the concrete for payment based on test results, satisfactory field placement, and performance.

E.2.a Department Designed Concrete Mixes

The Department will provide mix designs for the concrete defined in Table 2461.2-4 and Table 2461.2-5.

E.2.a(1) Department Designed Concrete Requirements

No additional submittal is required for Table 2461.2-4 mix designs.

Table 2461.2-4
Department Designed Concrete Mixes

Type of Concrete	Mix Number	Specification	Mix Design Location
Field Batched Patching Mix	3U18	2302, "Concrete Pavement Rehabilitation"	Table 2302.2-1
Low Slump Concrete	3U17A	2404, "Concrete Wearing Course for Bridges"	Table 2404.2-1
Bagged Patching Mix	3U18 and 3U58M	3105, "Bagged Portland Cement Concrete Patching Mix 3U18 and 3U58M"	Table 3105.2-2

E.2.a(2) Grout and Lean Mix Backfill

Submit final mix design proportions on the *General Concrete Mix Design Submittal* for Grout and Lean Mix Backfill in accordance with Table 2461.2-5.

Table 2461.2-5
Concrete Mix Design Requirements for Grout and Lean Mix Backfill Mixes

Mix Number	Maximum W/C Ratio	Water Content (pounds)	Cement Content (pounds)	Fly Ash Content (pounds)	Fine Aggregate Calculation (pounds)	Coarse Aggregate Calculation (pounds)	Percent Air Content	Slump Range	Minimum 28-Calendar Day Compressive Strength, f'c
1AGROUT*	0.50	379	758	0	100 percent †	0	3.0	As needed	4000 psi
3AGROUT *	0.44	379	865	0	100 percent †	0	10.0	As needed	4000 psi
Lean Mix‖	1.00	375	125	250	50 percent†	50 percent† ‡	N/A	10 inches ± 1 inch	#

* Do not provide grout containing coarse Aggregate or fly ash.
‖ Coarse Aggregate quality meets requirements of 3137.2D.1, "Coarse Aggregate for General Use."
† After adding the specified quantities of cement, fly ash, and water, provide the remaining Aggregate to an absolute volume 27.00 – 27.27 cubic feet.
‡ Meeting #67 gradation as shown in Table 3137.2-4.
# Maximum 28-Calendar Day compressive strength of 1500 psi.

E.2.b Contractor Designed Concrete Mixes

The Contractor will provide concrete mix designs for concrete defined in Table 2461.2-6 and Table 2461.2-7 and elsewhere as specified in the Contract.

The Contractor assumes full responsibility for the mix design and performance of the concrete.

E.2.b(1) General Concrete Mix Design Requirements

The Department specifies the concrete mix design requirements for Contractor designed mixes in accordance with Table 2461.2-6.

Table 2461.2-6
Concrete Mix Design Requirements
(Not applicable to High Performance Concrete or Mass Concrete)

Concrete Grade	Mix Number	Intended Use*	Maximum W/C Ratioll	Maximum Cementitious Content (pounds/cubic yard)	Maximum percent SCM (Fly Ash/ Slag/Ternary)	Slump Range	Minimum 28-Calendar Day Compressive Strength, f'c	3137, "Coarse Aggregate for Portland Cement Concrete."
B Bridge Substructure	3B52	Abutment, stems, wingwalls, paving brackets, pier columns and caps, pier struts	0.45	750	30/35/40	2 - 5 inches	4000 psi	2.D.1
F Flatwork	3F32	Curb and gutter	0.42	750	30/35/0	1/2 - 3 inches #	4500 psi	2.D.1
	3F52 3F57EX† 3F52CO‡	Sidewalks, curb and gutter, slope paving, median Sidewalks, driveway entrances, ADA pedestrian Sidewalks	0.45	750	25/30/0	2 - 5 inches	4500 psi	2.D.1
G General Concrete	1G52‡	Footings and pilecap	0.55	750	30/35/40	2 - 5 inches	4500 psi	2.D.1
	3G52‡	Footings, pilecap, walls, CIP manholes and catch basins, fence posts, signal bases, light pole foundations, erosion control Structures, CIP box Culverts, Culvert headwalls, open flumes, CIP wall stems	0.45	750	30/35/40	2 - 5 inches	4500 psi	2.D.1
M Median Barrier	3M12	Slipform barrier, median barrier, non-Bridge	0.42	750	30/35/40	1/2 - 1 inch#	4500 psi	2.D.1
	3M52	Barrier, median barrier, non-Bridge	0.45	750	30/35/40	2 - 5 inches	4500 psi	2.D.1
P Piling	1P42	MSE and gravity wall leveling pad	0.63	750	30/35/40	2 - 4 inches	3000 psi	2.D.1
	1P62	Piling, spread footing leveling pad	0.68	750	30/35/40	3 - 6 inches	3000 psi	2.D.1
R Pavement Rehabilitation	3R52‡	CPR - Full depth concrete repairs, concrete base	0.45	750	30/35/40	2 - 5 inches	4000 psi	2.D.3

Concrete Grade	Mix Number	Intended Use*	Maximum W/C Ratio‖	Maximum Cementitious Content (pounds/cubic yard)	Maximum percent SCM (Fly Ash/ Slag/Ternary)	Slump Range	Minimum 28-Calendar Day Compressive Strength, f'c	3137, "Coarse Aggregate for Portland Cement Concrete."
S Bridge Superstructure	3S12	Slipform Bridge barrier, parapets, end post	0.42	750	30/35/40	1/2 - 1 inch#	4000 psi	2.D.2
	3S52	Bridge median barrier, raised median, pilaster, curb, Sidewalk, approach panel, formed Bridge barrier, parapet, end post, collar	0.45	750	30/35/40	2 - 5 inches	4000 psi	2.D.2
X Miscellaneous Bridge	1X62	Cofferdam seals, rock sockets, drilled shafts	0.45	750	30/35/40	3 - 6 inches	5000 psi	2.D.1
	3X62	Drilled shafts above frost line	0.45	750	30/35/40	3 - 6 inches	5000 psi	2.D.1
Y Bridge Deck§	3Y42-M§ 3Y42-S§	Bridge decks, integral abutment diaphragms, pier continuity diaphragms, expansion joint replacement mix	0.45	750	30/35/40	2 - 4 inches	4000 psi	2.D.2
	3Y47**	Deck patching mix	0.45	750	30/35/40	2 - 4 inches	4000 psi	2.D.2

* If the intended use is not included elsewhere in the Specification or Special Provisions, use mix 3G52, unless otherwise directed by the Engineer.
‖ The minimum Water/Cement (W/C) Ratio is 0.30.
† Mix 3F57EX requires the use of Coarse Aggregate designation "7," "2" or "3" for the 4th digit in accordance with Table 2461.2-3.
‡ Identify specific color used on the Certificate of Compliance. Colored concrete is only allowed when specified in the Plans or the Contract.
# Adjust slump in accordance with 2461.3G.7.a, "Concrete Placed by the Slip-Form Method," for slip-form concrete placement.
§ The "-S" indicates a Bridge deck with a structural slab and "-M" indicates a monolithic Bridge deck.
** Mix 3Y47 requires the use of Coarse Aggregate designation "7" or "3" for the 4th digit in accordance with Table 2461.2-3.

E.2.b(2) High-Early Concrete Mix Design Requirements

The Department defines High-early (HE) concrete as concrete designed to achieve the minimum strength of 3000 psi for opening at 48 hours. Unless otherwise included in the Plans, HE concrete requires approval of the Engineer before incorporation into the Work.

The Engineer will allow one of the following methods to determine minimum time to opening:

(1) Field control cylinders in accordance with 2461.3G.5.c, "Field Control Strength Cylinders."
(2) Maturity method in accordance with 2461.3G.6, "Estimating Concrete Strength by the Maturity Method."

The Department defines the concrete mix design requirements for High-early concrete in accordance with Table 2461.2-7.

Table 2461.2-7
High-Early (HE) Concrete Requirements
(Not applicable to Bridge Superstructure or Mass Concrete)

Mix Number	Concrete Grades Allowed	Minimum Time to Opening	Ratio	Maximum Cementitious Content (pounds/ cubic yard)*	Slump Range	Minimum Strength to Opening	Minimum 28-Calendar Day Compressive Strength, f'c	3137 "Coarse Aggregate for Portland Cement Concrete"
1PHE62 ‖	P	-	0.63	750	3 – 6 inches	-	3000 psi	2.D.1
3HE32	F	48 hours	0.42	750	1 – 3 inches †	3000 psi	4500 psi	2.D.1
3HE52	B, F, G	48 hours	0.42	750	2 – 5 inches	3000 psi	4500 psi	2.D.1
3YHE52	Y (Repairs Only)	48 hours	0.42	750	2 – 5 inches	3000 psi	4000 psi	2.D.2
3RHE52	R (Repairs Only)	48 hours	0.42	750	2 – 5 inches	3000 psi	4000 psi	2.D.3

* Supplementary cementitious Materials allowed.
‖ Used only for placing concrete in piles during freezing temperatures, provide 30 percent additional cement to the concrete mix for concrete 10 feet below the ground line or water line in accordance with 2452.3D.6, "Cast-in-Place Concrete Piles."
† Adjust slump in accordance with 2461.3G.7.a,"Concrete Placed by the Slip-Form Method."

E.2.b(3) Project Specific Mix Design Requirements

Submit Project specific Contractor designed mixes on the *Project Specific Structural Concrete Mix Design Submittal* forms in accordance with Table 2461.2-8 and the Contract.

Table 2461.2-8
Project Specific Contractor Designed Mixes

Concrete Grade	Intended Use	Specification	3137 "Coarse Aggregate for Portland Cement Concrete"
A	Concrete Pavement	2301, "Concrete Pavement"	2.D.3
M, V, W, Z	Precast Concrete	2462, "Precast Concrete"	Varies
HPC	High Performance Concrete	2401, "Concrete Bridge Construction"	2.D.2
MC	Mass Concrete	Special Provision 2401	Varies
SCC	Self-consolidating Concrete	Special Provision 2401	Varies
CLSM	Cellular Concrete Grout	2519, "Cellular Concrete Grout – CLSM"	None
All concrete grades	Delivery Time is > 90 minutes	2461.3G.3.a, "Delivery Time Beyond 90 minutes"	Varies

E.3 Submittal Requirements

At least 21 Calendar Days before initial placement of the concrete, submit the appropriate *General concrete mix design submittal* form to the Concrete Engineer for approval. Use the most current forms available from the MnDOT Concrete Engineering website.

Design the concrete mix to an absolute volume of 27.00 – 27.27 cubic feet.

The Concrete Engineer will:

(1) Provide specific gravity and absorption data using oven dry (OD) weights for mix design calculations
(2) Review the mix design submittal and approve the Materials and mix design for compliance with the Specifications

Table 2461.2-9 specifies the mix design submittal requirements for Level 1 and Level 2 mixes.

Table 2461.2-9
Mix Design Submittal Requirements

	SCM Substitution Limits	Fine Aggregate Limit	Gradation Requirements	Preliminary Test Data Requirements	Submittal Package
Level 1 mixes *	Fly Ash: 0 – 15 percent Slag: 0 – 35 percent	40 – 45 percent of total Aggregate by volume ‖	3126, “Fine Aggregate for Portland Cement Concrete” and 3137, “Coarse Aggregate for Portland Cement Concrete”	None	General Concrete Mix Design
Level 2 mixes	Fly Ash: > 15 percent Ternary: Any	None	Use Either: 3126, “Fine Aggregate for Portland Cement Concrete” and 3137, “Coarse Aggregate for Portland Cement Concrete” or Job Mix Formula (JMF)	2461.2E.3.a, “Preliminary Test Data Requirements for Level 2 Mixes”	Use Either: General Concrete Mix Design or General Concrete Mix Design (JMF)
* High-early concrete in accordance with Table 2461.2-7 is defined as a Level 1 mix. ‖ Fine Aggregate limit does not apply to exposed Aggregate concrete mixes.					

E.3.a Preliminary Test Data Requirements for Level 2 Mixes

For Level 2 mixes, submit the proposed mix design proportions on the *General concrete mix design submittal* based upon either a suitable experience record or conventional trial mixtures not to exceed the limits specified in Table 2461.2-6 or Table 2461.2-7.

E.3.a(1) Suitable Experience Record

A suitable experience record consists of at least 30 consecutive tests, or 2 groups of consecutive tests totaling at least 30 tests, within the previous 18 months. If the Contractor does not have 30 tests, the Concrete Engineer will consider a minimum of 10 test results representing a time period of at least 45 Calendar Days.

The Concrete Engineer considers a suitable experience record to have the following characteristics as compared to the proposed mix:

(1) A required average strength f’c no greater than 1000 psi above the required 28-Calendar Day compressive strength
(2) Same type or grade of cementitious Materials
(3) Same class of coarse Aggregate
(4) Same supplementary cementitious proportion
(5) Individual Aggregate weights within 10 percent of the proposed
(6) Water/Cement Ratio no greater than 0.45

(7) Total cementitious weights within 5 percent of proposed
(8) Batching conditions and testing procedures similar to those expected for the proposed Work

Submit test results on the *Strength test data sheet* as part of the *General concrete mix design submittal*.

The Concrete Engineer reserves the right to request batching data representing the suitable experience record submittal.

E.3.a(2) Conventional Trial Mixtures

If the Contractor does not have a suitable experience record as required in 2461.2E.3.a(1), “Suitable Experience Record,” establish concrete proportions from trial mixtures, utilizing an AASHTO accredited laboratory in accordance with the following:

(1) Use proportions and consistencies required for proposed Work at the W/C Ratios or cementitious Materials content that will produce a strength meeting or exceeding the required 28-Calendar Day compressive strength (f’c) in accordance with Table 2461.2-6 or Table 2461.2-7
(2) Design trial mixtures to produce slump within allowable slump range
(3) For air-entrained concrete, design trial mixtures to produce air content within ± 0.5 percent of target air content
(4) For each W/C Ratio or cementitious Materials content, make and cure at least 3 test cylinders for 28-Calendar Day breaks in accordance with *ASTM C192*, *Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory*. For HE concrete mixes, in addition to the 28-Calendar Day cylinders, make a set of 3 test cylinders for 48-hour breaks in accordance with *ASTM C192*, *Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory*

Submit all test results for the trial mixtures, certified by the AASHTO accredited laboratory, in addition to the *General concrete mix design submittal*.

E.3.b Determining the Required Average Strength

Based upon the following information select the mix design proportions required to produce f’cr.

Using the Test Data spreadsheet, determine the following:

(1) The Standard Deviation (S)
(2) The Required Average Strength (f’cr) in accordance with Table 2461.2-10

Table 2461.2-10
Required Average Strength (f'cr) Equations*

	Required Average Strength
f'c ≤ 5000 psi*	f'cr = f'c + 1.34S or f'cr = f'c + 2.33S – 500
f'c > 5000 psi	f'cr = 0.90f'c + 2.33S
*When f'c ≤ 5000 psi, f'cr is the larger value computed from the equations.	

E.4 Contractor Mix Design Adjustments

The Department will allow mix design adjustments based upon the criteria as defined in Table 2461.2-11:

Table 2461.2-11
Mix Design Adjustments Requirements

	Type of Change or Adjustment	Mix Design Resubmittal Requirements
Level 1 mixes	Cementitious Sources Admixture Sources Admixture Dosage Rate	No resubmittal required
	Aggregate Sources Aggregate Proportions Any Cementitious Proportion (≤ 15 percent max fly ash)	Resubmittal of mix design
	Any Cementitious Proportion (> 15 percent max fly ash)	Resubmittal in accordance with 2461.2E.3.a, "Preliminary Test Data Requirements for Level 2 Mixes"
Level 2 mixes	Admixture Dosage Rate Cementitious Sources	No resubmittal required
	Aggregate Source, no change in Aggregate Class ≤ 5 percent Total Cementitious * ≤ 10 percent Individual Aggregate Weights	Resubmittal of mix design
	Aggregate Source and Class of Coarse Aggregate Supplementary Cementitious Proportions > 10 percent Individual Aggregate Weights Admixture Sources	Resubmittal in accordance with 2461.2E.3.a, "Preliminary Test Data Requirements for Level 2 Mixes"
* Only 1 increase in total cementitious allowed per mix design, next adjustment requires resubmittal in accordance with 2461.2E.3.a, "Preliminary Test Data Requirements for Level 2 Mixes"		

E.5 MnDOT Review for Continual Acceptance of Contractor Mix Designs

The Department Concrete Engineering unit will review test results relating to each individual Contractor approved mix design. Department will review the following test results:

(1) Plant and Field Test Results
(2) Compressive Strength at 28 Calendar Days
(3) Monthly Aggregate Quality Testing

Provided the concrete met the requirements of the Contract, had satisfactory placement and performance, the Contractor will have that mix design available for use during the next calendar year.

F Concrete Yield

The Department defines concrete yield as the ratio of the volume of mixed concrete, less accountable waste, to the planned volume of the Work constructed. The Department will not assume responsibility for the yield from a given volume of mixed concrete.

2461.3 CONSTRUCTION REQUIREMENTS

A Batching Equipment

A.1 Mixer Requirements

Provide stationary mixers or truck mixers.

A.2 General Condition

Maintain mixers as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examine to detect wear of blades.

Replace or recondition pickup and throwover blades in mixers with a rated capacity less than 14 cubic feet showing a blade wear loss of greater than 1/2 inch, and pickup and throwover blades in mixers of greater capacity, showing a blade wear loss of no greater than 3/4 inch from the original factory dimensions.

A.3 Manufacturer's Rating Plate

Provide mixers that include the manufacturer’s rating plate, showing the following information:

(1) Serial number of the unit
(2) Mixing speed of the drum or paddles
(3) Maximum capacity in terms of volume of mixed concrete

A.4 Drum Speed for Stationary Mixers

Operate the drum speed in the mixer as specified by the manufacturer or as directed by the Engineer.

A.5 Auxiliary Equipment Requirements

Provide mixers equipped with the following:

(1) Timing device
(2) Discharge locking device
(3) Water measuring device that operates mechanically and automatically during each batching cycle
(4) A graduated adjustable indicator device to represent the volume of discharge in increments no greater than 1/4 gallon in full view

A.6 Mixer Capacity

Do not exceed the manufacturer’s rated capacity of the mixer when mixing a single batch of concrete.

Batch concrete in volumes the mixer can accommodate without spilling, leaking, or segregating during the charging, mixing, or discharging operations.

A.7 Mixing Time

For the purpose of the Work specified in 2461.2E, “Concrete Mix Designs,” the Department defines the mixing time as the time period beginning when the cement and Aggregates enter the mixer drum and ending when the discharge begins.

Refer to the manufacturer's recommended minimum mixing time for single drum and dual drum mixers. In the absence of manufacturer's recommendation, the Engineer will designate the minimum mixing time. The minimum mixing time for any concrete batch is 60 s. The Contractor may reduce the manufacturer's recommended minimum mixing time or the Engineer designated mixing time if the Contractor obtains uniform mixing in accordance with 2461.3E, "Mixing Requirements," and as approved by the Engineer, in conjunction with the Concrete Engineer.

If there is evidence of inadequately mixed concrete (unmixed or partially mixed Materials) during concrete placement, the Engineer may direct an increase in the mixing time.

A.8 Turbine Type Mixers

Provide turbine type mixers meeting the applicable requirements for conventional type mixers in accordance with 2461.3A.1, "Mixer Requirements," through 2461.3A.7, "Mixing Time," and this subsection. Maintain the mixer drum in a cylindrical shape within 3/4 inches from the original factory dimensions at any point. Maintain the mixer discharge gate in a mortar tight condition in the closed position. Replace or recondition mixer paddles showing a wear loss greater than 1/2 inch from the original factory dimensions.

Add the mixing water to the batch Materials in a manner that distributes the water to the inner or central areas of the drum. Start the flow of water before introducing the solid batch Materials into the mixer drum.

During mixing, operate the paddles at a speed between 20 revolutions and 30 revolutions per minute. After adding the batch Materials to the drum, mix the concrete for an additional 60 seconds.

A.9 Horizontal Axial-Revolving Blade Type Mixers

Provide horizontal axial-revolving blade type mixers (single or multiple shaft) in accordance with the applicable requirements for conventional type mixers in accordance with 2461.3A.1, "Mixer Requirements," through 2461.3A.7, "Mixing Time," and this subsection.

Charge the water, Aggregates, and cement in the sequence recommended by the manufacturer. Test the concrete uniformity as directed by the Engineer. The Engineer will use concrete uniformity tests to determine the minimum mixing time.

B Transportation Units

B.1 General Requirements

Equip transportation units intended for both mixing and agitating with watertight revolving drums mounted, powered, and fitted with properly designed mixing blades in accordance with 2461.3A.1, "Mixer Requirements," through 2461.3A.7, "Mixing Time." Provide units capable of combining the ingredients into a homogeneous mixture and designed to provide two drum speeds, one for mixing and the other for agitating. Provide units capable of delivering the concrete without segregation or loss of any of the batch Materials.

Equip the mixer drum with a working counting device to record the number of revolutions.

Equip dump trucks and agitator trucks with vibrators to aid in discharge, are mortar tight, capable of complete discharge of the concrete, and in accordance with 2301.3F, "Placing Concrete."

B.2 Capacity of Transportation Units

Refer to the truck mixer manufacturer's certification plate attached to the unit for the maximum capacity of the unit. If the unit will not satisfactorily mix the maximum volume shown, reduce the batch volume to allow proper mixing or discontinue use of the mixing unit as directed by the Engineer until the problem is corrected.

C Handling and Storing Materials

C.1 Batch Material Requirements

Do not change the source, kind, or gradation of batch Materials after the start of concrete production for the Work unless otherwise approved by the Engineer. If the Engineer approves use of different Material, completely exhaust the supply on hand before changing to the different Material.

If delivering freshly washed Aggregates to the batching plant, drain the Aggregates for at least 12 hours before using in the batching operation. If draining freshly washed Aggregates at the site of the batching plant, completely separate the drained Material from the undrained Materials, and provide for the disposal of water that accumulates from the drainage of Materials.

Provide smooth, firm, and well-drained stockpile sites cleared of vegetation and extraneous matter. Where the natural foundation is unsatisfactory, as determined by the Engineer, construct the stockpiles on suitable platforms. Construct suitable bulkheads or partitions to separate different kinds of Aggregate, gradation, or water content.

Construct stockpiles by methods that hold segregation and degradation to a minimum. If the Engineer sees segregation or degradation, the Engineer may designate that pile as unacceptable for use.

Do not use Aggregates used to construct runways for loading or hauling Equipment in concrete batches.

Use of Aggregates from the bottom 1 foot of a stockpile placed on an unprepared surface in concrete batches is allowed only under the Engineer's direct supervision and if the Material meets requirements of 3126, "Fine Aggregate for Portland Cement Concrete," 3131, "Intermediate Aggregate for Portland Cement Concrete, " and 3137, "Coarse Aggregate for Portland Cement Concrete."

Provide Aggregates in accordance with the specified gradation requirements.

The Engineer will consider Aggregates unacceptable if the variation in moisture content carried by any of the Aggregates causes a marked variation in the consistency of successive batches of the mixed concrete, and will suspend operations until corrected.

C.2 Concrete Temperature Control

Produce concrete at temperatures from 50°F to 90°F and maintain temperatures until deposited in the Work.

If necessary to maintain placement temperature, uniformly heat or cool the water, Aggregates, or both, before introduction into the mixer. Control the temperature of the mixing water during heating or cooling.

Use Aggregate at temperatures from 32°F to 130°F. Do not allow cementitious Material to contact other batch Material when the Aggregate temperature exceeds 130°F.

Do not heat the cement, add salt, or add chemical admixtures to the concrete mix to prevent freezing.

Use a heating system to heat batch Materials as approved by the Engineer. Do not use steam jets to spot heat the Material as the Work progresses.

Do not place mixer heaters intended for heating the batch Materials in the mixer drum.

D Batching Requirements

The Concrete Engineer will allow only large capacity Scale companies authorized by the Minnesota Department of Commerce, Weights and Measures Division to calibrate weighting Equipment and meters for Department Projects. A list of authorized companies is available from the Concrete Engineering Unit website.

Calibration of weighing Equipment is required within three months prior to plant certification each calendar year. Calibrate weighing Equipment and perform spot checks in accordance with the *Concrete Manual*.

D.1 Batching by Weight

D.1.a Proportioning Methods

Proportion concrete batch Materials by weight in a central plant or by volume as directed by the Engineer, in conjunction with the Concrete Engineer.

D.1.b Weighing Equipment and Tolerances

Weigh or measure concrete mixture ingredients using load cells or meters for Ready-mix and paving concrete to within the targeted batch weight in accordance with the following:

(1) Water – 1 percent
(2) Cement – 1 percent
(3) Other cementitious Materials – 3 percent
(4) Aggregates – 2 percent
(5) Admixtures – 3 percent

D.1.c Batching of Mixing Water

Separately measure each type of mixing water on Scales or water metering devices containing the following:

(1) A discharge indicator capable of being set to within 1 gallon of a predetermined quantity
(2) A positive automatic shutoff valve
(3) An approved inspection seal on the Scale or water metering device dating the time of the previous calibration and adjustment

Calibration of the water meter is required within three months prior to plant certification each calendar year. Calibrate the water meter and perform spot checks in accordance with the *Concrete Manual*.

Check the water meter for accuracy at least once each month as the Work progresses.

D.1.d Batching of Cementitious Materials

Weigh the cementitious Material independently of the Aggregates in separate compartments or on separate Scales.

If the Contractor weighs the cement first and then separately records the weights of each individual cementitious Material, the Contractor may weigh the cementitious Materials cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.e Batching of Aggregates

If the Contractor records each individual fraction weight of Aggregates separately, the Contractor may weigh Aggregates cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.f Admixture Proportioning

If using two or more admixtures in a single concrete batch, add each admixture separately to prevent interaction of the different admixtures before mixing with other batch Materials. Agitate admixtures to ensure homogeneous concentrations in accordance with the manufacturer's recommendations.

Incorporate admixtures to the batch mix in liquid form. Maintain admixture solutions at a uniform concentration. Use the solution concentration and proportions designated by the manufacturer.

If using a mechanical dispenser for proportioning Class I or Class II admixtures, provide a site gauge or meter. Have the admixture manufacturer check admixture dispensers yearly to determine accuracy and ensure unobstructed flow.

D.2 Batching by Volume

Proportion concrete for Bridge deck overlays by volume or as required by the Contract.

If the Contractor calibrates the mixer for the specific batch Materials in use, the Contractor may proportion concrete on other items of Work by volume as approved by the Engineer in writing.

The Engineer will approve methods and Equipment used in volumetric proportioning.

Determine Material proportions and calibration settings on the basis of 100 pounds of cementitious Material.

Provide and use only sacked cement in the original mill containers unless the Contractor calibrates the mixer for the specific Materials in use. Do not use previously opened sacks.

E Mixing Requirements

The Engineer may check the water measuring Equipment for accuracy before mixing operations begin and at any other time the Engineer considers necessary.

Mix concrete by one of the following methods:

(1) A central plant (stationary plant)
(2) Entirely or in part in truck mixers
(3) At the construction site

Do not allow the mixing batch to merge or intermix with the subsequent dry batch during mixing.

Discharge water remaining in the drums before batching.

Mix concrete to provide a mixture that is homogeneous and uniform in color. The Engineer will reject concrete batches that show a marked variation in consistency or evidence of improper mixing as unacceptable Work in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

After completely mixing the concrete, either in a central plant mixer or truck mixer, continuously agitate while in transit to the point of placement until the concrete is discharged from the unit, unless otherwise allowed by the Engineer, in conjunction with the Concrete Engineer.

If the mixing does not appear uniform, perform slump tests at the 15 percentage point and the 85 percentage points during unloading. If the results show a slump variation greater than 1 1/2 inch, stop Work and correct the mixing unit.

Produce concrete in such quantity and at such a rate as proper placement and finishing will permit. Do not re-temper partially set concrete.

Do not hand mix concrete.

E.1 Mixing In Truck Mixer

Charge the Materials into the truck mixer drum by introducing sufficient water before adding solid Materials. Perform charging operations without losing Materials.

Leave the truck mixer at the plant site for a minimum of 5 minutes or 50 revolutions during the mixing period. Transport the concrete at agitating speed to the point of placement.

F Certified Ready-mix Concrete

Provide concrete from a certified ready-mix plant listed on the Concrete Engineering Unit website. Ensure the Producer performs Quality Control of concrete production and complies with the Department *Certified Ready-mix Program*.

Provide batches for a delivered load of concrete in sizes of at least 1 cubic yard.

The Engineer may reject Ready-mix Concrete delivered to the worksite that does not meet the specified requirements for delivery time, consistency, quality, air content, or other properties, as unacceptable Work in accordance with 1512, "Unacceptable and Unauthorized Work."

F.1 Certified Ready-mix Plant Program

The Producer will perform Quality Control (QC) under the certification program for Ready-mix Concrete plants in accordance with 2461.3F.3, "Contractor Quality Control (QC)." The Engineer will perform Quality Assurance (QA) as part of the acceptance process in accordance with 2461.3F.4, "Quality Assurance (QA)."

F.1.a Plant Certification

Prior to the production of Department concrete each construction season, a Department Certified Concrete Plant Technician, representing the Department, shall perform a thorough on-site inspection of the concrete plant with a Department Certified Concrete Plant Technician, representing the Producer.

In order to obtain certification, complete the following:

(1) The Producer will complete Department Form 2163, *Contact Report – ready-mix*, before the on-site inspection with the Department representative.

(a) A Department Certified Concrete Plant Technician, representing the Producer, signs the *Contact Report – ready mix* certifying compliance with the certified ready-mix requirements and continual maintenance of the plant to assure that the plant can produce concrete meeting Department Specifications.

(b) A Department Certified Concrete Plant Technician, representing the Department, signs the *Contact Report – ready mix* signifying that the plant complies with all requirements before concrete production.

(2) Identify persons responsible for testing and overseeing plant operations on Department Form 2163, *Contact Report – ready-mix*. Provide their email, cell phone number, and Department Technical Certification number.
(3) Include a site map showing stockpile locations identified with the Department pit number.
(4) Provide cementitious and admixture samples.
(5) Provide a computerized batching system capable of meeting the requirements of 2461.3F.2, "Certificate of Compliance."
(6) Provide continuous access on-site to the *Concrete Manual* available from Department's website.
(7) Supply a working email address, including an active internet connection, at the certified ready-mix plant.
(8) Provide calibrated electronic Scales for weighing Materials.
(9) Provide facilities in accordance with 1604, "Plant Inspection – Commercial Facility," for the use of the plant technician in performing tests.

The Department representative will submit the completed *Contact Report – ready-mix* and current Certificate of Compliance to the Concrete Engineer for final determination of certification.

F.1.b Maintaining Plant Certification

The Producer will maintain plant certification by:

(1) Displaying the current *Contact Report – ready-mix* and site map in plain sight at all times
(2) Updating the *Contact Report – ready-mix* with any Material or Equipment changes and submitting to the Department
(3) Making Producer plant QC workbook and QC charts available electronically at all times
(4) Performing the responsibilities identified in 2461.3F.3, "Contractor Quality Control (QC)"
(5) Supplying the following information at the request of the Engineer:

    (a) Approved mix design sheets
    (b) Agency cementitious and admixture test results
    (c) Agency verification gradation test results
    (d) Aggregate quality test results

(6) Keep plant reports, charts, and supporting documentation on file at the plant site for 5 calendar years.

F.1.c Certified Ready-mix Plant Decertification

The Concrete Engineer, with coordination from the Engineer, may decertify the plant and halt production of concrete under any of the following conditions:

(1) Unauthorized procedural, Material, or Equipment changes made after the completion of the *Contact Report – ready-mix*
(2) Failure to meet the required testing rates
(3) Failure to complete required documents
(4) Failure to provide competent Department Certified Plant Technicians
(5) Disregard of any of the requirements of 2461.3F, "Certified Ready-mix Concrete"
(6) Falsification of test records or Certificates of Compliance

F.2 Certificate of Compliance

Provide a computerized Certificate of Compliance with each truckload of Ready-mixed Concrete at the time of delivery. The Department defines computerized to mean a document that records mix design quantities from load cells and meters.

If the computer that generates the Certificate of Compliance malfunctions, the Engineer may allow the Contractor to finish any pours in progress if the Producer issues a handwritten Department Form 0042, *Certificate of Compliance* with each load. Do not allow the Producer to begin new pours without a working computerized Certificate of Compliance.

Provide a computerized Certificate of Compliance that includes the following information:

(1) Name of the Ready-mix Concrete plant
(2) Name of the Contractor
(3) Date
(4) State Project Number (SP) or (SAP)
(5) Bridge Number (if applicable)
(6) Time concrete was batched
(7) Truck number
(8) Quantity of concrete in this load
(9) Running total of each type of concrete, each day for each Project
(10) Type of concrete (Department Mix Designation Number)
(11) Cementitious Materials using Department Standard Abbreviations
(12) Admixtures using Department Standard Abbreviations
(13) Aggregate sources using 5 digit State Pit Numbers
(14) Admixture quantity in fluid ounces per 100 pounds of cementitious Materials or ounces per cubic yard
(15) Batch weights in columns in accordance with Table 2461.3-1:

(a) Print in order a through k
(b) Use formula to calculate weights
(c) Head columns with Standard Labels

Table 2461.3-1
Standard Certificate of Compliance Labels

	Formula Letter	Formula	Standard Label
a	Ingredients (Aggregate, cementitious, water, admixture type)	—	Ingredient
b	Product Source (Department Standard Abbreviation)	—	Source
c	Total moisture factor (in decimals to 3 places)	—	MCFac
d	Absorption Factor (in decimals to 3 places)	—	AbsFac
e	Mix design oven dry (OD) weights, pound/cubic yard	—	OD
f	Absorbed moisture in the Aggregates, pound/cubic yard	(e × d)	Abs
g	Saturated surface dry (SSD) weights for Aggregates, pound/cubic yard)	(e + f)	SSD
h	Free moisture, pound/cubic yard	(c - d) × e	Free Mst
i	Target weights for one cubic yard of concrete, pound/cubic yard	(g + h)	cubic yard Targ
j	Target batch weights, pounds	(cubic yard × i)	Target
k	Actual batch weights, pounds	—	Actual
NOTE: Actual cubic yards batched may vary due to differences in air content, weight tolerances, specific gravities of Aggregates, and other variables.			

(16) Total Water (Batch water + free moisture) in pounds
(17) Water available to add [(Mix design water × batch size) – Total water] in gallons
(18) Space to note the water adjustment information, including:

(a) Water in gallons added to truck at plant (filled in by Producer, enter zero if no water is added)
(b) Water in gallons added to truck at the jobsite (filled in by Producer or Engineer, enter zero if no water is added)
(c) Total actual water in pounds (Total water from Certificate of Compliance plus any additions)

(19) The following information printed with enough room beside each item to allow the Engineer to record the test results:

(a) Air content
(b) Air temperature
(c) Concrete temperature
(d) Slump
(e) Cylinder number
(f) Location or part of Structure
(g) Time discharge
(h) Signature of Inspector

(20) Location for the Producer signature
(21) For colored concrete, final color

F.3 Contractor Quality Control (QC)

The Producer’s daily responsibilities include the following:

(1) Provide qualified personnel
(2) Maintain plant and laboratory Equipment within allowable tolerances
(3) Randomly spot check concrete batching to verify batch weights and tolerances
(4) Check the bins and piles for segregation, contamination, or interblending of the Aggregates

(5) Check that mix trucks are clean, blades are not worn, and revolution counters are working properly.

F.3.a Personnel

The Producer will provide the following personnel:

(1) Quality Control Plant Technician(s) to perform all testing and QC requirements of 2461, “Structural Concrete.” The Quality Control Plant Technician shall hold a current Department Concrete Plant Certification.
(2) Quality Control Supervisor responsible for oversight of all QC testing and daily plant operations. The Quality Control Supervisor shall hold a current Department Concrete Plant Certification and is required to remain on-site during concrete production or have cellular phone availability.
(3) Quality Control Manager responsible for oversight of the Quality Control Supervisor and the Certified Ready-mix Plant Program.

F.3.b Sampling and Testing

Take samples randomly in accordance with *ASTM D3665, Standard Practice for Random Sampling of Construction*, Section 5, at a rate defined in accordance with the *Schedule of Materials Control*. Perform sampling and testing in accordance with the *Concrete Manual*. The Engineer may oversee the QC sampling and testing process.

Perform QC gradation and moisture testing at the certified ready-mix plant site. Use mechanical shakers for Sieve analysis.

Provide Equipment and perform calibrations meeting the requirements of the following:

(1) *AASHTO T 27*, “Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates”
(2) *AASHTO T 255*, “Standard Method for Test for Total Evaporable Moisture Content of Aggregate by Drying”
(3) *AASHTO M 92*, “Standard Specification for Wire-cloth Sieves for Testing Purpose”
(4) *AASHTO M 231*, “Standard Specification for Weighing Devices Used in the Testing of Materials”

F.3.c Aggregate Gradations

Complete the *Concrete Aggregate Worksheet* for each Aggregate size and source.

If a QC gradation fails, retest immediately documenting both results. If an additional QC test is required for that week, the Engineer will not allow a retest gradation as a substitute for a QC gradation. The Engineer will not allow a verification companion gradation as a substitute for a QC gradation.

Identify QC companion samples with the following information:

(1) Date
(2) Test number
(3) Time
(4) Type of Material

(5) Plant
(6) Sampling location

F.3.d Moisture Content

Determine the moisture content using the oven-dry method in the *Concrete Manual*. Moisture probes to determine moisture content in the Aggregates are not allowed without the approval of the Concrete Engineer.

Complete the *Batching Report (2152)* for each Aggregate size and source.

Observe the batch person enter moisture contents into the batching system. Verify the moisture contents were entered correctly on the Certificate of Compliance.

F.3.e Concrete Ready-mix Plant QC Workbook

Complete the *Concrete Ready-mix Plant QC Workbook* which includes the following documents:

(1) Producer Diary
(2) Batching Report (2152)
(3) Concrete Aggregate Worksheet (21762)
(4) Weekly Concrete Aggregate Report (2449)
(5) Concrete Aggregate Worksheet JMF (2449JMF)
(6) Weekly Concrete Aggregate Worksheet – JMF (2449JMF)

The Producer will maintain the *Concrete Ready-mix Plant QC Workbook* in Real Time using their full name for the diary and each test performed.

The Producer's designated Quality Control Supervisor will review and submit to the Engineer and the Concrete Engineering Unit by the Tuesday immediately following the previous week's production.

F.3.f Aggregate Gradation Control Charts and Sample Log

Complete the *Aggregate gradation control charts* in Real Time for each Aggregate size and Aggregate source by recording Producer QC gradations and verification companion gradation results. These results are included in the moving average calculation.

Complete *Sample Log* in Real Time for all samples taken as follows:

(1) Record all Aggregate samples taken by the Department
(2) Record cementitious and admixture samples taken by the Producer and picked up by the Department

F.3.g Signing the Certificate of Compliance

The Producer's Department Certified Plant technician will:

(1) Review the first Certificate of Compliance for each mix type, each day, for accuracy
(2) Legibly hand sign the Certificate of Compliance at a location designated for Producer signature signifying agreement to the terms of this program and to certify that the Materials comply with the requirements of the Contract
(3) Print the name and write the Department Technical Certification Number next to the signature

F.4 Quality Assurance (QA)

The Engineer's responsibilities each time the plant is visited includes the following:

(1) Confirm the *Concrete Ready-mix Plant QC Workbook* and *Aggregate Gradation Control Charts* are accurate and up-to-date
(2) Check Certificate of Compliance for completeness and accuracy
(3) Spot check concrete batching to verify batch weights and tolerances
(4) Check the bins and stockpiles for segregation, contamination, and interblending of the Aggregates
(5) Obtain Aggregate samples per *Schedule of Materials Control*
(6) Observe Producer's Certified Technician obtain Aggregate samples and run gradation and moisture tests when possible
(7) Verify cementitious and admixtures are certified and approved
(8) Collect cementitious and admixtures samples per the *Schedule of Materials Control*
(9) Provide the following Department test results to the Producer in a timely manner:

  (a) Cementitious Materials
  (b) Admixtures
  (c) Verification gradations
  (d) Coarse Aggregate quality

(10) If any Equipment malfunctions, testing procedures or test results are questionable, or unusual Activity is occurring during the plant visit perform the following:

  (a) Continue monitoring at the plant and document observations in the diary.
  (b) Investigate to determine the origin of the concern and document the resolution.
  (c) Contact Independent Assurance Inspector, Project Engineer, or Concrete Engineering Unit when necessary.

F.4.a Personnel

The Department will provide Department Certified Concrete Plant Technicians to perform the duties of 2461.3F.4, "Quality Assurance (QA)."

F.4.b Sampling and Testing

The Engineer will:

(1) Take all samples randomly in accordance with *ASTM D 3665, Standard Practice for Random Sampling Construction Materials,* Section 5, at a rate defined in the *Schedule of Materials Control*
(2) Perform all sampling and testing in accordance with the *Concrete Manual*
(3) Use mechanical shakers for Sieve analysis

F.4.c Aggregate Gradations

The Engineer will:

(1) Complete the *Weekly Certified Ready-mix Plant Report* for each Aggregate size and source.

(2) Compare the Department results with the Producer's companion gradation result for compliance with lab/field tolerance in accordance with 2461.5A.1.b, "Lab Field Tolerance."

F.4.d Batch Weight Verification

Each time the Engineer visits the plant, the Engineer will observe the actual water batched in a single load of concrete in accordance with the following:

(1) Watching the ready-mix truck reverse the drum after washing
(2) Verifying use of the current moisture test
(3) Verifying that any additional water added to adjust the slump is recorded
(4) Validating water weights on the load batched and comparing the Total water with the design water

The Engineer will document the actual water batched on the *Weekly Certified Ready-mix Plant Report*.

F.4.e Concrete Ready-mix Plant QA Workbook

The Engineer will complete the *Concrete Ready-Mix Plant QA Workbook* in Real Time which includes all of the following documents:

(1) Agency Diary
(2) Weekly Certified Ready-mix Plant Report (24143)
(3) Concrete Aggregate Worksheet (21763) if gradation testing performed in the field
(4) Concrete Aggregate Worksheet – JMF (21764) if gradation testing performed in the field

Submit to the Engineer and the Concrete Engineering Unit by the Thursday immediately following the previous week's production.

F.4.f Non-compliance with Certified Ready-mix Plant Program

If the Engineer observes the Producer not complying with the requirements of the Certified Ready-Mix Plant Program, the Engineer may perform the following:

(1) Verbally notify and promptly email the Producer and the Concrete Engineer the list of observed deficiencies and provide a deadline to correct the non-compliance.
(2) If non-compliance is not corrected by the deadline, notify the Contractor and Producer that concrete production is unauthorized in accordance with 1512, "Unacceptable and Unauthorized Work."

The Concrete Engineer will determine if the severity of the non-compliance results in decertification of the plant in accordance with 2461.3F.1.c, "Certified Ready-mix Plant Decertification."

G Concrete Placement

Assume full responsibility for the acceptable production, placement, finishing, and curing of concrete under the conditions prevailing, regardless of the restrictions imposed. Provide any artificial lighting and rain or cold weather protection necessary at no additional cost to the Department.

Place concrete after the Engineer inspects and approves the foundation preparations, forms and falsework erection, placement of reinforcement steel, Materials, Equipment condition, and cold weather protection.

Do not place concrete if portions of the base, subbase, or Subgrade Layer are frozen, or if the excessive moisture levels make the grade unstable. Maintain the surface temperature above freezing for forms, steel, and adjacent concrete that will come in contact with the poured concrete before concrete placement.

Protect the concrete from freezing.

Protect the concrete against damage from construction operations or traffic.

The Engineer will evaluate any defects in concrete or concrete surfaces resulting from weather conditions, inadequate lighting, or other causes in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.1 Notice of Inspection

Notify the Engineer at least 24 hours before beginning concrete production to allow the Engineer time to provide inspection forces needed for the Work and to approve preparations for concrete placement. If the Contractor fails to provide 24 hour notice, the Engineer may delay concrete placement and will consider any concrete incorporated into the Work as unauthorized in accordance with 1512.2, "Unauthorized Work." The Engineer will consider any delays to the Contract resulting from unauthorized Work as non-excusable in accordance with 1806.2C, "Non-Excusable Delays."

If the Producer needs to change plants during placement, notify the Engineer and obtain approval before changing the plant.

G.2 Placement Temperatures

Maintain concrete temperature from 50°F to 90°F until placement.

Unless Engineer approved cold weather protection Plans are in place, do not place concrete when the air temperature is either of the following at the point of placement:

(1) Below 36°F
(2) The National Weather Service predicts the temperature to fall below 36°F within the following 24 hour period

G.3 Delivery Requirements

Place concrete into the Work in accordance with the following:

(1) Type 1 Concrete—within 90 minutes of batching
(2) Type 3 Concrete—within 90 minutes of batching when all admixtures are added at the plant at the manufacturer's recommended dosage rates listed on the *Approved/Qualified Products List*. If the haul time does not facilitate mixing and placing the concrete within 90 minutes, test the concrete in accordance with 2461.3G.3.a, "Delivery Time Beyond 90 minutes"

The Contractor may transport Type 3 concrete in non-agitating Equipment if the concrete is discharged within 45 minutes of batching.

Batch time starts when the batch plant or the transit mix truck adds the cement to the other batch Materials.

G.3.a Delivery Time Beyond 90 minutes

If the haul time does not facilitate mixing and placing the concrete within 90 minutes, follow the procedures set out in this subsection for each proposed concrete mix to extend the delivery time to 120 minutes. Extending the delivery time beyond

120 minutes will require additional testing at 30-minute intervals up to the maximum desired delivery time as directed by the Concrete Engineer.

The Concrete Engineer will allow trial batching at an AASHTO accredited laboratory to pre-qualify the concrete mix in accordance with 2461.3G.3.a(1), “Lab Trial Batching.”

The Concrete Engineer may waive the lab trial batching requirement and allow only field trial batching of the proposed mix to extend the delivery time on an individual Project in accordance with 2461.3G.3.a(2), “Field Trial Batching.”

Upon completion of the trial batching, provide the trial batching test results and proposed mix design to the Concrete Engineer. Submit the Contractor mix design in accordance with 2461.2E.2.b, “Contractor Designed Concrete Mixes.” Final approval of the mixture is based on satisfactory field placement and performance.

G.3.a(1) Lab Trial Batching

Contact the Concrete Engineering Unit a minimum of 2 Calendar Days before trial batching.

Ensure the admixture manufacturer’s technical representative is present during the trial batching.

Laboratory trial batch and test the proposed mix in accordance with the following:

(1) After adding all admixtures to the concrete mixture, measure the slump, air content, unit weight, and temperature immediately after batching, at 90 minutes and at 120 minutes

(2) Fabricate concrete cylinders for compressive strength at 90 minutes and at 120 minutes (sets of 3). Test all of the cylinders for compressive strength at 28 Calendar Days

(3) Fabricate concrete cylinders for hardened air content testing at 90 minutes and at 120 minutes (sets of 5). Determine the hardened air content (*ASTM C457, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*) at a minimum of 7 Calendar Days on 2 samples representing 90 minutes and 2 samples representing 120 minutes. Provide Department with the other 6 samples for testing at their discretion. Retain any hardened concrete test specimens for a minimum of 90 days for Department to examine at their discretion.

Once accepted by the Concrete Engineer, the Department will consider the laboratory trial batching acceptable for use for 5 years; unless the Concrete Engineer determines the Material sources have changed significantly since the initial laboratory testing and acceptance.

G.3.a(2) Field Trial Batching

Submit a QC Plan for extending the delivery time beyond 90 minutes for review and approval to the Concrete Engineer a minimum of 2 Calendar Days before field trial batching.

The QC Plan includes the proposed Materials, batching sequences, anticipated timeline for admixture and/or water adjustments at the Project Site, delivery method, and anticipated typical travel time to Project Site.

The Contractor must demonstrate to the Engineer the ability to properly mix, control, and place the concrete in accordance with the proposed QC Plan and the Contract.

Perform field trial batching on the proposed mix in the presence of the Engineer in accordance with the following:

(1) Batch a minimum 5 cubic yards of concrete utilizing the same Materials and methods intended for use when supplying concrete placed into the permanent Work
(2) Maintain the ready-mix truck in transit; by either driving around the yard or on the Roadway; and maintain the drum speed at 5 to 7 revolutions per minute for the entire 120 minutes
(3) Measure the slump, air content, unit weight, and temperature after making all admixtures and water adjustments to the concrete mixture at 90 minutes and 120 minutes
(4) Fabricate concrete cylinders for compressive strength at 90 minutes and at 120 minutes (sets of 3). Test all of the cylinders for compressive strength at 7 Calendar Days
(5) Fabricate concrete cylinders for hardened air content testing at 90 minutes and at 120 minutes (sets of 2). Determine the hardened air content (*ASTM C457, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*) at a minimum of 7 Calendar Days on 1 sample representing 90 minutes and 1 sample representing 120 minutes. Provide Department with the other 2 samples for testing at their discretion. Retain any hardened concrete test specimens for a minimum of 90 Calendar Days for Department to examine at their discretion
(6) Incorporate the trial batched concrete into other Work with the approval of the Engineer

G.4 Field Adjustments

Mix the load a minimum of 5 minutes or 50 revolutions at mixing speed after addition of admixture or additional mixing water.

G.4.a Water Adjustments

The Engineer will allow water adjustments in accordance with the following:

(1) Before discharging approximately 1 cubic yard of concrete
(2) Water is available to add as stated on the Certificate of Compliance
(3) Concrete is within 60 minutes from the initial batch time stated on the Certificate of Compliance

G.4.b Water Adjustments for Concrete Placed by the Slip-Form Method

The Engineer will allow water adjustments for all grades of concrete placed by the slip-form method, except Grade A paving concrete, in accordance with the following:

(1) If water is available to add as stated on the Certificate of Compliance
(2) Concrete is within 60 minutes from the initial batch time stated on the Certificate of Compliance

G.4.c Admixture Adjustments

Approved admixture additions are allowed within 90 minutes from the initial batch time stated on the Certificate of Compliance. If the load of concrete has no available water to add, or the load is greater than 60 minutes old, the Engineer will allow one admixture adjustment diluted with up to 2 gallons of water.

G.4.d Consistency and Air Content Adjustments

The Engineer will test the concrete for compliance with 2461.3G.7, "Consistency," and 2461.3G.8, "Air Content," in accordance with the following:

(1) If the first test taken by the Engineer passes, the Engineer will continue verification testing in accordance with the *Schedule of Materials Control*
(2) If the test taken by the Engineer fails, make adjustments and perform any Quality Control testing before the Engineer performs a final test. Acceptance or rejection of the truck is based on the Engineer's final test result
(3) The Engineer will test up to 2 additional trucks in accordance with items (1) and (2) above
(4) If the concrete does not meet the Specifications after those 3 trucks, the Engineer will reduce their verification testing rate to once per truck for acceptance for the remainder of the pour

For concrete mixes 3U17A and 3U18, allow mix to hydrate 5 minutes before slump test to assure cement is saturated.

G.5 Concrete Strength

G.5.a Concrete Cylinder Requirements

The Contractor and Engineer will perform random sampling and testing in accordance with *ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete*; *ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field*; ASTM *C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*; and the *Schedule of Materials Control*.

Anyone performing concrete strength testing of cylinders is required to hold one of the following current certifications:

(1) ACI Concrete Strength Testing Technician Certification
(2) Department Strength Testing Technician Certification
(3) WisDOT Strength Testing Technician Certification

Anyone fabricating concrete cylinders or beams is required to hold either a current ACI Field 1 Technician Certification or a Department Field 1 Technician Certification.

G.5.b Standard Strength Cylinders

All standard strength cylinders have a minimum 28-Calendar Day compressive strength requirement unless modified elsewhere in the Contract.

The Engineer will perform the following for standard strength cylinders:

(1) Cast cylinders (sets of 3) for testing in accordance with the *Schedule of Materials Control* or as modified in the Contract
(2) Mark cylinders for identification of the represented unit or section of concrete in accordance with the following: (1.1, 1.2, 1.3/ 2.1, 2.2, 2.3/ 3.1, 3.2, etc.). In order to differentiate between portions of a Project, prefixes and suffixes are allowed
(3) Complete the Department Concrete Cylinder Identification Card including the results for air content, slump (if required), concrete, and air temperature testing from the same load

G.5.b(1) Curing Standard Strength Cylinders

Properly cure standard strength cylinders during each specified curing period in accordance with the following:

(1) Initial curing period as immediately after final finishing for a period of up to 48 hours
(2) Intermediate curing period as the time between specimen pickup from the initial curing site and delivery to the laboratory for final curing, Intermediate curing period is up to 7 Calendar Days from the day of casting. Cure the standard strength cylinders in the Contractor provided moist curing environment
(3) Final curing period as the time when cylinders are cured in the laboratory lasts a minimum of 21 Calendar Days

G.5.b(2) Moist Curing Environment

At least 24 hours before concrete placement, provide moist curing environment(s) of adequate size and number, including ancillary Equipment and Materials, necessary to maintain moist curing environment(s) in accordance with *ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field* and *2031*, “Field Office and Laboratory,” and the following:

For each separate moist curing environment:

(1) Provide a calibrated waterproof digital temperature recording device that records the daily maximum and minimum ambient temperatures for the previous 7 Calendar Days.
(2) During the initial curing period, maintain the standard strength cylinders or beams in an ambient temperature range from 60°F to 80°F.
(3) During the intermediate curing period, fully immerse the cylinders with lids in water maintained at a temperature from 60°F to 80°F.

The Engineer will monitor the daily temperatures of the curing environments. Department monitoring does not relieve the Contractor of the responsibility to maintain the water temperature as specified herein.

If the Contractor fails to comply with the requirements shown here-in, the Engineer may delay concrete placement and will consider any concrete incorporated into the Work as unauthorized in accordance with 1512.2, “Unauthorized Work.” The Engineer will consider any delays to the Contract resulting from unauthorized Work as non-excusable in accordance with 1806.2C, “Non-Excusable Delays.”

G.5.b(3) Transporting Cylinders

After the initial curing period, the Engineer will both transport and further cure the cylinders using intermediate curing or final curing conditions.

The Engineer will transport the cylinders from the initial curing site in accordance with the following:

(1) Transport all grades of concrete except mass concrete (Grade MC) a minimum of 16 hours after casting
(2) Transport mass concrete a minimum of at least 24 hours after casting
(3) Transport High-early strength concrete a minimum of at least 12 hours after casting
(4) With securely placed tight fitting plastic caps on plastic molds, or by other methods to prevent moisture loss
(5) Protect from jarring, bouncing, and freezing
(6) Not greater than 4 hours, unless cylinders are maintained in the moistened condition at ambient temperature of 60°F to 80°F

G.5.b(4) Testing Cylinders

The Engineer will perform compressive strength testing on the standard strength cylinders in accordance with *ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens* during the Departments normal laboratory operating hours. The Department will report the results in accordance with the *Laboratory Manual*.

G.5.c Field Control Strength Cylinders

The Engineer will use field control cylinders to determine when the sequence of construction operations is dependent upon the rate of concrete strength development. The Engineer will cast field control cylinders to determine when the concrete attains the required strength for desired field control limitations.

In lieu of field control cylinders, the Engineer will allow the Contractor to submit a strength-maturity relationship curve for use in accordance with 2461.3G.6, “Estimating Concrete Strength by the Maturity Method.”

The Engineer will perform the following for field control strength cylinders:

(1) Cast up to 3 field control cylinders per Structure; the Contractor is responsible for any additional field control cylinders
(2) Mark field control cylinders for identification of the represented unit or section of concrete in accordance with 2461.3G.5.b, “Standard Strength Cylinders,” Note (2)
(3) Complete the Department Concrete Cylinder Identification Card including the results for air content, slump (if required), concrete, and air temperature testing from the same load

G.5.c(1) Curing Field Control Cylinders

Cure field control concrete cylinders in the same location and under the same conditions as the concrete Structure or unit involved.

The Engineer will allow "Match Curing of Concrete Test Specimens" method in accordance with *AASHTO R72,* "Standard Practice for Match Curing of Concrete Test Specimens," modified as follows:

(1) Provide an apparatus that consist of a monitoring and heating system capable of maintaining concrete cylinders at a temperature no greater than 5°F above the temperature of the concrete at a specific location in the member. A satisfactory system to continually monitor the concrete temperatures may include a temperature sensor in the concrete Structure or unit involved, a controller, special insulated cylinder molds with built-in heating systems, and a temperature sensor in the molds.

(2) When the temperature exceeds 5°F or the temperature monitoring system fails, the Engineer will not accept field control cylinder results.

G.5.c(2) Testing Cylinders

The Engineer will perform compressive strength testing on the field control cylinders in accordance with *ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens* during the Departments normal laboratory operating hours.

If Project scheduling requires testing outside of the Department's laboratories normal operating hours or the Department's nearest laboratory is greater than 30 miles from the Project, provide certified and calibrated hydraulic cylinder-testing machine within 30 miles of the Project and at a location approved by the Engineer. Test the field control cylinders in the presence of the Engineer in accordance with *ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*.

G.5.d Strength Specimens for Concrete Paving

Use flexural beams to determine strength or provide cylinders approved by the Engineer.

Cast standard beams or cylinders for testing at 28 Calendar Days.

Cast a sufficient number of field control beams or field control cylinders to determine when the concrete attains the required strength for desired control limitations.

Cure the standard beams or cylinders in accordance with 2461.3G.5.b(1), "Curing Standard Strength Cylinders," and 2461.3G.5.b(2), "Moist Curing Environment," except standard beams are cured in intermediate curing conditions until broken at 28 Calendar Days.

Cure the field control beams or cylinders in the same location and under the same conditions as the concrete pavement.

The Engineer will test the flexural beams and record the results on Form 2162, *Concrete Test Beam Data*.

If using cylinders, the Engineer will submit cylinders and a completed identification card to the Department's laboratory.

G.5.e Concrete Compressive Strength

For purposes of the Work in section 2461.3G.5, "Concrete Strength," the Department defines a strength test as the average strength of 3 cylinders fabricated from a single sample of concrete and cured in accordance with 2461.3G.5.b, "Standard Strength Cylinders."

The maximum allowable range between the individual cylinders in a strength test is 350 psi. The Department will remove all individual cylinder strengths that are more than 350 psi below the highest individual cylinder strength and recalculate the strength.

The Engineer will review standard strength test results for acceptance in accordance with Table 2461.3-2 and 2461.5A.2, "Concrete Strength Non-Conforming Material."

Table 2461.3-2
Acceptance Criteria for Standard 28-Calendar Day Cylinders

	Single Strength Tests	**Moving average of 3 consecutive strength tests***
f'c ≤ 5000 psi	> (f'c – 500 psi)	≥ f'c
f'c > 5000 psi	> 0.90 * f'c	≥ f'c
* If a Project does not establish a moving average of 3 consecutive strength tests, use the average of 2 strength tests to determine acceptance. If there is only a single strength test, contact the Concrete Engineer for recommendation.		

G.6 Estimating Concrete Strength by the Maturity Method

The Engineer will allow the maturity method to determine development of concrete strength to open to traffic loading or form removal. Use of this method requires the establishment of a relationship between concrete strength and the computed maturity index (using the Nurse-Saul method) for a specific concrete mixture. Use this method, in accordance with this Specification and the "Estimating Concrete Strength by the Maturity Method" procedure available from the MnDOT Concrete Engineering website to estimate the in-place strength of the concrete.

G.6.a Development of Strength-Maturity Relationship

The Engineer will allow development of the maturity curve in a laboratory, at the concrete plant, or at the Project Site.

Determine the strength development criteria based on the type of concrete in accordance with the following:

(1) For concrete pavement: 2301.3O, "Opening Pavement to Traffic"
(2) For concrete pavement repairs: 2302.3C.4, "Opening to Construction Equipment and Traffic"
(3) For concrete Structures: 2401.3G, "Concrete Curing and Protection"

(4) For Sidewalks, driveway entrances, and curb and gutter, a minimum of 3000 psi is required

Until an acceptable strength-maturity relationship (maturity curve) is established and approved by the Engineer, use concrete beams or cylinders to open to traffic loading or form removal.

G.6.a(1) Procedure

Develop the strength-maturity relationship (maturity curve) to estimate concrete strength in accordance the "Estimating Concrete Strength by the Maturity Method" procedure available from the MnDOT Concrete Engineering Website and the following:

(1) Cast and cure 12 beams or 15 cylinders, plus 2 additional beams or cylinders to embed temperature sensors.
(2) Establish the maturity curve using the Concrete Maturity-Strength Development form.
(3) Test three (3) strength specimens at testing ages specified in Table 2461.3-3 for the type of concrete Work.

Table 2461.3-3
Chronological Testing Ages of Strength Specimens

Type of Concrete	Testing Ages*
Concrete Pavement as defined in 2301, "Concrete Pavement"	Test at least 2 sets of strength specimens before and the remaining sets after the anticipated opening strength
Normal Strength Concrete as defined in 2461, "Structural Concrete"	1, 2, 3, 7 and 28 Calendar Days
High-early (HE) Concrete as defined in 2461, "Structural Concrete"	12 hours, 1, 2, 7 and 28 Calendar Days
Ultra High-early (UHE) Concrete as defined in 2302, Concrete Pavement Rehabilitation"	3, 4 and 8 hours, 1 and 14 Calendar Days
* The Contractor may adjust the testing ages if approved by the Engineer, in conjunction with the Concrete Engineer.	

G.6.a(2) Equipment

Provide the following Equipment for determining the maturity:

(1) Maturity meter or temperature sensor and data logger with a secure means of collecting, measuring, recording, and storing temperature data that is unalterable
(2) Beam or cylinder molds for development of the maturity curve and other concrete making and testing Equipment

G.6.a(3) Estimating In-Place Strength Using Maturity

Place concrete maturity meters or temperature sensors within the concrete in accordance with Table 2461.3-4.

Table 2461.3-4
Maturity Meter or Temperature Sensor Placement and Frequency

Maturity Application	Placement	Frequency
Concrete Paving	Embed at approximately mid-depth and approximately 18 (but no less than 12) inches from the edge of the pavement.	Place one for each day within the last hour of placement. Place additional sensors as necessary.
Full Depth Concrete Pavement Repairs	Embed at approximately mid-depth and approximately 18 (but no less than 12) inches from the edge of the pavement.	Place one for each day within the last hour of placement. Place additional sensors as necessary.
Partial Depth Concrete Repairs	Embed at least 2 inches from the surface.	Place one for each day within the last hour of placement. Place additional sensors as necessary.
Sidewalk, Driveway Entrances, Curb and Gutter	Embed at approximately mid-depth and approximately 18 (but no less than 12) inches from the edge of the pavement.	Place one for each day within the last hour of placement. Place additional sensors as necessary.
Concrete Structures	Attach to the reinforcing steel near the edge of the exposed surface using a non-metallic fastener.	Place at least 2 for each concrete element.

The computed maturity results from each sensor will only apply to concrete placed under the following conditions:

(1) The same mix designation and the same Project as the test location
(2) Placed on the same day and on, before, or within 50 feet after placement of the sensor
(3) Cured under conditions similar to those of the test location

Record the maturity index (or temperature readings and calculate the maturity index) on the Maturity-Field Data form or as approved by the Concrete Engineer.

G.6.b Opening to Traffic Loading or Form Removal

Prior to opening the concrete to traffic loading or removal of the forms, submit the maturity index results to the Engineer. The Engineer will review and verify the maturity index has reached the required TTF of the maturity curve developed for that concrete mix.

G.6.c Validation of Strength-Maturity Relationship for Continued Use

When utilizing the maturity method on the Project, perform a strength-maturity test for each mix used to ensure the concrete strength correlates with the current maturity-strength relationship (maturity curve) as follows:

(1) Notify the Engineer at least 24 hours in advance of the specimen casting for the validation testing.
(2) The Contractor or their Representative is responsible for casting, curing, and testing three (3) beams or cylinders plus one additional beam or cylinder to embed the sensor. Cast the validation specimens at the concrete plant or at the Project Site.

(a) If the maturity curve was initially developed in a laboratory, perform a validation strength-maturity test on the first day of concrete placement.

(b) For slipform concrete paving utilizing a dedicated portable batching plant, perform a validation strength-maturity test once every 15 Calendar Days during plant production.

(c) For all other concrete, if the maturity curve was developed greater than 30 Calendar Days before the start of construction or has not been validated for 30 Calendar Days, perform a validation strength-maturity test on the first day of concrete placement. The Concrete Engineer will allow a single validation strength-maturity test fabricated at the concrete plant to validate a maturity curve used on multiple Projects. Validation strength-maturity tests fabricated at the Project Site only validate the maturity curve for that Project.

(3) The Contractor or representative is responsible for providing the curing environment for the specimens in accordance with the "Estimating Concrete Strength by the Maturity Method" procedure available from the MnDOT Concrete Engineering website.

(4) Perform the validation testing as close as practically possible to the maturity value determined to represent the opening, loading or form removal strength criteria. Record the results of the tests on the Concrete Maturity-Strength Validation form and provide to the Engineer within 24 hours of the test completion.

(5) If a specimen is obviously defective (i.e., out of round, not square, damaged due to handling), discard the specimen. If an individual specimen is greater than 10 percent for cylinders or 15 percent for beams outside the average of three specimens, consider the specimen defective and discard. When two of the specimens are defective, evaluate a new batch, unless additional acceptable specimens are available.

The Engineer may direct additional validation testing as necessary.

The Engineer will review the validation strength-maturity test results and determine if the validation testing confirms the maturity curve in accordance with Table 2461.3-5.

Table 2461.3-5
Evaluation of Validation Strength-Maturity Test Results

If the validation strength-maturity test falls:	Result	Action
Within the 10 percent limits of the maturity curve	Maturity curve validated	Continue using the current maturity curve
> 10 percent higher than the maturity curve	The Engineer will not consider the maturity curve validated, but will continue to allow use of the maturity curve	Develop a new maturity curve at the discretion of the Contractor
> 10 percent lower than the maturity curve	The maturity curve will no longer be acceptable	1. Develop a new maturity curve 2. Engineer will not allow the maturity method for that concrete mix until a new maturity curve is developed

G.6.d Changes in Concrete Mixture

Perform a validation strength-maturity test in accordance with 2461.3.G.6.c, "Validation of Strength-Maturity Relationship for Continued Use," if any of the following changes occur:

(1) Change in mixture proportions greater than 5 percent by weight
(2) Increase in the water-cementitious Materials ratio by more than 0.02
(3) Change in the cementitious source
(4) Change in the class of coarse Aggregate Material

Evaluate validation strength-maturity test results in accordance with Table 2461.3-5.

G.6.e Maturity Meter Calibration

Calibrate maturity meters yearly to ensure proper operation and temperature sensing in accordance with the "Estimating Concrete Strength by the Maturity Method" procedure available from the MnDOT Concrete Engineering website.

G.7 Consistency

Place concrete meeting the slump requirements in the Work.

The Contractor and Engineer will perform random sampling and testing in accordance with the *Concrete Manual* and determine testing rates meeting the requirements of the *Schedule of Materials Control*.

The Engineer will test the concrete for consistency using the slump test during the progress of the Work. The Engineer may reject concrete batches with consistencies outside of the slump range limits in Table 2461.2-5, Table 2461.2-6 and Table 2461.2-7.

If any test shows the slump outside of the slump range requirements, the Engineer will reject the concrete represented by that test. In order to bring the mixture back into the slump range requirements, the Engineer will allow adjustments to the concrete in accordance with 2461.3G.3, "Delivery Requirements" and 2461.3G.4, "Field Adjustments."

Adjust the slump not to exceed the slump range allowed to optimize both placement and finishing. Contact the Engineer if encountering unusual placement conditions that render the maximum slump unsuitable.

G.7.a Concrete Placed by the Slip-Form Method

Place concrete that does not slough and is adequately consolidated at a slump value that optimizes placement for the designated mixture and in accordance with 2461.3G.4, "Field Adjustments."

G.8 Air Content

Place Type 3 concrete meeting the air content requirements in the Work.

The Contractor and Engineer will perform random sampling and testing in accordance with the *Concrete Manual* and determine testing rates meeting the requirements of the *Schedule of Materials Control*.

Maintain the air content of Type 3 general concrete at the specified target of 6.5 percent (+2.0 percent and −1.5 percent) of the measured volume of the plastic concrete in accordance with 1503, "Conformity with Contract Documents," unless otherwise modified in the Contract. Maintain the air content of Type 3A Grout at the specified target of 10.0 percent (-2.0 percent and no maximum).

Measure the air content at the point of placement but before consolidation.

Make any adjustments immediately to maintain the desired air content.

G.9 Allowable Testing Tolerances

Allowable tolerances are based on the results from two different testers and two different pieces of Equipment from the same sample. Perform the test within the allowable tolerances in accordance with Table 2461.3-6.

Table 2461.3-6
Allowable Testing Tolerances

Test	Allowable Tolerance
Air content, percent volume of concrete	1.0 percent
Average slump < 4 inches	1.0 inch
Average slump 4 inches – 6 inches	1.5 inches
Average slump > 6 inches	2.0 inches
Unit weight, per cubic foot, calculated to an air-free basis	1.0 pound/cubic foot
Compressive strength 3,000 psi – 8,000 psi, average of 3 tests	500 psi

2461.4 METHOD OF MEASUREMENT

The Engineer will measure fresh concrete produced as required by the Contract by the theoretical volume.

The Engineer will deduct accountable waste from the concrete measurement.

The Engineer will measure concrete mixtures on the basis of the dimensions of the Structure shown on the Plans. If the Plans do not include a Contract Item for concrete used in miscellaneous items, include the cost of the concrete with the relevant Contract Items.

2461.5 BASIS OF PAYMENT

The Department will include the cost of the Certified Ready-mix Plant Program with other relevant Contract Items.

The Contract cubic yard price for Concrete Mix No. ___ includes the cost of production, placement, finishing, curing, and protection of concrete.

A Monetary Deductions

The Department must apply Incentives and Disincentives and may apply monetary deductions for Structural Concrete. The amounts of these adjustments are deemed reasonable.

A.1 Certified Ready-mix Concrete, Acceptance of Concrete Materials

Only place concrete meeting the Materials requirements in the Work. If the Contractor places concrete not meeting the Materials requirements into the Work, the Engineer will not accept non-conforming concrete at the Contract Unit Price.

A.1.a Aggregate Gradation (Does not apply to Job Mix Formulas)

The Engineer will base Material acceptance on individual and moving average test results in accordance with Table 2461.5-1 and the following:

(1) If the gradation tests on split samples from Quality Control or verification samples result in a variation between the Producer and the Engineer greater than that set forth in Table 2461.5-3, the

Engineer will substitute QA and/or verification test results into the moving average calculation to determine acceptance.

(2) If Producer test results are consistently coarser or finer than Engineer test results, the Engineer will review in accordance with 1503, “Conformity with Contract Documents.”

(3) The Engineer will determine the monetary deduction due to the moving average gradation failure.

(a) Calculate the quantity of non-complying concrete placed, beginning with the first individual gradation test within the moving average failure and ending with the first passing individual gradation test after the moving average failure.

(b) Based on the total quantity of non-compliant concrete placed, the Engineer will apply the monetary deductions outlined in Table 2461.5-2.

(c) If a moving average failure occurs on multiple Sieves, the Engineer will only reduce the price based on a single monetary deduction.

Table 2461.5-1
Acceptance Criteria for Aggregate Gradations

	Contractor Action	
	Within Gradation Limits of 3126, “Fine Aggregate for Portland Cement Concrete” or 3137, “Coarse Aggregate for Portland Cement Concrete”	**Outside of Gradation Limits in 3126, “Fine Aggregate for Portland Cement Concrete” or 3137, “Coarse Aggregate for Portland Cement Concrete.”**
Individual gradation test	Continue testing as required	(1) Immediately take second gradation (a) If second gradation passes, resume testing as required (b) If second gradation fails, stop production and contact Engineer (2) Resume production when corrective action results in a passing gradation and continue testing as required ‖
Moving average of 4 consecutive tests*	Continue testing as required	(1) Stop production and contact Engineer (2) Determine the cause of continual borderline or failing Material (3) Resume production when corrective action results in a passing gradation (4) Increase gradation testing at a rate of 1 per 100 cubic yards until the moving average is within the gradation limits

* If any Aggregate size or source does not establish a moving average of 4 consecutive tests, use the average of tests taken to determine acceptance.
‖ The Engineer may increase the testing rates if gradation issues persist.

Table 2461.5-2
Moving Average Gradation of Specification Sieves

Total Concrete Quantity Cubic Yards	Lump Sum Monetary Deduction
0 to 8	$125.00
> 8 to 15	$250.00
> 15 to 20	$375.00
> 20	$500.00 or $5.00 per cubic yard, whichever is greater

A.1.b Lab Field Tolerance

If the gradation tests on split samples from Quality Control or verification samples result in a variation between the Producer and the Engineer greater than that set forth in Table 2461.5-3, the parties shall follow the procedures for test result dispute resolution available from the *Laboratory Manual*.

Table 2461.5-3
Allowable Variations on Percent Passing Sieves

Sieve Size	Allowed Percentage
2 inches – 1 inch	± 8
3/4 inch – 3/8 inch	± 6
No. 4 – No. 30	± 4
No. 50	± 3
No. 100	± 2
No. 200	± 0.6

A.1.c Coarse Aggregate Quality

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted Contract Unit Prices for coarse Aggregate quality failures in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

A.1.d Cementitious Materials

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted Contract Unit Prices for cementitious failures in accordance with 1512, "Unacceptable and Unauthorized Work."

A.1.e Admixtures

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted Contract Unit Prices for admixture failures in accordance with 1512, "Unacceptable and Unauthorized Work."

A.2 Concrete Strength Non-Conforming Material

If the Contractor places concrete not meeting the strength requirements of 2461.3G.5.e, "Concrete Compressive Strength," into the Work, the Engineer may not accept nonconforming concrete at the Contract Unit Price. The Engineer will evaluate non-conforming strength results in accordance with the following:

A.2.a Strength Test ≤ 500 psi Below f'c

If any strength test result shows a strength ≤ 500 psi below f'c and is not deficient due to erroneous/invalid strength tests as defined in 2461.5A.2.d, "Moving Average Below f'c," no additional investigation will occur and the Engineer will include the low strength test result in the moving average.

A.2.b Strength Test > 500 psi Below f'c

If any strength test result shows a strength > 500 psi below f'c and is not deficient due to erroneous/invalid strength tests as defined in 2461.5A.2.d, "Moving Average Below f'c," the Engineer, in conjunction with the Concrete Engineer, will investigate to determine if the concrete has attained the critical load-carrying capacity.

The investigation may consist of, but is not limited to reviewing the following:

(1) Sampling and testing plastic concrete
(2) Handling of cylinders
(3) Cylinder curing procedures
(4) Compressive strength testing procedures
(5) Certificates of Compliance
(6) Evaluation using Rebound Hammer (*ASTM C805, Standard Test Method for Rebound Number of Hardened Concrete*), Penetration Resistance (*ASTM C803, Standard Test Method for Penetration Resistance of Hardened Concrete*), or other method approved by the Concrete Engineer
(7) Review of the design calculations for the concrete in question

If it is determined that the concrete represented by the standard strength test has attained the critical load carrying capacity, the Engineer will include the strength test in the moving average calculation.

If it is determined that the concrete has not attained the critical load carrying capacity, the Engineer will direct the Contractor to remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." The Contractor may dispute the remove and replace order within 7 Calendar Days of written notification by the Engineer. If the Contractor disputes the order, follow the dispute resolution coring procedure in accordance with 2461.5A.2.c, "Dispute Resolution Coring for Strength Test Failure."

A.2.c Dispute Resolution Coring for a Strength Test Failure

The Engineer and Contractor will mutually agree on an independent third-party to core and test the concrete in accordance with *ASTM C42, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete"* and the following:

(1) The Engineer will identify a minimum of 3 locations for the independent third-party to core.
(2) The independent third-party will take 1 core at each location.
(3) The independent third-party will complete coring within 14 Calendar Days of notification of the low strength concrete.
(4) The Contractor is responsible for ensuring the core holes are repaired.

The Engineer, in conjunction with the Concrete Engineer, will review the core test results and evaluate in accordance with Table 2461.5-4, providing other concrete tests meet requirements.

Table 2461.5-4
Evaluation of Core Test Results

Core (average of 3 cores) Test Results	Engineer considers concrete	Cost of Coring and Testing	Resolution
≥ 85 percent of f’c and no individual core is < 75 percent of f’c	Acceptable to remain in place	Department	No monetary deduction for single strength test failure.
< 85 percent of f’c	Unacceptable	Contractor	Remove and replace concrete in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work,” as directed by the Engineer, in conjunction with the Concrete Engineer.

A.2.d Moving Average Below f’c

If the moving average of 3 consecutive strength tests is less than the required f’c, the Concrete Engineer will review the strength test results and determine if a new mix design is required in accordance with Table 2461.2-6 or Table 2461.2-7.

The Concrete Engineer in conjunction with the Engineer will remove any strength test results from the moving average if the following occurs:

(1) After investigation, the cause for the deficient concrete strength is due to improper handling, curing, or testing of the cylinder
(2) Cylinders kept in the filed longer than 7 Calendar Days that negatively impact the moving average calculation
(3) The suspect concrete was removed and replaced
(4) Dispute resolution coring identified the concrete acceptable to remain in-place

For the quantity of non-conforming concrete not meeting the moving average of 3 consecutive strength tests, the Engineer will make determinations regarding the disposition, payment, or removal of the concrete in accordance with Table 2461.5-5.

Table 2461.5-5
All Concrete Grades

Moving average of 3 consecutive strength tests	Monetary Deductions for Moving Average Failure *
> 98.0 percent of f'c	No deductions for the Materials placed as approved by the Engineer.
93.0 percent to 98 percent of f'c	$20.00 per cubic yard or 10 percent of the Contractor-provided invoice for quantity represented by test that brought moving average into non-conformance.
≥ 87.5 percent and ≤ 93.0 percent of f'c	$50.00 per cubic yard or 25 percent of the Contractor-provided invoice for quantity represented by test that brought moving average into non-conformance.
< 87.5 percent of f'c	Remove and replace concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work," as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in-place, the Engineer will adjust the concrete at a reduction of $100.00 per cubic yard or 50 percent of the Contractor-provided invoice for quantity represented by test that brought moving average into non-conformance.

A.3 Consistency, Non-conforming Material

If the Contractor places concrete not meeting the slump requirements into the Work, the Engineer will not accept non-conforming concrete at the Contract Unit Price.

For the quantity of non-conforming concrete not meeting the required slump, the Engineer will make determinations regarding the disposition, payment, or removal of the concrete in accordance with Table 2461.5-6 and Table 2461.5-7.

Table 2461.5-6
All Concrete Grades > 1 inch slump

Outside of Slump Range	Monetary Deduction
Below slump range *	No deduction for Materials placed as approved by the Engineer
≤ 1 1/2 inches above slump range	$20.00 per cubic yard or 10 percent of the Contractor-provided invoice for quantity represented by the Materials placed
> 1 1/2 inches above slump range	$50.00 per cubic yard or 25 percent of the Contractor-provided invoice for quantity represented by the Materials placed
* The Engineer will not reduce Contract Unit Price for low slump concrete placed with the slip-form method as approved by the Engineer.	

Table 2461.5-7
Low Slump Concrete from 1/2 inch to 1 inch

Outside of Slump Range	Monetary Deduction
Below slump range *	No deduction for Materials placed as approved by the Engineer
≤ 1/2 inches above slump range	$20.00 per cubic yard or 10 percent of the Contractor-provided invoice for quantity represented by the Materials placed
≥ 3/4 inches above slump range	$50.00 per cubic yard or 25 percent of the Contractor-provided invoice for quantity represented by the Materials placed
*The Engineer will not reduce Contract Unit Price for low slump concrete placed with the slip-form method as approved by the Engineer.	

A.4 Air Content, Non-conforming Material

If the Contractor places Type 3 concrete not meeting the air content requirements into the Work, the Engineer will not accept non-conforming concrete at the Contract Unit Price.

For the quantity of non-conforming concrete not meeting the required air content, the Engineer will make determinations regarding the disposition, payment, or removal in accordance with Table 2461.5-8.

Table 2461.5-8
All Concrete (Target Air Content 6.5 percent)

Air Content percent	Monetary Deduction
> 10.0	$50.00 per cubic yard or 25 percent of the Contractor-provided invoice for quantity represented by the Materials placed.
>8.5 – 10.0	$20.00 per cubic yard or 10 percent of the Contractor-provided invoice for quantity represented by the Materials placed.
5.0 – 8.5	The Engineer will pay 100 percent of the Contract Unit Price for the concrete represented, for Material placed as approved by the Engineer.
>4.0 – <5.0	$50.00 per cubic yard or 25 percent of the Contractor-provided invoice for quantity represented by the Materials placed.
>3.5 – ≤4.0	The Engineer, in conjunction with the Concrete Engineer will determine the concrete suitability for the intended use in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” This may include testing on the hardened concrete as required by the Engineer, in conjunction with the Concrete Engineer.
≤ 3.5	Remove and replace concrete in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work,” as directed by the Engineer. This may include testing on the hardened concrete as required by the Engineer, in conjunction with the Concrete Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in-place, the Engineer may not pay for the concrete and may require coating with an approved epoxy penetrant sealer from the *Approved/Qualified Products List*.

B Schedule

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

Item No.	Item	Unit
2461.507	Concrete Mix No ___	cubic yard

2462 PRECAST CONCRETE

2462.1 DESCRIPTION

This Work consists of producing, providing, placing, curing, and protecting precast Portland cement concrete in Structures, pavements, and Incidental construction.

2462.2 MATERIALS

A Cementitious Materials

Provide cementitious Materials from certified sources listed on the *Approved/Qualified Products List*.

Use Type I, I/II, IS, IL, IP, or Type III cement to produce Type 1 non-air-entrained concrete.

Use Type I, I/II, IS, IL, IP, or Type III cement and an air-entraining admixture listed on the *Approved/Qualified Products List* to produce Type 3 air-entrained concrete.

A.1 Portland cement **3101**

A.2 Slag cement **3102**

A.3 Blended Hydraulic cement **3103**

A.4 Fly Ash **3115**

A.5 Ternary Mixes

Ternary mixes are identified as Portland cement or Type IL and two other supplementary cementitious Materials, Type IT blended cement, or blended cement (excluding IT) and one other supplementary cementitious Material.

B Aggregates

Provide Aggregates from sources listed on the Department *Concrete Aggregate Properties* list.

B.1 Fine Aggregate **3126**

B.2 Intermediate Aggregate **3131**

B.3 Coarse Aggregate **3137**

C Water 3906

D Concrete Admixtures 3113

Provide admixtures from the *Approved/Qualified Products List* for concrete grades shown in Table 2462.2-4.

D.1 Allowable Admixtures

Use of any of the following admixtures are at the precaster's discretion:

(1) Type A, Water-reducing Admixture
(2) Type B, Retarding Admixture
(3) Type D, Water-Reducing and Retarding Admixture
(4) Type F, High Range Water-reducing Admixture
(5) Type G, High Range Water-reducing and Retarding Admixture
(6) Type S, Specific Performance Based Admixture

D.2 Use of Accelerating Admixtures

The Materials Engineer may permit the use of Type C or Type E accelerating admixtures when the following conditions exist:

(1) The ambient temperature is below 36°F
(2) An Engineer approved cold weather protection Plan is in-place
(3) Cold weather protection Materials are on-site and ready for use

E Precast Concrete Mix Designs

E.1 Classification of Concrete

The Department will classify concrete by mix number to identify type, grade, consistency, Aggregate size, coarse Aggregate class and supplementary cementitious Material, if any, in accordance with Table 2462.2-1.

Table 2462.2-1
Mix Number Identification

First Digit	Second Digit	Third Digit	Fourth Digit	Additional Digits
Type Designation	Grade Designation	Maximum Slump	Coarse Aggregate Gradation Designation	Additional Digits Allowed or as Specified

E.1.a Type Designation

Provide Type 1 or Type 3 concrete in accordance with Table 2462.2-2:

Table 2462.2-2
Concrete Type Designation

Concrete Type	Target Air Content*, percent
1	2.0
3	6.5
* For concrete mix design purposes only.	

E.1.b Grade Designation

The Department will designate concrete grade in accordance with Table 2462.2-4 using a letter to represent the following:

(1) Intended use
(2) Maximum Water/Cement (W/C) Ratio
(3) Cementitious content range
(4) Maximum supplementary cementitious substitution (SCM)
(5) Slump range
(6) Minimum 28-Calendar Day compressive strength, f’c
(7) Coarse Aggregate quality in accordance with 3137, “Coarse Aggregate for Portland Cement Concrete”

E.1.c Slump Designation

The Department will designate the slump range as defined by the grade designation in accordance with Table 2462.2-4.

E.1.d Coarse Aggregate (CA) Designation

Determine the coarse Aggregate designation in accordance with Table 2462.2-3 based on the intended use and the gradation requirements in 3137, "Coarse Aggregate for Portland Cement Concrete."

Table 2462.2-3
Coarse Aggregate Designation for Concrete

Designation	Coarse Aggregate Gradation
1	2301, "Concrete Pavement," only
2	#67*
3	#7*
4	#89*
7	CA-70
8	CA-80
X	No gradation required
* Gradation sizes designated per *ASTM C33/C33M, Standard Specification for Concrete Aggregates*, Table 3.	

E.1.e Additional Concrete Mix Designation Digits

Specialty concrete mixes require additional concrete digits in accordance with Table 2462.2-4. The precaster may add additional digits to the right of the required digits in the concrete mix number.

E.2 Concrete Mix Design Requirements

The precaster assumes full responsibility for the mix design and performance of the concrete. The Department defines the concrete mix design requirements for precast designed mixes in accordance with Table 2462.2-4. When specified, precast Bridge deck, precast pavement panels, and any other special precast product requirements are included in the Special Provisions of the Contract.

Table 2462.2-4
Precast Concrete Mix Design Requirements

Concrete Grade	Mix Number*	Intended Use‖	Maximum W/C/ Ratio	Cementitious Content (pounds/ cubic yard)	Maximum percent SCM (Fly Ash/ Slag/ Ternary)	Slump Range‡	Minimum 28-Calendar Day Compressive Strength, f'c #	3137, "Coarse Aggregate for Portland Cement Concrete"
M	3M82	Precast concrete barrier	0.45	530 – 750	30/35/40	1 – 8 inches	4500 psi	2.D.1
V	3V82	Wetcast retaining wall blocks, noisewall panels, Equipment pad	0.45	605 - 850	30/35/40	1 – 8 inches	4000 psi	2.D.1
W	1W82	Bridge girders	0.42	660 – 850	30/35/40	1 – 8 inches	Design Strength Per Plan §	2.D.1
	3W82	Noisewall posts, box Culverts, Bridge girders†	0.42	660 - 850	30/35/40	1 – 8 inches	Design Strength Per Plan §	2.D.1
	3W8X	Pipe, manholes, inverts	0.45	470+	30/35/40	1 – 8 inches	Design Strength Per Plan §	2.D.1
Z	3Z82	Thin panel retaining walls	0.45	605 - 850	30/35/40	1 – 8 inches	4000 psi	2.D.2

* Unless otherwise modified in the Contract.
‖ If the intended use is not included elsewhere in the Specification or Special Provisions, design concrete mix 3W82.
† Review the Plans to determine if the Bridge girders require air entrainment.
‡ Flowable slumps exceeding the designated slump range require approval of the Materials Engineer.
# Requires strength cylinders in accordance with 2462.3G.4, "Test Methods and Specimens," for determining shipping strength.
§ If design strength is not indicated in Plan, minimum 28-Calendar Day compressive strength is 5700 psi for 1W82 and 5000 psi for 3W82 and 3W8X.

E.3 Precast Submittal Requirements

At least 21 Calendar Days before initial placement of the concrete, submit a Precast Mix Design Submittal to the Concrete Engineer for approval. Use the most current *Precast mix design submittal* available from the Concrete Engineering website.

Design the concrete mix to an absolute volume of 27.00 – 27.27 cubic foot.

The Concrete Engineer will:

(1) Provide specific gravity and absorption data using saturated surface dry (SSD) weights for mix design calculations.

(2) Review the mix design submittal and approve the Materials and mix design for compliance with the Specifications.

E.4 Precast Mix Design Adjustments

The Department will allow mix design adjustments based upon the criteria as defined in Table 2462.2-5:

Table 2462.2-5
Mix Design Adjustments Requirements

Type of Change or Adjustment	Mix Design Approval Resubmittal Requirements
Admixture Dosage Rate Cement or SCM sources	No Resubmittal Required
Admixture Source Aggregate Source Any Cementitious or SCM Proportion Aggregate Proportions	Resubmittal of Mix Design

2462.3 CONSTRUCTION REQUIREMENTS

A Batching Equipment

A.1 Mixer Requirements

Provide stationary mixers or truck mixers.

A.2 General Condition

Maintain mixers as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examine to detect wear of blades.

Replace or recondition pickup and throwover blades in mixers with a rated capacity less than 14 cubic feet showing a blade wear loss of greater than 1/2 inch, and pickup and throwover blades in mixers of greater capacity, showing a blade wear loss of no greater than 3/4 inch from the original factory dimensions.

A.3 Manufacturer's Rating Plate

Provide mixers that include the manufacturer's rating plate, showing the following information:

(1) Serial number of the unit
(2) Mixing speed of the drum or paddles
(3) Maximum capacity in terms of volume of mixed concrete

A.4 Drum Speed for Stationary Mixers

Operate the drum speed in the mixer as specified by the manufacturer or as directed by the Materials Engineer.

A.5 Auxiliary Equipment Requirements

Provide mixers equipped with the following:

(1) Timing device
(2) Discharge locking device
(3) Water measuring device that operates mechanically and automatically during each batching cycle
(4) A graduated adjustable indicator device to represent the volume of discharge in increments no greater than 1/4 gallon in full view

A.6 Mixer Capacity

Do not exceed the manufacturer's rated capacity of the mixer when mixing a single batch of concrete.

Batch concrete in volumes the mixer can accommodate without spilling, leaking, or segregating during the charging, mixing, or discharging operations. Provide mixers with a capacity of at least 1 cubic yard.

A.7 Mixing Time

For the purpose of the Work specified in section 2462.3A.7, "Mixing Time," the Department defines the mixing time as the time period beginning when the cement and aggregates enter the mixer drum and ending when the discharge begins.

Refer to the manufacturer's recommended minimum mixing time for single drum and dual drum mixers. In the absence of manufacturer's recommendation, the Materials Engineer will designate the minimum mixing time. The minimum mixing time for any concrete batch is 60 seconds. The precaster may reduce the manufacturer's recommended minimum mixing time or the Materials Engineer designated mixing time if the precaster obtains uniform mixing in accordance with 2462.3E, "Mixing Requirements," and as approved by the Materials Engineer, in conjunction with the Concrete Engineer.

If there is evidence of inadequately mixed concrete (unmixed or partially mixed Materials) during concrete placement, the Materials Engineer may direct an increase in the mixing time.

A.8 Turbine Type Mixers

Provide turbine type mixers meeting the applicable requirements for conventional type mixers in accordance with 2462.3A.1, "Mixer Requirements," through 2462.3A.7, "Mixing Time," and this subsection. Maintain the mixer drum in a cylindrical shape within 3/4 inch from the original factory dimensions at any point. Maintain the mixer discharge gate in a mortar tight condition in the closed position. Replace or recondition mixer paddles showing a wear loss greater than 1/2 inch from the original factory dimensions.

Add the mixing water to the batch Materials in a manner that distributes the water to the inner or central areas of the drum. Start the flow of water before introducing the solid batch Materials into the mixer drum.

During mixing, operate the paddles at a speed between 20 revolutions and 30 revolutions per minute. After adding the batch Materials to the drum, mix the concrete for an additional 60 seconds.

A.9 Horizontal Axial-Revolving Blade Type Mixers

Provide horizontal axial-revolving blade type mixers in accordance with the applicable requirements for conventional type mixers in accordance with 2462.3A.1, "Mixer Requirements," through 2462.3A.7, "Mixing Time," and this subsection.

Test the concrete uniformity as directed by the Materials Engineer. The Materials Engineer will use concrete uniformity tests to determine the minimum mixing time.

A.10 Counter-Current Pan Type Mixers

Provide counter-current pan type mixers in accordance with Industry Standards and the applicable requirements for conventional type mixers in accordance with 2462.3A.6, "Mixer Capacity," through 2462.3A.7, "Mixing Time." The counter-current pan type mixer must have stationary side wall scrapers, a primary mixing motor, and a secondary mixing plow. Completely clean the pan of concrete before proceeding with the next batch. Maintain the pan and all working parts of the counter to current manufacturer's recommended tolerances.

Test the concrete uniformity as directed by the Materials Engineer. The Materials Engineer will use concrete uniformity tests to determine the minimum mixing time.

B Transportation Units

B.1 General Requirements

Equip transportation units intended for both mixing and agitating with watertight revolving drums mounted and powered and fitted with properly designed mixing blades in accordance with 2462.3A.1, "Mixer Requirements," through 2462.3A.7, "Mixing Time." Provide units capable of combining the ingredients into a homogeneous mixture and designed to provide two drum speeds, one for mixing and the other for agitating. Provide units capable of delivering the concrete without segregation or loss of any of the batch Materials.

Equip the mixer drum with a working counting device to record the number of revolutions.

Equip dump trucks and agitator trucks with vibrators to aid in discharge, are mortar tight, capable of complete discharge of the concrete.

B.2 Capacity of Transportation Units

Refer to the truck mixer manufacturer's certification plate attached to the unit for the maximum capacity of the unit. If the unit will not satisfactorily mix the maximum volume shown, reduce the batch volume to allow proper mixing or discontinue use of the mixing unit as directed by the Materials Engineer until the problem is corrected.

C Handling and Storing Materials

C.1 Batch Material Requirements

Do not change the source, kind, or gradation of batch Materials after the start of concrete production for the Work unless otherwise approved by the Materials Engineer. If the Materials Engineer approves use of different Material, completely exhaust the supply on hand before changing to the different Material.

If delivering freshly washed Aggregates to the batching plant, drain the Aggregates before using in the batching operation. If draining freshly washed Aggregates at the site of the batching plant, completely separate the drained Material from the undrained Materials, and provide for the disposal of water that accumulates from the drainage of Materials. Drain any excess water from the Aggregate hoppers before batching concrete.

Provide smooth, firm, and well-drained stockpile sites cleared of vegetable and extraneous matter. Where the natural foundation is unsatisfactory, as determined by the Materials Engineer, construct the stockpiles on suitable platforms. Construct suitable bulkheads or partitions to separate different kinds of Aggregate, gradation, or water content.

Construct stockpiles by methods that hold segregation and degradation to a minimum. If the Materials Engineer sees segregation or degradation, the Materials Engineer may designate that pile as unacceptable for use.

Do not use Aggregates used to construct runways for loading or hauling Equipment in concrete batches.

Use of Aggregates from the bottom 1 foot of a stockpile placed on an unprepared surface in concrete batches is allowed only under the Materials Engineer's direct supervision and if the Material meets requirements of 3126, "Fine Aggregate for Portland Cement Concrete," 3131, "Intermediate Aggregate for Portland Cement Concrete," and 3137, "Coarse Aggregate for Portland Cement Concrete."

Provide Aggregates in accordance with the specified gradation requirements.

The Materials Engineer will consider Aggregates unacceptable if the variation in moisture content carried by any of the Aggregates causes a marked variation in the consistency of successive batches of the mixed concrete, and will suspend operations until corrected.

C.2 Concrete Temperature Control

Produce concrete at temperatures from 50°F to 90°F and maintain temperatures until deposited in the Work.

If necessary to maintain placement temperature, uniformly heat or cool the water, Aggregates, or both, before introduction into the mixer. Control the temperature of the mixing water during heating or cooling.

Use Aggregate at temperatures from 32°F to 130°F. Do not allow cementitious Material to contact other batch Material when the Aggregate temperature exceeds 130°F.

Do not heat the cement, add salt, or add chemical admixtures to the concrete mix to prevent freezing.

Use a heating system to heat batch Materials as approved by the Materials Engineer. Do not use steam jets to spot heat the Material as the Work progresses.

Do not place mixer heaters intended for heating the batch Materials in the mixer drum.

D Batching Requirements

The Concrete Engineer will allow only large capacity Scale companies authorized by the Minnesota Department of Commerce, Weights and Measures Division to calibrate weighting Equipment and meters for Projects. A list of authorized companies is available from the Concrete Engineering Unit website.

Calibration of weighing Equipment is required within three months prior to plant certification each calendar year. Calibrate weighing Equipment and perform spot checks in accordance with the *Concrete Manual*.

D.1 Batching by Weight

D.1.a Proportioning Methods

Proportion concrete batch Materials by weight in a central plant or by volume as directed by the Materials Engineer, in conjunction with the Concrete Engineer.

D.1.b Weighing Equipment and Tolerances

Weigh or measure concrete mixture ingredients to within the targeted batch weight in accordance with the following:

(1) Water – 1 percent
(2) Cement – 1 percent
(3) Other cementitious Materials – 3 percent
(4) Aggregates – 2 percent

(5) Admixtures – 3 percent

D.1.c Batching of Mixing Water

Measure the mixing water on Scales or water metering devices containing the following:

(1) A discharge indicator capable of being set to within 1 gallon of a predetermined quantity
(2) A positive automatic shutoff valve
(3) An approved inspection seal on the Scale or water metering device dating the time of the previous calibration and adjustment

An authorized service agency will calibrate the water meter in accordance with the following:

(1) Before startup of the production season
(2) Every 6 months during production
(3) When requested by the Materials Engineer

Make adjustments as necessary before use meeting the requirements of the weighing procedure in the *Concrete Manual*.

Check the water meter for accuracy at least once each month as the Work progresses.

D.1.d Batching of Cementitious Materials

Weigh the cementitious Material independently of the Aggregates in separate compartments or on separate Scales.

If the precaster weighs the cement first and then separately records the weights of each individual cementitious Material, the precaster may weigh the cementitious Materials cumulatively as approved by the Materials Engineer, in conjunction with the Concrete Engineer.

D.1.e Batching of Aggregates

If the precaster records each individual fraction weight of Aggregates separately, the precaster may weigh Aggregates cumulatively as approved by the Materials Engineer, in conjunction with the Concrete Engineer.

D.1.f Admixture Proportioning

If using two or more admixtures in a single concrete batch, add each admixture separately to prevent interaction of the different admixtures before mixing with other batch Materials. Agitate admixtures to ensure homogeneous concentrations in accordance with the manufacturer’s recommendations.

Incorporate admixtures to the batch mix in liquid form. Maintain admixture solutions at a uniform concentration at all times. Use the solution concentration and proportions designated by the manufacturer.

If using a mechanical dispenser for proportioning Class I or Class II admixtures, provide a site gauge or meter. Have the admixture manufacturer check admixture dispensers yearly to determine accuracy and ensure unobstructed flow.

D.2 Batching by Volume

Proportion concrete for precast products by volume or as required by the Contract.

The Materials Engineer will approve methods and Equipment used in volumetric proportioning.

Determine Material proportions and calibration settings on the basis of 100 pounds of cementitious Material.

Provide and use only sacked cement in the original mill containers unless the precaster calibrates the mixer for the specific Materials in use. Do not use previously opened sacks.

Increase the cementitious content by 10 percent in the computation of volume proportions unless the precaster calibrates the mixer for the specific Materials in use.

E Mixing Requirements

The Materials Engineer may check the water measuring Equipment for accuracy before mixing operations begin and at any other time, the Materials Engineer considers necessary.

Mix concrete by one of the following methods:

(1) A central plant (stationary plant)
(2) Entirely or in part in truck mixers
(3) At the construction site

Do not allow the mixing batch to merge or intermix with the subsequent dry batch during mixing.

Discharge water remaining in the drums before batching.

Mix concrete to provide a mixture that is homogeneous and uniform in color. The Materials Engineer will reject concrete batches that show a marked variation in consistency or evidence of improper mixing as unacceptable Work in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

After completely mixing the concrete, either in a central plant mixer or truck mixer, continuously agitate while in transit to the point of placement until the concrete is discharged from the unit, unless otherwise allowed by the Materials Engineer, in conjunction with the Concrete Engineer. Transport in non-agitating Equipment is exempt from this requirement.

If the mixing does not appear uniform, perform slump tests at the 15 percentage point and the 85 percentage points during unloading. If the results show a slump variation greater than 1 1/2 inch, stop Work and correct the mixing unit.

Produce concrete in such quantity and at such a rate as proper placement and finishing will permit. Do not retemper partially set concrete.

Do not hand mix concrete.

E.1 Mixing In Truck Mixer

Charge the Materials into the truck mixer drum by introducing sufficient water before adding solid Materials. Perform charging operations without losing Materials.

Leave the truck mixer at the plant site for a minimum of 5 minutes or 50 revolutions during the mixing period. Transport the concrete at agitating speed to the point of placement.

F Batch Ticket

Provide a computerized or handwritten batch ticket for each batch of concrete. The Department defines computerized to mean a document that records mix design quantities from load cells and meters.

Provide a batch ticket for each item of information, including the following:

(1) Date
(2) Time concrete was batched
(3) Quantity of concrete in this load
(4) Mix number
(5) Labels identifying each Material that correlates with the precast mix design
(6) Target weight of Materials
(7) Actual batched weights of Materials

Review and sign the first batch ticket for each mixer, each mix type, each day, for accuracy.

G Concrete Placement

Assume full responsibility for the acceptable production, placement, finishing, and curing of concrete under the conditions prevailing, regardless of the restrictions imposed. Provide any artificial lighting, rain, or cold weather protection necessary, including that directed by the Materials Engineer, at no additional cost to the Department.

Place concrete after the Materials Engineer inspects and approves forms and falsework erection, placement of reinforcement steel, Materials, Equipment condition, and cold weather protection.

Do not place concrete if portions of the form are frozen. Maintain the surface temperature above freezing for forms, steel, strands, inserts, brackets, and adjacent concrete that will come in contact with the poured concrete.

Protect the concrete from freezing.

Protect the concrete against damage from construction operations.

The Materials Engineer will evaluate any defects in concrete or concrete surfaces resulting from weather conditions, inadequate lighting, or other causes in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

G.1 Placement Temperatures

Maintain concrete at a temperature from 50°F to 90°F until placement.

Unless approved cold-weather Plans are in-place, do not place concrete when the air temperature is either of the following at the point of placement:

(1) Below 36°F
(2) The National Weather Service predicts the temperature to fall below 36°F within the following 24 hour period

G.2 Delivery Requirements

Place concrete into the forms in accordance with the following:

(1) Type 1 Concrete—within 90 minutes of batching
(2) Type 3 Concrete—within 90 minutes of batching when admixtures are added at the plant at the manufacturer’s recommended dosage rates listed on the *Approved/Qualified Products List*

The precaster may transport Type 1 or Type 3 concrete in non-agitating Equipment if the concrete is discharged within 45 minutes of batching.

Batch time starts when the batch plant or the transit mix truck adds the cement to the other batch Materials.

G.3 Field Adjustments

Mix the load a minimum of 5 minutes or 50 revolutions at mixing speed after addition of admixture or water.

G.3.a Water Adjustments

The Materials Engineer will allow water adjustments in accordance with the following:

(1) Before discharging approximately 1 cubic yard of concrete
(2) Not to exceed the Total water available to add stated on the Certificate of Compliance
(3) Provided the concrete is within 60 minutes from the initial batch time stated on the Certificate of Compliance

G.3.b Admixture Adjustments

Approved admixture additions are allowed within 90 minutes from the initial batch time stated on the Certificate of Compliance. If the load of concrete has no available water to add, or the load is greater than 60 minutes old, the Materials Engineer will allow one admixture adjustment diluted with up to 2 gallons of water.

G.3.c Consistency and Air Content Adjustments

(1) If the first test taken passes, continue verification testing in accordance with the *Schedule of Materials Control*.
(2) If the test taken fails, make adjustments and perform any Quality Control testing before the final test. Acceptance or rejection of the truck is based on the final test result.
(3) Test up to two additional trucks in accordance with items (1) and (2) above, and
(4) If the concrete does not meet the Specification after those three trucks, increase verification testing rate to once per truck for acceptance for the remainder of the pour.

G.4 Test Methods and Specimens

Perform random sampling and testing in accordance with the *Concrete Manual* and test according to the requirements of the *Schedule of Materials Control*.

Anyone fabricating concrete cylinders is required to hold either a current ACI Field 1 Technician Certification or a Department Field 1 Technician Certification.

Anyone performing concrete strength testing of cylinders is required to hold one of the following current certifications:

(1) ACI Concrete Strength Testing Technician Certification
(2) Department Strength Testing Technician Certification
(3) WisDOT Strength Testing Technician Certification

Furnish molds based on the maximum size Aggregate.

G.4.a Strength Cylinders

The precaster will cast strength cylinders to determine the following:

(1) Handling or "Stripping" Strength
(2) Shipping Strength
(3) Verification

Cast cylinders used for determining strength at each stage for types of precast operations. Cure cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of *ASTM C31*, *Standard Practice for Making and Curing Test Specimens in the Field*.

G.5 Consistency

Test the concrete for consistency using the slump test during the progress of the Work.

If any test shows the slump outside of the slump range requirements, reject the concrete represented by that test. In order to bring the mixture back into the slump range requirements, the Materials Engineer will allow adjustments to the concrete in accordance with 2462.3G.2, "Delivery Requirements" and 2462.3G.3, "Field Adjustments.

Adjust the slump not to exceed the slump range allowed to optimize both placement and finishing. Contact the Materials Engineer if encountering unusual placement conditions that render the maximum slump unsuitable.

G.5.a Non-Conforming Material

Only place concrete meeting the slump requirements in the Work. If the precaster places concrete not meeting the slump requirements into the Work, the Materials Engineer will determine acceptance in accordance with 1512, "Unacceptable and Unauthorized Work."

G.6 Air Content

Maintain the air content of Type 3 general concrete at the specified target of 6.5 percent (+2.0 percent and -1.5 percent) of the measured volume of the plastic concrete in accordance with 1503, "Conformity with Contract Documents."

Measure the air content at the point of placement but before consolidation.

Make any adjustments immediately to maintain the desired air content.

The Materials Engineer will reject concrete with a measured air content greater than 8.5 percent or less than 5.0 percent.

G.6.a Non-Conforming Material

Only place Type 3 concrete meeting the air content requirements in the Work. If the precaster places Type 3 concrete not meeting the air content requirements into the Work, the Materials Engineer will determine acceptance in accordance with 1512, "Unacceptable and Unauthorized Work."

2462.4 METHOD OF MEASUREMENT - BLANK

2462.5 BASIS OF PAYMENT

The Department will include the cost of precast concrete in accordance with 2405, "Prestressed Concrete Beams," 2411, "Minor Concrete Structures," and 2545, "Lighting Systems."

2471 STRUCTURAL METALS

2471.1 DESCRIPTION

This Work consists of shop and field Work for manufacturing, fabricating, and coating structural metals.

A Definitions

For the purpose of the work specified in section 2471, “Structural Metals,” the Department defines:

Fabricator
Manufacturer or supplier of fabricated structural metals. In the event that the Contractor performs this Work, the term will mean the Contractor or the Contractor’s agent.

Minor Structural Components
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) Metal fabricated railings and fencing (excluding standard chain link fencing)
(3) Electric lighting, traffic signs, and signal systems
(4) Pedestrian Bridges
(5) Other system or component designated by the Bridge Engineer

Major Structural Components
Components other than minor structural components as defined in Minor Structural Components.

Supplier
Fabricator, galvanizer, and paint shop.

Tension Areas
(1) Any location in a rolled beam or welded girder where the Superstructure curvature is greater than 4 degrees, and/or members are designed as an interactive 2-D structure where members are sharing or distributing load to one another, and/or Contract requires full assembly in fabrication.
(2) Any other Tension Area as shown in the Project Plan.

2471.2 MATERIALS

Provide new Materials in accordance with the following sections. Unless otherwise required by the Contract, use structural steel in Bridges in accordance with 3309, “High-Strength Low-Alloy Structural Steel,” and use structural steel for other Structures in accordance with 3306, “Low-Carbon Structural Steel.”

Provide Materials from mills, warehouses, or processors with supporting certified MTRs meeting the requirements of applicable ASTM specifications. If the MTR does not contain sufficient information, provide copies of the test results to the Bridge Engineer for review and approval before fabrication.

A Low-Carbon Structural Steel 3306

B General Requirements for Structural Steel 3308

C Structural Alloy Steel

2471.3 CONSTRUCTION REQUIREMENTS

A General

Provide the Bridge Engineer with a list of Fabricators, galvanizers, and painters, including addresses, and a list of products they will provide.

Do not order Materials or direct the Fabricator to perform shop Work until the Bridge Engineer approves of the shop drawings.

If installing fabricated components on an existing Structure, measure field dimensions in accordance with 2433, “Structure Renovation.

B Certification Requirements

B.1 Simple Steel Bridge Structures and Components

Provide a certification from a Fabricator certified in accordance with AISC Quality Certification Program Category, Simple Steel Bridge Structures (Sbr) for the following types of Structures and Structure components:

(1) Rolled beam Bridges with a pay quantity for structural steel no greater than 300,000 pounds
(2) Pedestrian Bridges
(3) Steel diaphragms with a linear quantity greater than 5,000 feet
(4) Diaphragms designated Major Structural Components (curved steel Bridges)
(5) Other items as directed by the Bridge Engineer

B.2 Major Steel Bridges

Provide a certification from a Fabricator certified in accordance with AISC Quality Certification Program Category, Major Steel Bridges (Cbr) for the following types of Structures and Structure components:

(1) Rolled beam Bridges with a pay quantity for structural steel of at least 300,000 pounds
(2) Welded Bridge girders
(3) Tubs
(4) Boxes
(5) Trusses
(6) Other items designated by the Bridge Engineer

B.3 Fracture Critical Items

Provide a certification from a Fabricator certified in accordance with AISC Quality Certification Program Category, Major Steel Bridges (Cbr) with Fracture Critical Member endorsement (F).

B.4 Coating Application

Contractor/Fabricator performing coating application must demonstrate qualification by obtaining the AISC Sophisticated Paint Endorsement (SPE), SSPC QP Certification, or a quality certification system acceptable to the Bridge Engineer, and a Quality Manual (QM) that is acceptable to the Bridge Engineer.

C Shop Drawings

C.1 General

Submit to the Bridge Engineer shop drawings from the Fabricator that include the following:

(1) Detailed Plans showing the dimensions and sizes of Materials
(2) Details and information necessary for fabrication
(3) Fastener lists for shop and field erection
(4) Blocking and camber diagrams
(5) Match marking diagram
(6) Radiographic diagram showing weld locations and identification in accordance with 2471, “Structural Metals”
(7) Complete field erection Plan showing piece marks
(8) All dimensions as measured in the field

Ensure shop drawings include welding symbols meeting the requirements of *ANSI/AWS A2.4*, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Verify that the Fabricator placed Welding Procedure Specification (WPS) numbers in the tail of the arrow(s).

Submit shop drawings from the Fabricator for the complete fabrication of structural metals as required by the Contract. If the Department provides standard detail drawings as required by the Contract, submit finished detail drawings from the Fabricator with additions and revisions.

If the Contract requires a Standard Plate, the Department will not require redetailed plates except to indicate fit at connections to other structural members for changes shown on the Plans or to complete detailed information to the shop or the Material Supplier. Provide these detail changes from the Fabricator.

C.2 Format

Submit shop drawings from the Fabricator meeting the following characteristics and requirements:

C.2.a Full Size Paper Format

(1) Prepared in a neat and legible form on media from which clear, sharply defined prints can be made for the Bridge Engineer's review and inspection purposes
(2) 22 inch by 34 inch
(3) 1/2 inch edge border except a 2 inch border on the 22 inch left edge
(4) Containing title box in the lower right hand corner with the following information:

(a) Department's structure number
(b) Project number
(c) Federal Project number (if applicable)
(d) Fabricator's name
(e) Fabricator's Contract number
(f) Detailer's and checker's initials
(g) Date of preparation
(h) Brief description of the details shown on each sheet

(5) Height of letters and numerals on each drawing at least 0.14 inches
(6) Text, details, lines, and dimensions capable of reducing in size to 11 inch by 17 inch without affecting readability
(7) Containing a complete bill of Materials listing the individual pieces with piece marks and quantities, including dimensions
(8) Consecutively numbered sheets
(9) First drawing of the shop details containing a schedule of sheet numbers, including a brief description for reference

C.2.b PDF Format

(1) When requested by the Fabricator and agreed by the Bridge Engineer prepared in a neat and legible form in electronic PDF format that is clear, sharply defined electronic prints can be made for the Bridge Engineer's review and inspection purposes
(2) File format size to be at least 11 inch by 17 inch
(3) The same requirements of (3) through (9) as specified in 2471.3C.2.a, "Full Size Paper Format"

C.2.c Standard Sheets

Contractor may also provide standard sheets from the Fabricator with fastener lists.

C.3 Submittal for Bridge Engineer's Review and Acceptance

Submit two sets of prints of required shop drawings, meeting 2471.3C.2, "Format," from the Fabricator to the Bridge Engineer for review and release for fabrication. Shop drawings must comply with the Contract documents. Provide written authorization from the design EOR (Engineer of Record) for any deviation from the Contract documents. Incorporate contractor comments into shop drawings prior to submittal to reviewer. The reviewer will return one set of prints of the shop drawings to the Fabricator with comments.

Submit only checked drawings, in complete collated sets, from the Fabricator for review. The Contractor may submit details such as ice-breakers, anchorages, bearing plates, and castings, separately to facilitate the Work.

Fabricator may submit the shop drawings to the Contractor. Stamp these drawings with "For Contractor Use Only." Do not forward these stamped drawings to Department.

Submit a schedule showing the submission dates of shop drawings and anticipated dates for shop fabrication from the Fabricator, as directed by the Bridge Engineer. Arrange the schedule to avoid delay in completing the Work. If constructing a Structure composed of several units, consider submitting shop drawings of the separate units in proper order to expedite the review and release for fabrication of the details.

If the Bridge Engineer requests changes to the submitted drawings or if the Fabricator makes additional changes not required by the Bridge Engineer, provide revised drawings, with revision control, from the Fabricator with circles, underscores, or other marks to distinguish the changes from unchanged details or dimensions.

The Bridge Engineer will release shop drawings for fabrication after corrections are completed. Provide six sets of corrected drawings and additional copies as required by the Contract or requested by the Bridge Engineer from the Fabricator at no additional cost to the Department. Mark the corrected drawings as Revision 0 and remove all comments and marks to make clean drawings for acceptance, stamping, and distribution for use.

The shop drawings accepted by the Bridge Engineer will become part of the Contract. Do not make changes on accepted drawings unless otherwise approved by the Engineer in writing. Mark changes approved by the Bridge Engineer on the accepted shop drawings with revision version in number sequence next to all changes and resubmit them for approval, stamping as revised sheet and distributing to replace the superseded version of drawings.

The Bridge Engineer's acceptance 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 structural members.

C.4 Submittal for Completed Work

After the Fabricator completes the shop Work, provide detailed shop drawings to the Bridge Engineer in two formats:

(1) One set of drawings on 11 inch by 17 inch bond paper
(2) An electronic file in PDF format containing all sheets

Ensure that the drawings submitted accurately reflect the actual configuration of structural members and components, including modifications made during fabrication and after delivery to the Project, under the fabricator's direction. If making the electronic files by scanning, use a minimum scan resolution of 400 dpi.

D General Fabrication Practices

Provide structural Material fabricated and assembled meeting the requirements of AASHTO/NSBA Steel Bridge Collaboration *Steel Bridge Fabrication Guide Specification* and AWS welding codes, except as modified in this section. Provide Material structurally welded meeting the requirements of ANSI/AASHTO/AWS D1.5, *Bridge Welding Code*, for Major Structural Components and *AWS D1.1*, *Structural Welding - Steel*, for Minor Structural Components. Ensure the Certified Welding Inspector (CWI), or an equivalent, witnesses the welder and welding operator qualification tests unless otherwise specified in this section.

Before the start of Work, the Supplier will be qualified on *Approved Suppliers for Fabricated Structural Metals Products* list as maintained by the Structural Metals Engineer on the Bridge Office website or become qualified. To become qualified, the Supplier is to submit a Quality Manual (QM) to the Structural Metals Engineer for review and acceptance, at least 60 Calendar Days before beginning Work. The QM is to meet the requirements of the *MnDOT Supplier Qualification Standard* which will be the basis for acceptance by the Structural Metals Engineer. Upon acceptance of the QM, a supplier is qualified and will be listed on the *Approved Suppliers for Fabricated Structural Metals Products* list. In addition to routine inspections, the Structural Metals Engineer will audit suppliers with approved QMs on a biannual or annual basis or as otherwise directed by the Structural Metals Engineer to ensure the implementation of the QM.

The Department will invoke its Corrective Action Process if the routine inspections or audits indicate non-conformance. Any corrective actions deemed appropriate by the Structural Metals Engineer, are effective immediately and apply to any Work remaining on current and future Projects. If the

Structural Metals Engineer determines that Work does not comply with the QM or that fabrication does not follow approved fabrication procedures, the Structural Metals Engineer will deem the Materials as non-conforming in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” If the Structural Metals Engineer finds non-conforming Work, direct the Supplier to immediately correct the procedure and submit a written non-conformance report, containing data required by the Structural Metals Engineer to ensure compliance with the QM, Specifications, and drawings. Perform additional testing as required by the Structural Metals Engineer at no additional cost to the Department. For repeat offences or negligence, the Department will require corrective action of hiring a third-party Quality Control Inspector at no additional cost to the Department. The Contractor may obtain a copy of the Department’s Corrective Action Process from the Structural Metals Engineer.

D.1 Prefabrication Conference

Before fabrication, the Bridge Engineer may schedule a prefabrication conference with the Contractor and the Fabricator to discuss pertinent Specifications, procedures, and requirements of the job. The Bridge Engineer will consult the Contractor and the Fabricator to decide the location, date, and agenda items for the conference.

D.2 Notification

Notify the Bridge Engineer at least 5 Business Days before the Fabricator begins Work so that the Bridge Engineer may perform inspections. Do not allow the Fabricator to begin Work before notifying the Bridge Engineer.

D.3 Identification of Materials

Before fabrication begins, the Fabricator will provide a copy of purchase orders, Mill Test Report (MTR), or other documentation required by the Bridge Engineer, indicating that the Materials meet the physical, chemical, and source (mill) requirements of this section for each heat of steel used in the Work. The Fabricator will provide copies of purchase orders when placing the orders. When the Materials are received, the Fabricator will indicate in writing or by ink stamp that the MTRs have been checked for compliance. Include the name of the individual who checked the MTR and the date of inspection with the purchase order. If the Bridge Engineer determines that the documentation is incomplete, direct the Fabricator to sample and test Materials as directed by the Bridge Engineer at no additional cost to the Department. Provide Scale weights of individual members or sections as required by the Bridge Engineer.

Except for the following, the Fabricator of Minor Structural Components will provide Certificates of Compliance and shipping documents for each Contract Item to the Bridge Engineer instead of submitting purchase orders and MTRs:

(1) Pedestrian Bridges
(2) Post and truss chord Materials for traffic signs
(3) High mast Light Poles
(4) Modular expansion devices
(5) Pot bearings
(6) Other items designated by the Bridge Engineer

In conjunction with the Fabricator, keep appropriate documentation on file for at least seven years.

During each stage of fabrication of Major Structural Components, ensure the Fabricator provides and maintains identification to establish the heat of the Material from which the component is fabricated. Provide the Bridge Engineer with a list showing heat numbers referenced to the Material incorporated into each component. The Bridge Engineer will reject

Material that loses its identity unless the identity can be reestablished to the satisfaction of the Bridge Engineer.

Provide wide flange beams, flanges, webs, splice plates, welded cover plates, and fracture critical members with identification numbers placed on each individual piece of Material that referenced to the corresponding heat number.

Ensure the Fabricator uses non-oil-based markers or low stress die stamps for the identification coding of Material.

D.4 Weld Identification System

Before implementation, ensure the Fabricator uses the Department standard weld identification system as described in 2471.3D.4.a, “Standard Weld Identification System,” or an alternate system approved by the Bridge Engineer to identify welds subject to radiographic testing, ultrasonic testing, or both. Use a traceability system with a unique identification assigned to welds being examined. Do not repeat identification numbers. Use identification numbers traceable back to the original member examined and document the identification number on the shop drawings.

D.4.a Standard Weld Identification System

D.4.a(1) Piece Mark

Provide Material marked with the Fabricator’s piece identification as shown on the approved shop drawings.

D.4.a(2) Splice Plane Number

For the purpose of the Work specified in section 2471.3D.4.a, “Standard Weld Identification System,” the Department defines a splice plane as a 3 feet wide vertical section of a piece that contains a full penetration welded splice in any component of the piece. The Department considers any other full penetration welded splice in any component of the piece within the 3 feet vertical splice plane in the same splice plane.

Provide the number of the splice plane on the piece starting from the left end of the piece as shown on the radiographic diagram.

D.4.a(3) Piece Components Code

Verify that the Fabricator placed film identification numbers or location marks, only on film, meeting the requirements of AWS D 1.5, *Bridge Welding Code*. Begin marking from near side (NS) edge for flanges and the bottom edge for webs.

(1) Bottom flange
(2) Web – single web or near side (NS) web for two webs
(3) Top Flange – single top flange or NS flange for two top flanges
(4) Web – far side (FS) web for two webs
(5) Top Flange – FS flange for two top flanges

D.4.a(4) General Notes

Ensure the Fabricator performs the following:

(1) Performs radiographic and ultrasonic testing of welds meeting the requirements of AWS D1.5, *Bridge Welding Code* except as modified by this section

(2) Establishes the centerline of the weld on the components of the piece before welding by placing punch marks 1 foot back from the centerline of the weld and 1 inch from the edge of the plate

(3) Provides image quality indicators (wire penetrameters) as directed by the Bridge Engineer

(4) For joints radiographically inspected less than 100 percent, include the untested areas in the Film Identification Number scheme

D.5 Storage of Materials

Store Material above ground on platforms, skids, or other supports. Protect Material from dirt, oil, and other foreign matter. Drain Material so that water is never in constant contact with the surface. Replace damaged Material with new Material or repair using a procedure approved by the Bridge Engineer.

D.6 Nonconformances

Provide an established quality system outlined in the QM for controlling nonconforming Material from the Fabricator, including procedures for identification, isolation, and disposition.

Submit Nonconformance Report (NCR) forms from the Supplier to the Bridge Engineer documenting deviation from the QCP, approved shop drawings, the Plans, or Specifications. Include the following in the Nonconformance Report form:

(1) Company name and address
(2) Report title
(3) Nonconformance Report number
(4) Date
(5) Company job number
(6) Piece mark
(7) Owner of Bridge/Structure
(8) Contractor
(9) Owner’s Project number
(10) Location
(11) Detailed description of the non-conformance
(12) Photo, sketch, or drawing
(13) Proposed repair/disposition of the non-conformance
(14) Identify any possible increase in cost or delay to the Project
(15) Quality Control Manager’s signature and date

Address non-conforming Material with an NCR no more than 5 Working Days after discovery.

The Bridge Engineer will advise the supplier of the resolution to non-conformance in writing.

E Structural Components

E.1 Welded Shear Stud Connectors

In accordance with OSHA Subpart R 1926.754, attach shear stud connectors and other similar devices to the top flange of beams or other steel components after the installation of decking falsework or other walking surfaces.

E.2 End Connection Angles

The Bridge Engineer will only require finishing of end connection angles to correct a non-conforming assembly. Produce a finished angle at least 3/8 inch thick. Do not reduce the original thickness of the angle by greater than 1/8 inch. Grind flush portions of members extending beyond the face of the connection angles. Do not recess the web of a connecting member by greater than 3/8 inch from the face of the connection angles.

E.3 Bolts

Provide high strength structural steel bolts in accordance with 3391, "Fasteners," except the Contractor may use common structural steel bolts for connections in expansion and deflection devices and in hand railings. Place structural bolts with a projection from 1/8 inch to 3/8 inch through the nut.

Provide extra bolts in the amount of 5 bolts plus 5 percent of the actual number of field bolts necessary, at no additional cost to the Department. The Department will not include this number of additional bolts in the Plan Quantity and will include the cost of these additional bolts in the Contract Unit Prices for the bolts in the Contract Item.

E.4 Pins and Rollers

Provide pins and rollers with a 75 micro inch finish.

Provide pin threads meeting the requirements of American Standard Coarse Thread Series Class 2 and free fit meeting the requirements of *ANSI B1.1*. Thread pin ends and nuts with diameters of at least 1 3/8 inches with 6 threads per 1 inch. Provide nuts meeting the following requirements and characteristics:

(1) Made of structural steel in accordance with 3306, "Low-Carbon Structural Steel," 3309, "High-Strength Low-Alloy Structural Steel," and 3310, "High-Strength Low-Alloy Columbium-Vanadium Steel"
(2) Recessed
(3) Hexagonal
(4) Galvanized in accordance with 3392, "Galvanized Hardware"

Machine the grip face of the nut square to the axis of the pin. Ensure the recessed face of the nuts will bear uniformly against the end face of the pin when turning the nut tight. Place pins with a projection of at least 1/4 inch through the nut after assembly. If making a recessed cut between the threads and the shoulder of the pin, do not make cuts wider than 1/4 inch or deeper than the base of the thread.

E.5 Shims

For the purpose of the Work specified in section 2471.3E.5, "Shims," the Department defines shims as metal plates not shown on the Plans that bring metal surfaces of members into contact or bring the Structure to the grade or alignment shown on the Plans.

Make shims 1/8 inch or thicker of structural steel. Make shims 1/8 inch or thinner from sheet steel or sheet brass.

Provide shims at no additional cost to the Department.

F Structural Fabrication

Ensure the Fabricator performs the following:

F.1 Cutting

Cut steel and fabricate steel plates and splice plates for Major Structural Components so the primary direction of rolling is parallel to the direction of the main tensile or compressive stresses.

Cut metals to the size shown on the Plans with allowance for necessary or required finishing operations. Cut metals within 1/16 inch from true lines. For the purpose of the Work specified in section 2471.3F, Structural Fabrication," the Department defines true lines as theoretical lines exactly corresponding to and used to transfer dimensions as shown on the Plans to Materials for cutting, drilling, and fitting.

Cut flange plates or other members to a true curve. Do not use a series of straight cuts to create the curve.

F.1.a Re-Entrants

Form interior and reentrant corners with a radius of at least 1 inch. Form filleted corners with radii no greater than 1 inch by drilling.

F.1.b Shearing

Do not shear nonferrous metals with a thickness greater than 1/2 inch.

F.1.c Edge and Corner Condition

All exposed edges and corners are to be free of slag, burrs, and gouges.

F.2 Machining

F.2.a General

Perform heat treatment before final machining. For the purpose of the Work in section 2471.3F.2, "Machining," the Department defines heat treatment as intentionally and systematically applying heat at a temperature below the melting point of any ferrous castings, weldment, or other components.

F.2.b Machining Tolerances

For members requiring machine finishing, the standard tolerance is ±0.005 inch.

For bearing assemblies, a tolerance of ±0.03 inches will be applied to the following:

(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

F.2.c Machine Lubricant

Use machining lubricant on structural Material requiring machine Work or drilling capable of being completely removed.

F.2.d Surface Finish

For machine finish surfaces, unless otherwise specified, the required finish will be 125 micro inches.

F.3 Bending

Before bending, round the corners of the plates to a radius of 1/16 inch throughout the portion of the plate at which the bending is to occur as shown on the Plans. Bend metals before coating or heat treatment. Bend without causing fractures, kinks, reduced section below minimum, or other defects in the Material.

F.4 Cambering and Curving

The Bridge Engineer will verify measurements of vertical camber and horizontal curvature for final acceptance after the completion of welding and heating operations and after the flanges cool to uniform ambient temperature. The Bridge Engineer will check horizontal curvature with the girder in the vertical position.

The Bridge Engineer may reject Materials showing over hardening, fractures, or other defects due to improper heating.

F.5 Straightening Material

Straighten Material without shearing, fracturing, stressing, or damaging the bolts, welds, or base metal. Use straightening methods approved by the Bridge Engineer. Replace Material damaged during straightening operations with new Material at no additional cost to the Department.

If the Bridge Engineer determines it is not possible to straighten a member as part of an assembly, remove the bent Material from the assembly, straighten, and reassemble.

F.6 Dimensional Tolerances

Provide fascia beam webs with a flatness tolerance no greater than half the limit in ANSI/AASHTO/AWS D1.5*, Bridge Welding Code*.

Flange and splice plates to be longitudinally flat to 1/16 inch in the contact area in order to achieve full connection contact with bolts tightened to the snug tight condition. Additionally, flange plates are to be perpendicular to the web within 1/16 inch in the connection area.

Flatness of surfaces intended for contact bearing with other structural parts will be within 0.03 inches for each contact surface.

For Materials that are warped or distorted, straighten to 1/8 inch in 10 feet, with Bridge Engineers approval.

G Structural Welding

Ensure the Fabricator performs the following:

G.1 General

Obtain written approval from the Bridge Engineer before performing welding, including weld repair, or deviating from the approved shop drawings or Project Plan.

Submit Weld Procedure Specifications (WPS) with shop drawings. Do not begin fabrication until the Bridge Engineer has approved the WPS(s). The Bridge Engineer may require testing for particular weld details described in the WPS to assure the Bridge Engineer that proper welds can be made. Test welds as required by the Bridge Engineer.

Provide information or Procedure Qualification Records (PQRs) demonstrating that the proposed WPSs meet the requirements of the *ANSI/AASHTO/AWS D1.5*, *Bridge Welding Code* (BWC) as approved by the Bridge Engineer. PQRs, once approved, will remain valid indefinitely.

Provide a minimum weld size per BWC when a weld symbol is void of a weld size.

For the purpose of the Work in 2471.3G, "Structural Welding," a weld repair is defined as any area of the welded product not in compliance with the WPS, approved Quality Manual, or current edition of BWC.

Notify the Bridge Engineer to witness welding and testing. If the Bridge Engineer cannot witness qualification or certification welding or testing, arrange the witness of an approved third-party, at no additional cost to the Department.

Conduct testing of qualification welds in a laboratory accredited by the American Association for Laboratory Accreditation (A2LA) or an approved equal at no additional cost to the Department.

G.1.a Welded Flange Splices

Place welded flange splices at least 12 inches from web splices. For welded girders with radii no greater than 1,900 feet, the Department will allow additional splices only on individual flanges that are uniform in thickness and greater than 39 feet in length. The Department will allow these splices in addition to the splices shown on the Plans. Provide flanges with no more than two additional splices.

Locate additional splices in accordance with the following:

(1) Near the third points of individual flange plates
(2) Midway between adjacent diaphragm connections
(3) At least 12 inches from transverse stiffeners and welded connection plates
(4) At least 10 feet from field splices, bearing points at piers, and flange groove welds as shown on the Plans
(5) At locations approved by the Bridge Engineer

G.1.b Web-to-Flange Welds

For the purpose of the Work in 2471.3G.1, "General," the Department defines a repair as any area of the welded product not meeting the requirements of BWC. Limit each individual web-to-flange weld repairs to 2 percent of the weld length and grinding web-to-flange weld repairs to 5 percent of the weld length. If the Contractor exceeds the repair limits, the Bridge Engineer will revoke the WPS used to perform the initial production welding.

G.2 Preparation of Base Metal

For coated metals, remove coatings on either side of the weld area to a distance of at least 2 inches.

G.3 Conditions for Welding

Preheat without producing visible moisture in the weld joint before welding.

G.4 Backing

Produce "Complete Joint Penetration" (CJP) groove welds using steel backing that is continuous for the full length of the weld. Make joints in the steel backing CJP joints, also.

H Fracture Critical Members

Ensure the Fabricator performs the following:

(1) Provide fracture critical members meeting the requirements of BWC, Fracture Control Plan (FCP) for fracture critical Bridge members and as modified by this section

(2) Provide fracture critical members as shown on the Plans. The Bridge Engineer may provide written exemption from these requirements for welds in designated members not subject to tension forces

(3) Do not weld or drill holes for temporary attachments to rolled beams or girders

H.1 Fracture Critical Welder Qualifications

Provide fracture critical members welded by welders meeting the certification requirements in accordance with BWC. Annual requalification is to be based on acceptable radiographic test results of either a production groove weld or test plate. If employing a welder requalified by test, use a WPS written in accordance with the requirements of BWC and show the applicable test plate.

I Hole Forming Operations

I.1 Bolt Holes

Hole forming operations other than drilling will require a written procedure in the suppliers Quality Manual and a verification test for each hole forming process. Produce holes after any required bending, cambering, curving, or heat-treating of member. Sub-punching or sub-drilling of holes is permitted only where specifically allowed by this Specification.

Except for field connections and field splices, the Contractor may punch Material forming parts of a member composed of no greater than five thicknesses of metal 1/16 inch larger than the Nominal diameter of the bolts for any of the following:

(1) Structural steel no thicker than 3/4 inch

(2) High strength steel no thicker than 5/8 inch

(3) Quenched and tempered alloy steel and non-ferrous metals no thicker than 1/2 inch

In addition to drilling and punching, the Fabricator may produce holes for Minor Structural Components by plasma, water jet, or laser cutting methods.

Produce holes and slots that meet the following criteria:

(1) Free of sharp, torn, or jagged edges

(2) Walls square to the surface

(3) Surface roughness not exceeding 1000 micro inches

(4) Size tolerance of -0/+1/32 inch when compared to as detailed

I.1.a Line Assembly

Ensure the Fabricator performs the following:

(1) If the Contract requires line assembly, drill the connection holes in flange and web splices full size in the assembled position

(2) Drill connection holes in secondary members, including diaphragms, diaphragm stiffeners, lateral bracing, and lateral bracing connection plates +3/16 inch greater than the bolt diameter to facilitate alignment

(3) Use predrilled splice plates as a template only one time

(4) For oversized holes, place hardened washers meeting the requirements of *ASTM F436, Standard Specification for Hardened Steel Washers Inch and Metric Dimensions*, under the bolt head and nut

I.1.b Full Assembly

If the Contract requires full assembly, ensure the Fabricator drills bolt holes for field connections, in members and components of each structural unit, from the solid to the specified size while assembled with the following exceptions:

Two sub-sized holes may be used to attach each diaphragm to stiffeners and field splice plates to webs and flanges to facilitate assembly.

The Fabricator has the option to drill one ply of a field connection with full size holes providing it is used as a template only once.

I.1.c Punched Bolt Holes

Ensure the diameter of the die does not exceed the diameter of the punch by greater than 1/16 inch. If the Fabricator enlarges holes to admit the bolts, provide a written repair procedure from the Fabricator to the Bridge Engineer for approval.

I.1.d Field Connection Bolt Holes

Ensure the fabricator drills holes full size to a steel template while assembled for the following:

(1) Floor beams
(2) Stringer end field connections
(3) Holes in field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames

The Contractor may drill holes for the following full size and unassembled to a steel template if approved by the Bridge Engineer in writing:

(1) Field splices of rolled beam stringers continuous over floor beams or cross frames
(2) Holes for floor beams, cross frames, or bent plate diaphragms

If using a steel template for drilling field connection holes to full size, ensure the Fabricator locates the template to the correct position and angle, bolts the template in place before drilling, and uses duplicate templates to drill matching members and the opposite faces of a single member.

I.2 Boring Pin Holes

Ensure the Fabricator produces the final surface of pin holes by a finishing cut, and provides pin holes in diameters in accordance with the following:

(1) No greater than 1/64 inch for pins no greater than 5 inches in diameter
(2) No greater than 1/32 inch for pins greater than 5 inches in diameter

Ensure the distance outside-to-outside of end holes in tension members and inside-to-inside of end holes in compression members does not vary from that specified by greater than 1/32 inch. Ensure the Fabricator bores pin holes in built-up members after the completion of assembly.

J Shop Assembly

Ensure the Fabricator performs the following:

Complete fabrication, weld inspection, nondestructive testing, and any repairs, before placing any component in the assembly.

Adjust each assembly unit to the true field position with respect to alignment, camber, grade and skew, as shown on the Plans, prior to drilling field connection. The Fabricator may angularly rotate the assembly from true field position, with respect to grade, providing the Fabricator supplies shop drawings showing elevations at points of bearing and the relative position of webs of main members, with respect to true field position. Provide calculations to support the information shown in the drawings. Rotation is not allowed on hold over members.

For multiple span continuous Structures, both straight and curved, progressive assembly is allowed providing a length no shorter than the length supported by three adjacent points of bearing is used as a minimum length of each structural sub-assembly. For these progressive assemblies, hold over pieces between adjoining assemblies shall be held to the following tolerances in relation to their documented position prior to removal:

Table 2471.3-1
Assembly Tolerances

	Vertical (inch)	Horizontal (inch)	Tilt (inch)
At point of support	+1/16, -0	+/-1/32	+/-1/32
At member ends	+/-1/32	+/-1/32	+/-1/32

Clean metal surfaces in contact with each other before assembling. Assemble, pin, and draw together the parts of a member before drilling or bolting.

Assemble Structures that contain secondary members utilizing full size holes in accordance with 2471.3J.2, "Full Assembly."

In the assembly Plan, identify maximum deviations of differential camber and sweep between girder lines.

Provide a written record of each shop assembly set-up. Submit written record to Contractor and Bridge Engineer. The inspection of the assembly and the written report shall be completed by a competent individual with experience in structural assemblies. If a total station or similar device is used to check the assemblies the operator shall be certified to a National Standard or the Equipment manufacture. If a progressive assembly is used the written report shall contain the required information for each assembly and a final written report for the full length and width of the Structure. Include the following assembly dimensions, theoretical (as shown on a blocking diagram) and actual measurements with the written record:

(1) X, Y, and Z dimensions (horizontal offset, elevations, and tilt) at bearing points, 1/4 span points, field splice locations, Plan ordinates closest to mid span and any other connection points
(2) Span lengths

Temporary bolts shall be drawn sufficiently tight to bring the required parts into bearing and to preclude loosening of the nut. The permanent bolt assembly shall be in accordance with 2402, "Steel Bridge Construction."

Take apart assembled pieces, if necessary, to remove burrs, shavings, or other irregularities produced by the operation. Adjust the members if they have any twists, bends, and other deformations.

J.1 Line Assembly

Assemble Major Structural Components, pedestrian truss Bridges, overhead sign trusses, and modular and finger expansion joint devices at the fabrication shop, unless otherwise required by the Contract. Line assemble primary members (such as but not limited to beams, girders, arches, trusses, etc.) full length with components completely assembled.

J.2 Full Assembly

Performs full assembly as required by the Contract in accordance with the following:

(1) Assemble, in totality, the main members for the complete length as required by the Contract and assemble to the full width of the structural unit
(2) Block members in the "no load" or "zero gravity" position unless other requirements are specified in the Contract. This shall include at a minimum, five points of support for each individual main member: ends, 1/4 points, and midpoint
(3) Include components such as diaphragms, brackets, laterals, wind frames, links, and transverse floor systems. The Department will not require components such as expansion and deflection devices and bearings to be assembled

J.3 Match Marking

Match mark connecting parts assembled in the shop to assure proper fit in the field using low stress die stamps before disassembly.

Use a match marking system that uses a series of letters and numbers to indicate the exact location in the Structure without continual reference to detail drawings. Do not use shop piece marks as a match marking scheme. Mark pieces or parts planned for assembly at a point with the same mark to avoid rotation of pieces.

Use Material used for match marking capable of removal without damage to the appearance of painted or unpainted surface visible in the completed Structure.

K Uncoated Weathering Steel Surfaces

Ensure the Fabricator performs the following:

(1) Removes foreign matter including oil, grease, dirt, and concrete spatter from uncoated 3309, “High-Strength Low-Alloy Structural Steel,” or other types of weathered steel Material in accordance with *SSPC-SP 1*, “Surface Preparation Specifications – Solvent Cleaning”
(2) Blasts clean uncoated weathering steel, including contact areas of bolted structural connections, in the shop or field in accordance with *SSPC-SP6/NACE No. 3*, “Commercial Blast Cleaning”

L Coating

For the purpose of Work in specified in this section, the Department defines coating as any protective barrier including paint, galvanizing, or metalizing.

Ensure the Fabricator performs the following:

(1) Before performing Work, supply a Quality Manual (QM) as approved by the Bridge Engineer and meeting the requirements of the *AASHTO/NSBA Steel Bridge Fabrication QC/QA Guide Specification* and the *AASHTO/NSBA Guide Specification for Coating Systems with Inorganic Zinc-rich Primer*
(2) Do not apply the coating Material to a part until the Bridge Engineer inspects and approves the Work

The Bridge Engineer may reject Material coated before approval in accordance with 1512, “Unacceptable and Unauthorized Work.” Remove rejected Material as directed by the Bridge Engineer.

L.1 Galvanizing

Galvanize in accordance with 3392, “Galvanized Hardware,” 3394, “Galvanized Structural Shapes,” 2471, “Structural Metals,” and as shown in the Special Provisions.

Purchase order(s) shall identify which specific items are to be duplex coated and which Materials to be galvanized are reactive (e.g. 3309, "High-Strength Low-Alloy Structural Steel," etc.).

Completely seal weld contacting or welded overlapping surfaces. Degrease Material for rolled or folded joints before forming.

Clean Material of paint, lacquer, and crayon markings before galvanizing. Do not galvanize closed or blind sections of pipe.

Prior to pickling and galvanizing, abrasive blast clean surfaces to be galvanized to *SSPC-SP 6/NACE No. 3*, "Commercial Blast Cleaning.” The following products are exempt from this requirement:

(1) Bearings
(2) Channel, Bent Plate, or Bolt assembled Diaphragms
(3) Sole Plates
(4) Expansion Devices
(5) Shear Connectors
(6) Ballast Plates
(7) Piling
(8) Drainage Systems
(9) Conduit
(10) Protection Angles
(11) Other systems or components designated by the Bridge Engineer

L.2 Metallizing

Before metalizing steel surfaces, blast and clean meeting the requirements of *AWS C2.18, “*Guide for Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites.”

Use zinc metalizing wire or powder of a purity equal to *Federal Specification MIL-W-6712* (99.9 percent zinc). Metalize to an average coating total thickness of 0.010 inches. Coat to a thickness of at least 0.0075 inches.

Preheat the substrate to 250°F to eliminate surface condensation and reduce shrinkage and differentials between the coating and the substrate. Do not metalize unless approved by the Bridge Engineer in writing.

L.3 Painting

Prepare the surface and paint in accordance with 2479, “Inorganic Zinc-Rich Paint System,” unless otherwise required by the Contract.

Bevel corners of painted Bridge member edges to at least 1/16 inch. If thermal cutting Material to final size, grind or mill edges to remove thermal cutting marks sufficient to achieve and measure the required painting surface profile.

M Fabricator Inspection

Ensure the Fabricator provides QC personnel as required by the approved Quality Manual (QM) and the following:

M.1 Nondestructive Testing

M.1.a General

Ensure the Fabricator performs nondestructive testing (NDT) in accordance with the appropriate ASTM specifications and applicable welding code specifications and the following:

(1) Use trained personnel, who have at least two years of experience as an American Society for Nondestructive Testing (ASNT) NDT Level II operator and qualified in accordance with *ASNT-TC-1A*
(2) Submit a copy of the NDT operators training and certification records to the Bridge Engineer before performing any NDT inspections
(3) Provide the Bridge Engineer a copy of the written practices and procedures for each NDT method used
(4) Submit a final written report of NDT to the Bridge Engineer, with interim test reports submitted as performed

M.1.b NDT Bridge Components

Perform NDT at locations and frequencies in accordance with the Contract and/or the applicable welding code with the following modifications:

(1) 100 percent Radiograph Testing (RT) is required of any CJP horizontal web splices
(2) 100 percent RT or Ultrasonic Testing (UT) is required for backing bars, when used and left in place
(3) Radiograph Testing (RT) is required for any CJP web or flange welds in compression or shear areas
(4) In addition to testing one-sixth of the web depth beginning at the point(s) of maximum tension 50 percent of the remaining area will be tested

If the Contract or welding code does not otherwise specify NDT, 100 percent Ultrasonic Testing (UT) of any CJP is required.

Ensure the Fabricator performs the following:

(1) Do not weld groove-welded parts to other members until the Bridge Engineer approves NDT of groove welds
(2) Perform NDT of repair welding in accordance with the repair procedure as described in 2471.3D.6, “Nonconformances,” at no additional cost to the Department
(3) Perform NDT of areas required by the Bridge Engineer

The Department may require NDT of areas not designated in the Contract for such inspection. If the inspection shows the area to be defective, the Fabricator shall perform the NDT at no additional cost to the Department. If the inspection is satisfactory, the Department will pay for the inspection as Extra Work in accordance with 1402, “Contract Revisions.” In addition, when NDT of an area designated in the Contract for inspection shows defects, the Bridge Engineer may direct the Fabricator to perform NDT of adjacent areas to determine the extent of the defective area, at no additional cost to the Department.

M.1.c Visual Testing

Ensure the Fabricator performs visual inspections during the entire welding process and again after the weld is complete, cool, and clean of slag and residue. Final visual inspections for acceptance will be documented and made available to the Bridge Engineer for review.

M.1.d Dye Penetrant Testing

Ensure the Fabricator checks edges of complete penetration groove welds on Major Structural Components for 3 inches on each side of the centerline of the weld or 1 inch beyond either side of the weld area, whichever is greater, using Dye Penetrant Testing. The Fabricator may substitute Magnetic Particle Testing with approval from the Bridge Engineer.

M.1.e Magnetic Particle Testing

Ensure the Fabricator performs Magnetic Particle Testing on the following:

(1) At least 12 inches of every 10 feet of length for fillet welds in Major Structural Components and pedestrian Bridges
(2) 100 percent of bearing stiffener welds
(3) At least 20 percent of weld terminations
(4) 100 percent of the base plate and gusset plate welds for overhead signs and high mast Light Poles

Ensure the Fabricator locates the tests at random areas of the weld. Do not use the prod method unless approved by the Bridge Engineer.

M.1.f Radiographic Testing (RT)

Provide Computed Radiography (CR) or Digital Radiography (DR). The Department will retain ownership of radiographic images provided by the Contractor. Name image files with Bridge number and weld identification shot number.

Electronic Radiography method(s) consist of CR utilizing Storage Phosphor Imaging Plate (SPIP) or DR utilizing a Digital Detector Array (DDA).

Ensure CR complies with *ASTM E2033, Standard Practice for Radiographic Examination Using Computed Radiology (Photostimulable Luminescence Method)*, and *ASTM E2445, Standard Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems*. Ensure DR complies with *ASTM E2698*, *Standard Practice for Radiological Examination Using Digital Detector Arrays*, and *ASTM E2737, Standard Practice for Digital Detector Array Performance Evaluation and Long-Term Stability*.

Ensure SPIP and DDA widths are sufficient to depict all portions of the weld joint, including the HAZs, and provide sufficient additional space for the required hole-type or wire-type IQIs and radiograph identification without infringing upon the area of interest.

Ensure radiographic images are free from mechanical, chemical, or other blemishes to the extent that they cannot mask or be confused with the image of any discontinuity in the area of interest in the radiograph. Such blemishes include, but are not limited to the following:

(1) False indications due to defective plates or internal faults
(2) Artifacts due to non-functional pixels

Ensure the contrast and brightness range that demonstrates the required sensitivity be considered valid contrast and brightness values for interpretation. When multiple IQIs are utilized to cover different thickness ranges the contrast and brightness range that demonstrates the required IQI image of each IQI is determined. Intervening thicknesses may be interpreted using the overlapping portions of the determined contrast and brightness ranges. When there is no overlap, additional IQI(s) are to be used.

When performing CR or DR, ensure a measuring Scale is utilized to serve as a length reference. The Scale is to be attached to the SPIP holder or DDA prior to exposure. As an alternative, when using SPIPs a transparent Scale with opaque gradations may be placed on the SPIP prior to processing. In any case, the reference comparator cannot interfere with interpretation of the image.

Provide a Work station monitor for evaluating images equipped with a display resolution with a pixel count which is at least equal to the pixel count of the direct imaging plate.

Archive images using a reproducible electronic medium. Provide data file format and storage that comply with *ASTM E2339, Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)*, format. Documented and prove the image archival method (at system installation). Include the image file nomenclature to enable the retrieval of images at a later date. Archived image files must maintain the bit depth and spatial resolution of the original image. Image data compression is not allowed. Preserve (store) the initial image presented by the CR or DR system without altering the original spatial resolution and pixel intensity. Preserve (store) the final image used for disposition when additional image processing is applied (excluding window/level and digital image zoom) to achieve the required image quality level. Store annotations made to the image in a manner which will not mask or hide diagnostic areas of the image.

M.1.g Overhead Signs

The Department considers sign posts and trusses for free standing cantilevered and non-cantilevered overhead signs as cyclically loaded Structures. Bridge mounted signs are considered statically loaded Structures. Provide overhead sign Structures welded in accordance with the requirements of *AWS D1.1*, “Structural Welding – Steel,” as outlined in the *AASHTO Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. Perform RT, UT, and MT, as outlined in the current overhead sign standards sheets. The Bridge Engineer will base acceptance for overhead signs in accordance with *AWS D1.1*.

N Department Inspection

N.1 General

The Bridge Engineer will inspect Major and Minor Structural steel Components before use in the Work. The Bridge Engineer may perform inspections at the mill, foundry, fabrication shop, or in the field.

The purpose of Department inspection(s) is to establish compliance with those test requirements and process controls outlined in the Contract as required by federal and State laws. The Department inspection does not supplement or replace the Supplier’s own Quality Control and does not relieve the Supplier of its responsibility for the correction of errors and faulty workmanship, or for the replacement of nonconforming Materials.

The Department may reject Work not performed in accordance with the Supplier's approved QM in accordance with 1512, "Unacceptable and Unauthorized Work."

The Department will not charge the Contractor for plant inspections by Department personnel.

Provide the Department Inspectors with suitable hard hats, face and hand shields, safety glasses, respirators, and other safety Equipment necessary to ensure the Inspector's safety while performing structural metals inspections.

Notify the Bridge Engineer at least 5 Business Days before the Fabricator begins Work to allow the Bridge Engineer to perform inspections. Do not allow the Fabricator to perform Work or manufacture Material until after notifying the Bridge Engineer. The Bridge Engineer may reject Work performed without notice in accordance with 1512, "Unacceptable and Unauthorized Work," or may subject the Work performed to additional NDT, at no additional cost to the Department.

The Department may reject Material or Work not meeting the requirements of the Contract. The Contractor, in conjunction with the Fabricator, may appeal to the Bridge Engineer. The Bridge Engineer will make final decisions on disputes.

The Bridge Engineer may reject Material shipped to the Project Site without a Department inspection tag as unacceptable Work in accordance with 1512, "Unacceptable and Unauthorized Work."

N.2 Facilities for Inspection

Ensure the Fabricator provides an office, access to a computer and a copy machine, and any needed tools and assistance to the Inspector for at least 30 Business Days before Work is scheduled to start to 30 Business Days after the shipment of Material.

Ensure the Fabricator provides an Inspector's office meeting the following requirements and characteristics:

(1) Floor space of at least 100 square feet
(2) Containing at least 2 desks, or a desk and table, 2 chairs, a file case, and other necessary furniture
(3) Clean, modern, and having adequate lighting, heating, and ventilation
(4) Located in a completely partitioned area and provided with a separate locking door
(5) Contains telephone service and a separate high-speed computer data connection

The relevant Contract Unit Price for steel Bridge construction includes the cost of providing, maintaining, and repairing, or replacing inspection facilities as included in the cost of steel bridge construction.

O Marking and Shipping

Ensure the Fabricator performs the following:

(1) Before shipping, legibly mark Material according to the field erection Plan, and as approved by the Bridge Engineer
(2) Place markings on the "inside" of fascia beams on a Bridge
(3) Mark duplicate pieces unless otherwise approved by the Bridge Engineer
(4) Bolt connection plates for members in position for shipment

(5) Ship pins, bolts, nuts, and washers in weatherproof containers no greater than 500 pounds. Ship pins with nuts in place

(6) Package bolts of the same length and diameter, nuts, and washers meeting the requirements of *ASTM F3125, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, "*Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength"

(7) Pad coated Material to keep the Material clean and undamaged during loading, transporting, unloading, handling, and storage

(8) Ship beams and girders in an upright position, unless otherwise approved by the Bridge Engineer. Block Material to prevent buckling, warping, or twisting during transportation

(9) Block cambered members to prevent loss of camber

2471.4 METHOD OF MEASUREMENT - BLANK

2471.5 BASIS OF PAYMENT - BLANK

2472 METAL REINFORCEMENT

2472.1 DESCRIPTION

This Work consists of providing and placing metal reinforcement of the types, shapes, and sizes as required by the Contract.

2472.2 MATERIALS

A Reinforcement Bars 3301

B Welded Wire Reinforcing 3303

C Spiral Reinforcement 3305

2472.3 CONSTRUCTION REQUIREMENTS

A Bending

Bend bars to the shapes as shown on the Plans. The Contractor may bend the bars cold. If hot bending a non-coated bar, do not heat bars to temperatures greater than 1,200°F and do not quench the bars.

Bar bending details shall conform to the *American Concrete Institute 315*, "Details & Detailing of Concrete Reinforcement," unless otherwise shown or noted in the Plans. Ensure that the bar bend diameters are as shown "Recommended" in the *American Concrete Institute 315*.

Repair bond loss or coating damage after bending epoxy coated reinforcement bars in accordance with 3301, "Reinforcement Bars." Clean damaged areas to remove loose or deleterious Material before patching. Remove rust by blast cleaning. The Engineer, in conjunction with the Materials Engineer, will not require the repair of hairline cracks with no bond loss or other damage. Perform repairs before oxidation appears.

B Storage and Protection

Do not store metal reinforcement in a manner that will cause, induce, or accelerate corrosion or contamination of the metal. Locate timbers (dunnage) on the ground to support the bundles and keep them free of contamination. Store Materials at the Project Site to allow the Engineer to visually inspect and check the various types of reinforcement for conformance to the dimensions as shown on the Plans. Store bars of the same type together. Identify reinforcement bars with tags bearing the identification symbols as shown on the Plans.

Protect coated reinforcement bars before handling or shipping to prevent damage to the coating. Pad bundling bands and lift bundles using an OSHA-approved spreader bar, multiple supports, or platform Bridge to prevent bar-to-bar abrasion from sags in the bar bundle. Do not drag or drop bars or bundles. Support bars or bundles in transit to prevent damage to the coating.

If the epoxy-coated reinforcing steel is incorporated into the Project and is exposed to the weather or stored exposed to the weather for more than 60 Calendar Days, cover the steel to protect the Material from sunlight, salt-spray and weather exposure. Provide for air circulation around the covered steel to minimize condensation under the protective covering.

C Placing, Supporting, and Tying Bar Reinforcement

C.1 General Requirements

Before placing concrete in a unit, ensure the reinforcement bars meet the condition defined in the current CRSI manual *Placing Reinforcing Bars*, Chapter VII, “Unloading, Storing, and Handling Bars on the Job.” Place the bars as specified in “Tolerances in Placement” section in Chapter X, “General Principles for Bar Placing, Splicing and Tying Reinforcing Bars.”

Carefully place the beam seat/pedestal reinforcement to avoid interference with drilling holes for fixed bearing anchor rods. Provide a template demonstrating that the anchor rods have a 2 inch clear distance to all reinforcement for the entire embedment at all bearing anchor rod locations. Confirm the proper clearance to the reinforcement with the Engineer prior to placing the affected Substructure concrete. Place the beam or girder in its final position prior to drilling or coring holes for the anchor rods. If reinforcement steel is encountered during the drilling or coring process, contact the Engineer, and the Engineer will determine how to proceed. Verify the depth of the holes in the presence of the Engineer prior to inserting the anchor rods.

Firmly support and securely tie reinforcement bars in their proper position. Tie all outermost intersections, and enough of the intermediate intersections, to ensure that no shifting or displacement of the bars will occur during subsequent operations. Bar supports are intended to support the steel reinforcement and normal construction loads; and are not intended to, and should not be used to, support runways for concrete buggies or similar loads. Use black, soft iron wire of at least 16 gauge for tying the reinforcement bars. Do not use welded ties. Do not place concrete before the Engineer inspects and approves the placement, support system, and ties for the reinforcement bars.

Provide supports with any of the following characteristics for reinforcement bars bearing on the falsework sheathing for exposed concrete surfaces:

(1) Stainless steel
(2) Hot-dip galvanized, epoxy, vinyl, or plastic coated tips extending at least 1/2 inch above the sheathing
(3) Plastic

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

C.2 Special Requirements for Bridge Slabs

Support and tie reinforcement bars for Bridge slabs in accordance with the 2472.3C.1, “Placing, Supporting, and Tying Bar Reinforcement, General Requirements,” and the maximum spacing requirements specified in Table 2472.3-1. These spacing requirements define only the maximum permissible distances between ties or lines of support. Table 2472.3-1 does not relieve the Contractor of responsibility for providing additional supports or ties for holding and supporting bars firmly in their correct position.

For Bridge slabs, use slab bolsters as the primary support for the bottom transverse reinforcement bars meeting the requirements of “Bar Support Specifications and Standard Nomenclature” in the *CRSI Manual of Standard Practice*. Place the bolsters on the falsework sheathing in continuous lines, parallel to the beams, girders, or centerline of the Roadway at locations that will permit placement of supports for the top transverse reinforcement bars directly over the bolsters on the bottom transverse bars.

Use continuous lines of upper continuous high chairs with wire runners as the support system for the top transverse reinforcement bars. Place the high chairs to transfer load to the bottom bolsters without causing deflection in the bottom transverse bars. Use individual type high chairs only as supplemental support or for sections where the use of continuous type high chairs is not practical and the Engineer approves, in writing, the use of the individual type high chairs.

For interior bays on beam span Bridges, place slab bolsters and upper continuous high chairs within 6 inches of the edge of beam flanges.

Use tie wires to tie down the top mat of Bridge slab reinforcing to the in-place beam stirrups or shear connectors at spacing no greater than 5 feet, as measured longitudinally along each beam.

If the support system specified in this section is not practical, the Contractor may propose an alternative support system for slab span Bridges or other special designs. Provide working drawings showing the proposed support system to the Engineer. If accepted by the Engineer in writing, the Contractor may use the proposed support system.

Table 2472.3-1
Maximum Spacing of Supports and Ties for Bridge Slabs

Bar Size Number	Maximum Spacing for Slab Bolsters and Continuous Type High Chairs, feet
3 and 4	3.00
5, 6, and 7	4.00

Support the bottom layer of longitudinal reinforcement bars for slab span Bridges, cast-in-place concrete girders, beams, struts, and similar sections on beam bolsters or heavy beam bolsters commensurate with the mass to be supported. Do not use precast concrete block or brick supports on formed surfaces.

Use the upper beam bolsters or the upper heavy beam bolsters to support subsequent Layers of longitudinal bottom reinforcement, except for bars that can be tied to vertical bars, unless otherwise approved by the Engineer.

After the completion of the placement and tying of the reinforcement bars for a section of Bridge slab, and before ordering concrete delivery for that section, set the strike-off rails or guides to the correct elevation. Notify the Engineer when the section is ready for a final check. Operate the strike-off device over the entire section in the presence of the Engineer. Attach a filler strip, 1/4 inch less in thickness than the minimum concrete cover requirement, to the bottom of the strike-off during this check to detect areas where the top reinforcement may encroach on the required clearance. Do not place concrete for a Bridge slab before the Engineer inspects and approves the deck grades.

Tie the top mat of epoxy-coated reinforcement bars at every transverse bar intersection along each continuous row of longitudinal bars. Tie the bottom mat of reinforcement bars and non-continuous rows of top mat bars at least at every second transverse bar intersection.

Stagger the ties for the bottom mat along adjacent rows of longitudinal bars. Use plastic or nylon-coated tie wires.

Use plastic bar supports or epoxy-coated wire bar supports with coating resistant to abrasion. Provide epoxy coating for bar supports at least 0.005 inch thick and in accordance with 3301, “Reinforcement Bars.” Provide plastic coated tips or additional epoxy coating on the legs of the supports for wire bar supports that bear on falsework sheathing for exposed concrete surfaces. Ensure the additional Material extends at least 1/2 inch above the sheathing, not including portions of the supports other than the legs. Use a grey-colored coating with a total coating thickness on the 1/2 inch portion, including the initial 0.005 inches of epoxy coating, of at least 3/32 inch. Use incompressible and abrasion resistant plastic or epoxy Material.

C.3 Special Requirements for Coated Bars

The Engineer will not require the Contractor to repair damage caused during shipment of coated bars or by the installation procedures if the damaged area is no greater than 1/4 inch by 1/4 inch and the sum of damaged areas in each 1 foot length of bar is no greater than 2 percent of the bar surface area. Repair damage greater than 1/4 inch by 1/4 inch as recommended by the manufacturer of the epoxy coating (consisting of a two-part epoxy not a spray can). The Engineer will reject bars with total damage greater than 2 percent of bar surface area. Remove and replace rejected bars at no cost to the Department. Ensure the total bar surface area covered by patching Material is no greater than 5 percent.

Do not flame cut coated reinforcing bar in any application.

If using an abrasive blade to cut epoxy-coated reinforcing bar and the cut ends are properly coated with a two-part epoxy patching Material as recommended by the manufacturer of the epoxy coating, the Department will allow cutting of epoxy-coated bars.

Use a non-metallic vibrator head to consolidate the concrete around coated reinforcement bars and other components.

D Splicing Metal Reinforcement

Provide reinforcement in the lengths shown on the Plans. Do not place splices unless otherwise shown on the Plans or approved in writing by the Engineer. Place field splices at locations and with details as approved by the Engineer.

D.1 Lap Splices

Provide lap splices as shown on the Plans. If not shown on the Plans, provide bar reinforcement lap lengths per Table 2472.3-2.

Table 2472.3-2
Length of Bar Splices

U.S. Customary Bar Size	Diameter		Number of Diameters	Length of Splice, inches
	Fraction, inches	Decimal, inches		
3	3/8	0.375	36	14
4	1/2	0.500		18
5	5/8	0.625		23
6	3/4	0.750		27
7	7/8	0.875		32
8	1	1.000	40	40
9	1-1/8	1.128		45
10	1-1/4	1.270		51
11	1-3/8	1.410		56
14	1-3/4	1.693	Must be pre-approved by the Engineer in writing	
18	2-1/4	2.257		

Lap wire mesh reinforcement at least the width of one full mesh plus 2 inches for transverse laps or one full mesh plus 2 inch plus two end overhangs for longitudinal laps.

D.2 Mechanical Splice Couplers for Reinforcement Bars

At least 42 Calendar Days before incorporating the mechanical splices in the defined location, submit to the Engineer a Materials list of the splicers selected from *Approved/Qualified Products List* to be used on the Project for "Mechanical Splices for Reinforcement Bars."

For each product submitted from the *Approved/Qualified Products List*, provide a separate written list that includes the following:

(1) Name of manufacturer
(2) Model of mechanical splice
(3) Size of mechanical splice
(4) Quantity ordered for the Project
(5) Bar type recommended per the Contract

(a) Plain non-coated steel reinforcement
(b) Epoxy-coated in accordance with 3301, “Reinforcement Bars”
(c) A manufacturer recommended shrink wrap Material
(d) Stainless steel in accordance with the "Stainless Steel Reinforcement Bars" Special Provision in the Proposal

Assemble mechanical splices as recommended by the manufacturer.

E Spiral Reinforcement

The Contractor may provide rigid or collapsible cages of spiral reinforcement for circular columns. Finish the ends of each column spiral with one and one-half turns of the reinforcement.

The Contractor may make the spiral cages rigid by tying the vertical column bars to the spiral wires at their intersections or by using epoxy-coated metal spacer strips. Provide enough tied intersections or use enough spacer strips to ensure a rigid non-collapsible cage with properly spaced loops when the cage is in its final position. Do not tack weld the reinforcement.

Provide full-length spiral reinforcement cages. If approved by the Engineer, provide spiral reinforcement cages in two pieces with added stock to provide for lapping the two adjoining ends at least one and one-half turns.

2472.4 METHOD OF MEASUREMENT

A Reinforcement Bars

The Engineer will measure Reinforcement bars, including reinforcement in bar mats, by the weight incorporated into the structure in accordance with Table 2472.4-1. The Engineer will only include quantities for splices shown on the Plans.

Reinforcement bars are marked in U.S. Customary or metric sizes. Table 2472.4-1 specifies the Nominal dimensions of the bar:

Table 2472.4-1
Reinforcement Bars - Theoretical Weights

U.S. Customary Bar Size	Metric Bar Size*	Nominal Dimensions		
		Diameter inches (millimeter)	Area square inches (millimeters squared)	Weight pound/foot (kilogram/foot)
3	10	0.375 (9.5)	0.11 (71)	0.376 (0.560)
4	13	0.500 (12.7)	0.20 (129)	0.668 (0994)
5	16	0.625 (15.9)	0.31 (199)	1.043 (1.552)
6	19	0.750 (19.1)	0.44 (284)	1.502 (2.235)
7	22	0.875 (22.2)	0.60 (387)	2.044 (3.042)
8	25	1.000 (25.4)	0.79 (510)	2.670 (3.973)
9	29	1.128 (28.7)	1.00 (645)	3.400 (5.060)
10	32	1.270 (32.3)	1.27 (819)	4.303 (6.404)
11	36	1.410 (35.8)	1.56 (1006)	5.313 (7.907)
14	43	1.693 (43.0)	2.25 (1452)	7.650 (11.380)
18	57	2.257 (57.3)	4.00 (2581)	13.600 (20.240)
* Bar designation numbers approximate the Nominal diameter of the bar in millimeters.				

B Welded Wire Reinforcing

The Engineer will measure Welded wire reinforcing by the weight incorporated into the Structure, based on the quantity shown on the Plans. The Engineer will only include quantities for splices shown on the Plans.

C Spiral Reinforcement

The Engineer will measure Spiral reinforcement by the weight incorporated into the Structure, based on the weight shown in the table in Chapter 250 of the *Bridge Construction Manual*. The Engineer will only include quantities for splices shown on the Plans.

D Mechanical Splice Couplers

The Engineer will measure Reinforcement bar couplers by the number of mechanical splice couplers installed as required by the Contract and as directed by the Engineer.

2472.5 BASIS OF PAYMENT

The Department will pay for metal reinforcement at the Contract Unit Prices for the Contract Items listed in the detailed Specifications for the type of Structure where the metal reinforcement is used. For Structure type, with no detailed Specifications, the Department will pay for metal reinforcement on the basis of the following schedule. The Contract Unit Price for the relevant metal reinforcement Contract Item includes the cost of providing, fabricating, delivering, placing the metal reinforcement as specified in this section, bar supports, bar chairs, spacers, and tie wire.

The Contract Unit Price for Spiral Reinforcement includes the cost of metal spacer strips, bar supports, and tie wires.

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

Item No.	Item	Unit
2472.502	Mechanical Splice Couplers (Reinforcement Bars) T-___	each
2472.508	Reinforcement Bars	pound
2472.508	Welded Wire Reinforcing	pound
2472.508	Spiral Reinforcement	pound

2473 EXPANSION JOINT DEVICES

2473.1 DESCRIPTION

This Work consists of providing and installing a watertight expansion joint device consisting of a preformed non-reinforced strip seal that is mechanically locked into a structural steel rail anchored into a Bridge or other Structure.

2473.2 MATERIALS

A Single Joint Device

Provide a watertight expansion joint device for movement up to 4 inches.

A.1 Joint Seal

Furnish a single diaphragm unreinforced neoprene gland whose physical and chemical properties conform to *ASTM D5973, Standard Specification for Elastomeric Strip Seals with Steel Locking Edge Rails Used in Expansion Joint Sealing*.

Department Special Requirements:

(1) Durometer requirement of 60 ±5

(2) Seal 1/4 inch thick, subject to a minimum thickness of 7/32 inches; furnish certified test results from the manufacturer attesting to the physical and chemical properties of the expansion joint devices in accordance with 1603, "Materials: Specifications, Samples, Tests, and Acceptance"

(3) Provide copies of the Certificate of Compliance test results from Department Laboratory for the Engineer including the lot number of the seal provided

A.2 Steel Extrusion

Provide only one of the devices shown on the Department's *Approved/Qualified Product Lists* for Bridge products, “Expansion Joint System.” The Fabricator will install a filler Material in the seal groove in the steel rail which will prevent any unwanted Material from entering.

A.3 Lubricant-Adhesive

Provide only one of the approved lubricant adhesives shown on the Department's *Approved/Qualified Product Lists* for Bridge products, “Expansion Joint Lubricant Adhesive.”

A.4 Cover Plates

Provide expansion joint cover plates on pedestrian Bridges and Sidewalk areas that are raised pattern plate.

B **Modular Bridge Joint Systems**

Provide a watertight expansion joint device for movement greater than 4 inches.

Provide only one of the devices shown on the Department's *Approved/Qualified Product Lists* for Bridge products, “Modular Bridge Joint System.” For products not on the Department's prequalified list, provide information as required on the website so it can be evaluated and potentially qualified.

2473.3 CONSTRUCTION REQUIREMENTS

A **General**

Perform the Work in accordance with the applicable requirements of 1703, "Patented Devices, Materials, and Processes," 2401, “Concrete Bridge Construction, “ 2402, "Steel Bridge Construction," 2471, “Structural Metals,” the Plans, and the following:

B **Single Joint Device**

B.1 **Joint Seal**

Extend seals beyond the ends of the edge and center beams by at least 2 inches.

Remove filler Material and clean joint seal to steel contact areas of dirt, oil, grease, or other contaminants before installing the seal.

Lightly sandblast the contact areas so as to roughen but not damage the galvanized surface just before applying the lubricant-adhesive.

Apply lubricant-adhesive on both seal and galvanized steel contact areas when installing the seal.

Install the seal only with tools recommended by the manufacturer.

B.2 **Field Welding**

A certified welder will be permitted to weld galvanized sections of expansion device steel rail at the crown breaks if the following is met:

(1) Individual is qualified in accordance with *AWS D1.1,* “Structural Welding - Steel”; welding must be done by an individual certified in accordance with *AWS D1.1* using an approved weld procedure for the application
(2) Provide Roadway sections that are not less than 10 feet long
(3) Provide an anchorage within 9 inches of each end of the sections. This may require inclusion of additional anchorages
(4) Bevel abutting ends 1/4 inch on 3 edges and de-burr the edges
(5) Prepare the surfaces to be welded as per 2471.3G.2, "Preparation of Base Metal"
(6) Groove weld the sections on 3 sides preventing weld metal from entering the gland seal groove
(7) Grind the weld smooth on the top of the extrusion
(8) Repair the welded surface as per 3394, "Galvanized Structural Shapes," prior to encasing in concrete. Repair the welded surface as per 3394, "Galvanized Structural Shapes”

B.3 **Steel Extrusion**

Provide only one of the devices shown on the Department's *Approved/Qualified Product Lists* for Bridge Products, “Expansion Joint System.”

B.4 Lubricant-Adhesive
Apply as recommended by the manufacturer.

C Modular Bridge Joint Systems (MBJS)
Install the MBJS in a manor acceptable to the manufacturer and the Engineer.

C.1 Submittals
Furnish Certificates of Compliance to:

Structural Metals Engineer
MnDOT Bridge Office
3485 Hadley Ave. N.
Oakdale, MN 55128-3307

C.1.a Material Certifications, Calculations, Installation and Maintenance Plan, and Acceptance
Include the following information in the Certificates of Compliance submittal:

Certification that the control springs are produced by the same manufacturer with the same process and in the same configuration as those used in the Opening Movement and Vibration (OMV) Test. Certification that the same lubricant-adhesive used for the Seal Push Out Test was also used to assemble the MBJS. Include the manufacturer's name and contact information as well as production date and lot identifiers.

Certification that MBJS sub-assemblies with similar center beam and support bar cross-sections and joints have passed pre-qualification testing requirements described in this Specification.

Design calculations sealed by a Professional Engineer licensed in Minnesota.

Method of installation including, but not limited to, sequence, installation gap setting for various temperatures, support during placement of the concrete, and installation at curbs.

Any required changes to the blockout reinforcement in order to accommodate the MBJS.

A temporary bridging Plan for any MBJS for which construction and public traffic is anticipated following installation.

Submit a 12 inch section of elastomeric seal Material from each lot of Material furnished, and samples of the PTFE sheet, size 2 inches by 3 inches by 1/8 inch from the production Material to the Engineer for testing, if requested in writing.

C.1.b Shop Drawings
Submit shop drawings for the MBJS in accordance with the requirements of 2473.3C.1.b, "Shop Drawings," and include, but not limited to, the following additional items:

Plans and section views of the MBJS for each movement rating and Roadway width showing dimensions and tolerances.

Show welded center beam-to-support bar joints.

Show welded shop splices and welded field splices.

Complete details of components and sections showing Material incorporated into the MBJS.

All appropriate Material designations (MnDOT, ASTM, AASHTO etc.).

Corrosion protection system.

Lifting locations and lifting mechanisms for installation.

Opening adjustment devices for temperature variations and opening dimensions relative to temperature.

C.2 Fabrication Requirements

The same manufacturer is required to fabricate all MBJS components.

Hot-dip galvanize all structural steel surfaces, except those made of stainless steel, after fabrication per 3394, "Galvanized Structural Shapes."

Weld stainless steel sheet at each end to the steel substrate with an accepted welding procedure. Clamp down the stainless steel sheet to have full contact with the substrate during welding. Do not allow welds to protrude beyond the sliding surface of the stainless steel. Intermittent fillet welds are not allowed.

Ensure tops of the edge and center beams are in the same plane with a maximum tolerance of 1/8 inch difference in elevation among the tops of the center beams or edge beams.

Ensure the support box flatness at bearing and compression spring locations is not out of flat in excess of 1/32 inch.

Ultrasonically inspect the full-penetration weld that connects the center beam to the support bar in accordance with 2471, "Structural Metals," and *AWS D1.1*, "Structural Welding - Steel." Test 25 percent of the center beam-to-support bar welds, or as directed otherwise by the Engineer. If ultrasonic inspection reveals a rejectable weld defect, the Fabricator shall then ultrasonically inspect an additional 25 percent of the center beam-to-support bar welds (25 percent of the original total of welds). If a rejectable defect is found in the second 25 percent set of welds (50 percent of total), all remaining non-inspected welds shall then be inspected. Repair each weld that is rejected by ultrasonic inspection using a welding procedure approved by the Engineer. Retest the repaired welds by ultrasonic inspection in accordance with the original requirements.

CJP welds will be tested to cyclically loaded criteria.

The Fabricator will be permitted to shop-weld galvanized sections of the edge and center beams if the following requirements are met:

(1) Provide Roadway sections that are not less than 10 feet long
(2) Bevel abutting ends 1/4 inch and deburr the edges
(3) Prepare the surfaces to be welded as per 2471.3G.2, "Preparation of Base Metal"
(4) Groove-weld sections with care taken to prevent weld metal from entering the seal groove. Completely remove galvanizing from the weld area. Grind smooth the weld across the top of the beams. Repair areas of galvanizing damaged by welding operations in accordance with 2471.3L.1, "Galvanizing"

(5) Attach anchorages and support boxes to the edge beam section prior to galvanizing. Provide an anchorage within 9 inches of each end of each pre-galvanized section

If field splices will be used, stagger the ends of the edge and center beams so that they are not at the same point on each beam.

Assemble each MBJS at the fabrication shop. Install elastomeric seals at the shop. Use continuous seals for the full length of each MBJS. Apply lubricant adhesive to elastomer-to-steel contact areas for seal installation.

C.3 Lifting and Preset Opening Devices

Provide lifting devices for the MBJS. Provide other devices to maintain the preset openings at a uniform spacing not greater than 15 feet along its length. Use at least 3 such devices per fabricated segment.

C.4 Joint Seal

Extend seals beyond the ends of the edge and center beams by at least 2 inches.

C.5 Field Splice Welds in Edge and Center Beams

Fabricate and ship each MBJS to the Project Site as a single unit unless any of the following conditions apply:

(1) The Bridge will be constructed in stages with longitudinal construction joints.
(2) The full length of a MBJS would make shipping impractical.
(3) Other factors unique to the Project that would require field splices.

Only field splice details that have been designed in accordance with *AASHTO LRFD Bridge Design Specifications* can be used for the MBJS. Locate splices away from wheel tracks and in areas of least live load stress. Edge beams may be field-welded with fillet welds covering only part of the beam profile.

Ensure center beam splices are welded connections. The span – between support beams – in which the field splices are located, cannot exceed the maximum length of 3 feet.

If the MBJS contains only a single center beam, a complete joint penetration (CJP) field weld will be used.

Design the MBJS, taking into account any different installation procedures required under conditions that require field splices. Clearly indicate such procedures on the shop drawings.

C.6 Field Installation Requirements

To aid in assuring proper installation of the MBJS, the manufacturer shall furnish technical assistance to the Contractor and Engineer through a technical representative who is a full-time employee of the manufacturer. The representative shall be accessible to the Engineer and at the site during the Work that involves the setting of all parts of each device. Inform the representative of the date of installation.

Immediately prior to installation, the Engineer will inspect the MBJS and the blockout for:

(1) Proper alignment
(2) Complete bond between the seals and the edge/center beams

(3) Placement and effectiveness of the anchorage devices. Correct any bends, kinks, disconnected seals, and other deficiencies, per the judgment of the Engineer, before installation at no expense to the Department. Perform an audio hammer test on the welded stud anchors. Replace studs that do not emit a ringing sound when struck lightly with a hammer as ordered by the Engineer.

Maintain the clearance shown in the Plans and/or shop drawings between the bottoms of the support boxes and the tops of the beams.

Reposition reinforcement bars that are cast into the deck and abutment, if possible, in lieu of cutting to provide a minimum of 2 inches of clearance to the support boxes, anchorage devices, and edge beams. Also, maintain a minimum of 2 inches of clearance for reinforcement bars placed during installation of the MBJS. Alter bar spacing shown in the Plans to clear the MBJS.

If welded field splices are used for the edge and center beams, prevent weld metal from entering the seal retainer grooves.

Install each MBJS at the joint opening given on the shop drawings for a specific ambient temperature, or as adjusted by the manufacturer's installation technician for the temperature at time of installation. Ensure tops of the edge and center beams are in the same plane with a maximum tolerance of 1/8 inch difference in elevation among the tops of the center beams or edge beams. Measure this variation vertically from a straight line connecting the top of the deck profile on each side of the MBJS. Ensure there is no more than 1/2 inch longitudinal difference among gap widths at either end of a seal or among multiple gaps.

Ensure formwork for the blockout concrete prevents entry of concrete into the support boxes, and do not allow concrete to impede free movement of the MBJS.

Fully support the MBJS during placement of the concrete in the blockout. Grout pads under the support boxes are not recommended, but if used, shall terminate beyond the sides of the support boxes.

Do not pour concrete until the MBJS installation and joint opening(s) – at the time of the pour – have been inspected and accepted by the Engineer in writing.

If there is a vertical grade on the Bridge, place concrete on the down-grade side of the block out first. Thoroughly vibrate the concrete so as to adequately consolidate the concrete underneath the support boxes and against the backside of the edge beams.

Construction loads will not be allowed on the MBJS for at least 72 hours after installation, including concreting, is complete. If necessary to cross the joint during that 72-hour period, bridge over the MBJS in a manner approved by the Engineer.

Ensure the complete MBJS installation is watertight at all points and test it by filling the joint opening or portions thereof, as designated by the Engineer, with water and observe the results over a period of not less than one hour.

2473.4 METHOD OF MEASUREMENT

A Expansion Joint Devices

The Engineer will measure Expansion joint devices of each type by length based on the horizontal distance between the outside edges of the deck measured along the centerline of the joint.

B Modular Bridge Joint System

The Engineer will measure Modular Bridge joint system of each type by length based on the horizontal distance between the outside edges of the deck measured along the centerline of the joint.

2473.5 BASIS OF PAYMENT

The Contract Unit Price for Expansion joint devices Type ___ includes the cost of providing and installing the devices complete in-place, including curb, Sidewalk, median, barrier sections, cover plates, and waterproof glands.

The Contract Unit Price for Modular Bridge joint system, Type ___ includes the cost of providing and installing the devices complete in-place, including curb, Sidewalk, median, barrier sections, cover plates, and waterproof glands.

The Department will pay for Expansion joint devices on the basis of the following schedule:

Item No.	Item	Unit
2473.503	Expansion Joint Devices Type _____	linear foot
2473.503	Modular Bridge Joint System Type ___	linear foot

2474 HIGH-LOAD MULTI-ROTATIONAL BEARINGS

2474.1 DESCRIPTION

Provide high-load multi-rotational (HLMR) bearing assemblies for use in Bridges and other Structures.

A Definitions

For the purpose of the Work specified in section 2474, “High-Load Multi-Rotational Bearings,” the Department defines:

Fixed Bearings
Allow rotation in the vertical plane, but no longitudinal or transverse movement in the horizontal plane.

Guided Bearings
Allow rotation in the vertical plane and movement in a horizontal plane in the longitudinal or transverse direction of the Bridge, as defined in the Plan. Horizontal movement in a direction transverse or longitudinal to the Bridge shall be restricted, as defined in the Plan.

Non-guided Bearings
Allow rotation in the vertical plane and horizontal movements in all directions.

2474.2 MATERIALS

Ensure all Materials used in the manufacture of pot and disc bearings are new and unused, with no reclaimed Material incorporated into the finished product.

2474.3 CONSTRUCTION REQUIREMENTS

A General

Perform the Work in accordance with the applicable requirements of 1703, "Patented Devices, Materials, and Processes," 2402, "Steel Bridge Construction," 2471, “Structural Metals,” the Plans, and the following:

Before the start of Work, the supplier will be qualified on *Approved Suppliers for Fabricated Structural Metals Products* list as maintained by the Structural Metals Engineer on the Bridge office website or become qualified. To become qualified, the supplier is to submit a Quality Manual (QM) to the

Bridge Engineer for review and acceptance, at least 60 Calendar Days before beginning Work. The QM is to meet the requirements of the *MnDOT Supplier Qualification Standard* which will be the basis for acceptance by the Bridge Engineer. Upon acceptance of the QM, a supplier is qualified and will be listed on the *Approved Suppliers for Fabricated Structural Metals Products* list. In addition to routine inspections, the Bridge Engineer will audit suppliers with approved QMs on a biannual or annual basis or as otherwise directed by the Bridge Engineer to ensure the implementation of the QM.

The Department will invoke its Corrective Action Process if the routine inspections or audits indicate non-conformance. Corrective actions deemed appropriate by the Bridge Engineer, are effective immediately and apply to any Work remaining on a current and future Projects. If the Bridge Engineer determines that Work does not comply with the QM or that fabrication does not follow approved fabrication procedures, the Bridge Engineer will deem the Materials as non-conforming in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” If the Bridge Engineer finds non-conforming Work, direct the supplier to immediately correct the procedure and submit a written Nonconformance Report, containing data required by the Bridge Engineer to ensure compliance with the QM, Specifications, and drawings. Perform additional testing as required by the Bridge Engineer at no additional cost to the Department. For repeat offences or negligence, the Department will require corrective action of hiring a third-party Quality Control Inspector at no additional cost to the Department. The Contractor may obtain a copy of the Department’s Corrective Action Process from the Bridge Engineer.

A.1 Bearing Types

Three types of bearings are specified in the Plans; Fixed, Guided, and Non-guided bearings, of varying load capacities.

A.2 Shop Drawings

Shop drawings for the bearing assemblies shall include, but not be limited to, the following:

(1) Complete details of components and sections showing Materials used in the bearing assemblies
(2) A listing of applicable MnDOT, ASTM, and AASHTO Specifications
(3) Load capacity for each bearing assembly
(4) Name and address of the manufacturer and location of the fabrication plant
(5) Name and telephone number of the manufacturer's representative who will be responsible for coordination of production, inspection, sampling, and testing
(6) Welding procedures used in the bearing assembly manufacture shall be clearly described and detailed
(7) Table of longitudinal offsets for installation at varying temperatures. Use 45°F as the mean temperature for zero-inch offset

Supplemental to the shop drawings, furnish design calculations which indicate that the bearings furnished by the manufacturer are adequate for the requirements of the Contract. Calculations shall include rotation and horizontal movement capacity, and compression stresses on elastomeric and sliding surfaces.

Furnish an erection Plan to the Engineer at or before the time of delivery showing the location and orientation of each of the bearings.

A.3 Bearing Dimension Options

Overall heights of the bearing assemblies, including the sole plates, are given in the Plans. The bearing manufacturer shall determine the thickness of the masonry and sole plates through design of the bearing assemblies and set the final height, Dimension "H,” of each of the assemblies.

Horizontal dimensions given for the masonry plates may be changed by the manufacturer in accordance with design. Anchor rod offsets from the centerline Pier/centerline Bearing shall remain as shown in the Plans to avoid causing interference of the anchor rods with the main reinforcement in the bearing seats.

If the final height of the bearing assemblies is different from that given in the Plans, the manufacturer shall clearly indicate the revised Dimension "H" and provide new bearing seat elevations to the Engineer.

A.4 Design and Fabrication Requirements

Design the bearings so that the pot cylinder and piston assembly of pot bearings, and the disc and both mating surfaces of disc bearings, can be removed for replacement or repair.

Provide for vertical and lateral loads, movements from temperature changes, rotation, camber changes, and the effects of creep/shrinkage of post-tensioned concrete box girders. Service and strength limit state design loads and movement values are given in the Plans.

Ensure Materials used in the manufacture of disc and pot bearings are new and unused, with no reclaimed material incorporated into the finished product.

Size stainless steel sliding surfaces to completely cover the PTFE surfaces in operating positions plus one additional inch in all directions of movement as given in the Plans except transversely in Guided Bearings.

Do not start fabrication of the bearing assemblies until the shop drawings have been approved by the Bridge Engineer.

Ship upper and lower components of the bearings to the job site fully assembled.

B Disc Bearings

Ensure disc bearings consist of an elastomeric structural rotational element (disc) confined by upper and lower steel bearing plates plus masonry and sole plates. The function of the bearings is to transfer loads and accommodate relative movement, including rotation, between the Bridge Superstructure and the piers.

Ensure disc bearings are produced by a firm specializing in the design and manufacture of disc bearings, with a minimum of 8 years of successful bearing installations.

Design, fabricate, and test in accordance with the requirements of the *AASHTO LRFD Bridge Design Specifications*, Article 14.7.8, Disc Bearings and the *AASHTO LRFD Bridge Construction Specifications*, Article 18.3, Pot and Disc Bearings.

Provide the Bridge Engineer with written notification of bearing testing at least 30 Calendar Days prior to the start of testing operations.

Ensure fabrication of the disc bearings conforms to the applicable requirements of *AASHTO LRFD Bridge Construction Specifications*, Article 18.3.3.

C Pot Bearings

Ensure pot bearings consist of a confined elastomeric element encased in steel, the function of which is to transfer loads and accommodate relative movement, including rotation, between the Bridge Superstructure and the piers and abutments. All Material shown in the Plans for a single pot bearing unit shall make up an assembly.

Ensure pot bearings are produced by a firm specializing in the design and manufacture of pot bearings, with a minimum of 8 years of successful bearing installations.

Design, fabricate, and test in accordance with the requirements of *AASHTO LRFD Bridge Design Specifications*, Article 14.7.4 Pot Bearings and the *AASHTO LRFD Bridge Construction Specifications*, Article 18.3, Pot and Disc Bearings.

Ensure brass sealing rings are rectangular cross-section conforming to *AASHTO LRFD Bridge Design Specifications*, Article 14.7.4.5.2 with no less than 3 rings per bearing assembly.

Provide the Bridge Engineer with written notification of bearing testing at least 30 Calendar Days prior to the start of testing operations.

2474.4 METHOD OF MEASUREMENT

The Department will measure High-load multi-rotational bearings by the number of acceptable units of each type provided, which consists of all components shown in the Plans or on the approved shop drawings for a single bearing assembly, whether it is a pot or disc bearing.

2474.5 BASIS OF PAYMENT

The Contract Unit Price for High-load multi-rotational bearings includes the cost of providing and installing the pot or disc bearings complete in-place.

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

Item No.	Item	Unit
2474.502	High-load Multi-rotational Bearings	each

2475 METAL RAILING

2475.1 DESCRIPTION

Furnish and install metal railing, including anchorages and fittings.

2475.2 MATERIALS

A Low-Carbon Structural Steel **3306**

B Pipe and Pipe Sleeves

B.1 Gray Iron Castings **3321**

B.2 Structural Steel Pipe **3362**

C Threaded Rods, Bolts, Nuts, and Washers

C.1 Galvanized .... **3391 and 3392**

C.2 Electroplate .... **3391 and *ASTM B633, Type III, SC 4***

D Part of a proprietary anchorage assembly

D.1 Anchor Rods **3385**

D.2 Fasteners **3391**

2475.3 CONSTRUCTION REQUIREMENT

A General

Perform the Work in accordance with the applicable requirements of 2433, "Structure Renovation," 2402, "Steel Bridge Construction," 2471, “Structural Metals,” 3321, “Gray Iron Castings,” the Plans, and the following:

Before the start of Work, the supplier will be qualified on *Approved Suppliers for Fabricated Structural Metals Products* list as maintained by the Structural Metals Engineer on the Bridge Office website or become qualified. To become qualified, the supplier is to submit a Quality Manual (QM) to the Bridge Engineer for review and acceptance, at least 60 Calendar Days before beginning Work. The QM is to meet the requirements of the *MnDOT Supplier Qualification Standard* which will be the basis for acceptance by the Bridge Engineer. Upon acceptance of the QM, a supplier is qualified and will be listed on the *Approved Suppliers for Fabricated Structural Metals Products* list. In addition to routine inspections, the Bridge Engineer will audit suppliers with approved QMs on a biannual or annual basis or as otherwise directed by the Bridge Engineer to ensure the implementation of the QM.

The Department will invoke its Corrective Action Process if the routine inspections or audits indicate non-conformance. Corrective actions deemed appropriate by the Bridge Engineer, are effective immediately and apply to any Work remaining on a current and future Projects. If the Bridge Engineer determines that Work does not comply with the QM or that fabrication does not follow approved fabrication procedures, the Bridge Engineer will deem the Materials as non-conforming in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” If the Bridge Engineer finds non-conforming Work, direct the supplier to immediately correct the procedure and submit a written Nonconformance Report, containing data required by the Bridge Engineer to ensure compliance with the QM, Specifications, and drawings. Perform additional testing as required by the Bridge Engineer, at no additional cost to the Department. For repeat offences or negligence, the Department will require corrective action of hiring a third-party Quality Control Inspector, at no additional cost to the Department. The Contractor may obtain a copy of the Department’s Corrective Action Process from the Bridge Engineer.

B Fabrication and Inspection Requirements

Fabricate metal railing in accordance with 2471, "Structural Metals," the Plan, and the *AWS D1.1, “*Structural Welding - Steel.” Submit Welding Procedure Specifications (WPSs) to the Bridge Engineer for approval in writing, prior to the start of fabrication.

Mark metal railing components during fabrication with individual piece marks. Identify the marking and its location on the shop drawings. Identify the proper location on the Bridge for piece marks on an erection drawings [with shop drawing submittal]. Markings should not be readily visible to the public when the railing is in the installed position. Ensure piece marks are durable markings which will be readily visible after galvanizing (e.g. welded numbers/letters with 1-1 1/2 inch height). Ensure markings represent good workmanship as to not degrade the aesthetics of the product. For standard post/rail designs, mark post pieces near the bottom of the post [near the base plate] on the exterior post side and mark railing panels on the bottom side of the bottom rail. For special rail designs, mark railing panels and posts in locations which are underneath or toward the exterior of the Bridge in locations which minimize their view. Identify/tag bundled pieces, prior to shipping/storage, with the following identification information: individual piece marks included in bundle, Bridge and/or Project number(s), fabricator name.

The Department QA shop inspections are not intended to supplement or replace the fabricator’s Quality Control (QC). The Contractor is ultimately responsible for the correction of errors and faulty workmanship or for the replacement of non-conforming Materials.

The fabricator will visually inspect parts of the fabrication and have the inspections documented by QC personnel. The fabricator will ensure that the rail meets a straightness tolerance of 1/8 inch in

10 feet. The fabricator will perform and document any nondestructive testing required by the Contract documents using an ASNT-TC-1A Level II qualified Inspector.

Document parts found to be in nonconformance by using a Nonconformance Report form (NCR), and describe in detail the fabrication error and the proposed repair procedure(s) in accordance with the QCP. Repair(s) performed are subject to the written approval of the Bridge Engineer.

C Galvanizing Requirements for Metal Railing

Galvanize railing Material in accordance with 3394, "Galvanized Structural Shapes."

2475.4 METHOD OF MEASUREMENT

Unless otherwise shown on the Plans, the Engineer will measure the length based on the sum of the lengths of the various sections as shown on the Plans and as measured at the base of the rail.

2475.5 BASIS OF PAYMENT

The Contract Unit Price for metal railings includes the cost of fabrication, surface preparation, coating, galvanizing, metal posts, fittings, castings, anchor bolts, accessories required for erection, and installation.

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

Item No.	Item	Unit
2475.503	Ornamental Metal Railing ___	linear foot
2475.503	Structural Tube Railing Design ___	linear foot
2475.503	Pipe Railing ___	linear foot

2477 POWDER COATING

2477.1 DESCRIPTION

This Work consists of the following for shop applications of powder coating systems for new construction:

(1) Surface preparations
(2) Application of powder
(3) Coating thicknesses
(4) Handling, storage, and shipping of components
(5) Coating repairs
(6) Work Incidental to these operations

A Definitions

For the purpose of the Work specified in section 2477, “Powder Coating,” the Department defines:

Coating System

The surface preparation and application of specific coating classifications (i.e., Inorganic Zinc-Rich, Organic Zinc-Rich, Polyurethane, Acrylic, Polyurea, Latex, Galvanize, Powder, etc.) of coating products to provide a film forming a unified whole for the purpose of corrosion protection and/or aesthetics.

Coating Thickness

The Dry-Film Paint Thickness (DFT) above the peaks of the blast profile.

Contractor
Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and applies the coatings.

Duplex Coating System
A system whereas galvanizing replaces the zinc-rich primer and subsequently intermediate and top coated in accordance with this Specification.

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.

Lot
The amount of components that are baked at one time in a curing oven. If a continuous feed oven is used a "Lot" shall be defined in the QM.

Powder System
A set of interacting film forming powder Materials and products which combine to make up a complete coating system.

Prime Coat
Application of a zinc-rich coating to a bare metal substrate.

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.

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.

Quality Control (QC)
The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality. The job foreman or production painter cannot be this person.

MnDOT Quality Manual (QM)
The formal written document prepared by the Contractor that describes the policies and procedures that ensure and verify that the coated structural steel component will satisfy the Contract requirements.

Shop (in shop coating)
The indoor facility where structural metals are prepared and coated.

Verification Testing
Testing of powders currently listed on the APL by applicator that did not perform the initial qualification testing.

Well Lighted
A minimum of 50 foot candles of artificial light or natural daylight. Use a light meter with readings in foot candles to verify the adequacy of the lighting.

2477.2 MATERIALS

Provide a Powder System listed on the *Approved/Qualified Products List* for "Bridge Railing Powder Coating."

Deliver the powder to the applicator in the original unopened containers.

Provide the Bridge Engineer with Material Safety Data Sheets (MSDS), Material certifications, and Technical Data Sheets (TDS) for each powder shipment.

Ensure a manufacturer's technical representative with knowledge of this Powder System is available to assist during coating application.

2477.3 CONSTRUCTION REQUIREMENT

A Qualification for Shop Applicators

Before the start of Work, the supplier will be qualified on *Approved Suppliers for Fabricated Structural Metals Products* list as maintained by the Structural Metals Engineer on the Bridge Office website or become qualified. To become qualified, the supplier is to submit a Quality Manual (QM) with a Verification Testing procedure to the Bridge Engineer for review and acceptance, at least 60 Calendar Days before beginning Work. The QM and the Verification Test is to meet the requirements of the *MnDOT Supplier Qualification Standard* which will be the basis for acceptance by the Bridge Engineer. Upon acceptance of the QM, a supplier is qualified and will be listed on the *Approved Suppliers for Fabricated Structural Metals Products* list. In addition to routine inspections, the Bridge Engineer will audit suppliers with approved QMs on a biannual or annual basis or as otherwise directed by the Bridge Engineer to ensure the implementation of the QM.

The Department will invoke its Corrective Action Process if the routine inspections or audits indicate non-conformance. Corrective actions deemed appropriate by the Bridge Engineer, are effective immediately and apply to any Work remaining on a current Project and future Projects. If the Bridge Engineer determines that Work does not comply with the QM or that fabrication does not follow approved fabrication procedures, the Bridge Engineer will deem the Materials as non-conforming in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the Bridge Engineer finds non-conforming Work, direct the supplier to immediately correct the procedure and submit a written Nonconformance Report, containing data required by the Bridge Engineer to ensure compliance with the QM, Specifications, and drawings. Perform additional testing as required by the Bridge Engineer at no additional cost to the Department. For repeat offences or negligence, the Department will require corrective action of hiring a third-party Quality Control Inspector at no additional cost to the Department. The Contractor may obtain a copy of the Department's Corrective Action Process from the Bridge Engineer.

B General

Preserve or transfer erection markings to ensure legibility when erecting members. Provide removable markings or place markings at locations not visible in the completed Structure. Use marking Material that will not damage the Powder System.

Protect the environment and property as required by federal, State, and Department regulations.

C Inspection

Perform QC inspections of the Shop coating process in accordance with an approved QM and Table 2477.3-1.

Perform coating application and QC inspections of coated products by persons with normal color vision, in a Well Lighted area during each coating phase and prior to final acceptance.

Use a light meter with readings in foot candles to verify the adequacy of the lighting.

The Department will appoint a Quality Assurance Inspector (QAI) as a Department representative to accept Work meeting the Contract requirements.

C.1 MnDOT Quality Manual (QM) Requirements

Provide the minimum requirements and frequencies in the QM as shown in Table 2477.3-1:

Table 2477.3-1
Powder Coating Inspection Requirements

	Requirement	Criteria	Frequency/Event
	Date and Time	Each Lot of Work	Each Lot of Work
	Compressed air test	*ASTM D4285**	Daily – When abrasive blasting or blow down operations are occurring
	Final Coat Dry Film Thickness (DFT)	As submitted by Manufacturer (listed on the APL)	*SSPC-PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements*
Surface Preparation	Abrasive blast clean Duplex System (prior to galvanizing) Duplex System (prior to powder) Powder Only System (prior to powder) Surface cleanliness (all systems)	*SSPC-SP6*, *Commercial Blast Cleaning*, *SSPC-SP 16*, *Surface Preparation Specification*/*ASTM D7803*‖, *SSPC-SP10, Near-White Metal Blast Cleaning* *SSPC-PA1*, *Shop, Field and Maintenance Coating of Metals*	Each component to be powder coated
Pre-Bake for Outgassing	Surface cleanliness	*SSPC-PA 1*	100 percent Visual examination prior to coating
	Pre-bake oven temperature	Same procedure used to pass qualification/verification	Each Lot of Work prior to each out-gassing event
	Baking procedure	*ASTM D7803*† in conjunction with the same procedure used to pass qualification	Each Lot of Work
Prime / Intermediate Coat	Powder product number	Track for each Lot	Each batch of powder
	Surface cleanliness inspection	*SSPC-PA 1*	Visual examination prior to coating (within 1 hour of coating)
	Prime / Intermediate coat oven temperature	Same procedure used in qualification / verification	Each Lot of Work
	Temperature of component at time of coating	Same procedure used in qualification / verification	Each Lot of Work
	Verification of coating coverage	100 percent Coverage of powder	100 percent Visual Inspection
Top Coat	Powder product number	Track for each lot	Each batch of powder
	Surface cleanliness inspection	*SSPC-PA 1*	Visual examination prior to coating

	Requirement	Criteria	Frequency/Event
	Top coat oven temperature	Same procedure used in qualification / verification	Each Lot of Work
	Final cure temperature of component	Same procedure used in qualification / verification	Each Lot of Work
	Curing time	Per manufacturer Technical Data Sheet	Each Lot of Work
	Coating evaluation / repair	Visual Inspection: Coating shall be smooth and uniform free of runs, drips, sags, pinholes, blisters, and other deleterious conditions. (Pinhole density shall not be greater than 5 pin holes per square foot in any given area)	100 percent Visual Inspection (without the aid of magnification)

* *ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air*
‖ *ASTM D7803*, *Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coat*ing
† *ASTM D7803*, *Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coating*

Provide written records meeting the QM powder Coating inspection requirements in Table 2477.3-1 to the Bridge Engineer on an ongoing basis as the Work is being performed. Provide written records meeting the QM Powder Coating inspection requirements in Table 2477.3-1, in its entirety, at the completion of the job, prior to receiving final payment. The QAI or the Bridge Engineer may reject the Coating System or apply a monetary deduction per 1512, “Unacceptable and Unauthorized Work,” if the Contractor did not adhere to the approved QM or provided inadequate documentation of adherence to the QM. Conduct subsequent testing with the QAI or the Bridge Engineer’s approval, at no additional cost to the Department, to determine compliance.

D Surface Preparation

The QAI or Bridge Engineer will inspect the surface preparation as it is done, after its completion, review the QM documentation, or any combination of the three. Notify the QAI or the Bridge Engineer at least 5 Working Days before beginning surface preparation.

D.1 Cleaning

D.1.a Solvent Cleaning

Clean areas containing organic and synthetic and other visible contaminants with solvent meeting the requirements of *SSPC-SP 1*, *Solvent Cleaning*. Protect the adjacent environment and property while solvent cleaning.

D.1.b Abrasive Cleaning

D.1.b(1) Duplex Coating Systems

Perform preparation of galvanized surfaces prior to the application of powder in accordance with *SSPC SP16, Brush-off Blast Cleaning of Non-Ferrous Metals* and *ASTM D7803, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Products and Hardware Surfaces for Powder Coating.* Inspect brush-off blasted surfaces for fins, tears, reduced DFTs that fall below the required minimum, or any other damage. Submit to the Bridge Engineer an NCR documenting all damage prior to repairing the surface.

D.1.b(2) Powder Only System

Perform preparation of bare steel surfaces prior to application of powder in accordance with *SSPC-SP10*, *Near-White Metal Blast Cleaning*.

D.1.c Post Blasting

After blast cleaning, remove blasting debris from surfaces using procedures that leave the surfaces free of moisture and contaminants. Remove the blasting residue from the containment area, specifically the floor area, to prevent dust from being airborne once coating process starts.

E Application of Powder

E.1 General

Prior to application of powder, submit documentation to the Quality Assurance Inspector (QAI) showing that the powder manufacturer's technical representative trained, directly involved Shop personnel (including QC) on the proper storage, handling, and application of the Coatings System for the Project. Make training curriculum available to the Bridge Engineer upon request.

Do not start applying powder until the QAI or the Bridge Engineer accepts the surface preparation. Before applying powder, clean the surface of oxidation, dust, dirt, grease, oil, moisture, overspray, and other deleterious contaminants that will prevent the powder from adhering. Apply powder to produce a smooth and uniform film free of runs, drips, sags, pinholes, blisters, and other deleterious conditions. Apply powder in accordance with manufacturer’s printed instructions except as follows:

Do not apply powder to metal surfaces when weather conditions that the manufacturer’s literature defines as unsatisfactory are present, and when:

(1) The air temperature falls below 40°F
(2) Metal surface temperatures are less than 5°F above the dew point
(3) Water mist is in the air
(4) Metal surfaces are damp or frosted

Do not apply powder if other Work operations or wind causes the air to carry dust, dirt, or sand onto the prepared or newly coated metal surfaces. The QAI or Bridge Engineer will suspend coating operations if the applicator does not properly control coating application.

Powder coat sweep blasted galvanized railing with the subsequent coat(s) within the time frame defined in *ASTM D7803*, *Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coat*ing, or within the same 8-hour shift, maintaining manufacturer defined control and environmental conditions. The powder coating applicator’s QC personnel shall document that parameters were followed.

Remove surface contamination, if any exist. Repair or replace defective previously applied coats as required by the Bridge Engineer, at no additional cost to the Department.

Submit coating repair procedures to the QAI or the Bridge Engineer for approval.

Ensure the color of the first coat presents a distinct contrast from other coat(s).

E.2 Applying Powder

Apply and cure powder per the same procedure used in qualification/verification. Apply powder in a neat and workman-like manner to evenly coat surfaces.

F Powder Coats

F.1 Measurement of Coating Thickness

The Department refers to "Dry Film Thickness" (DFT) when using the term "thickness" in this section. Use a properly calibrated thickness gage to measure the coating thickness and average thickness meeting, at a minimum, the requirements of *SSPC-PA 2*, "Measurement of Dry Coating Thickness with Magnetic Gages." Measure coating thickness from the top of the peaks of the blast profile.

For Duplex Coated Systems use a DFT measurement thickness tool capable of differentiating the individual thicknesses of both Powder Coating System and galvanizing Layer.

Perform coating operations as recommended by the manufacturer's literature, unless otherwise specified in this section.

F.2 Prime Coat

For powder only systems, apply a zinc-rich primer powder. Remain within the minimum and maximum DFT limits as defined by the manufacturer.

For Duplex Coating Systems, the hot-dip galvanize coating replaces the zinc-rich prime coat.

F.3 Intermediate Coat

Remain within the minimum and maximum DFT limits as submitted by the manufacturer. Ensure the color of the intermediate coat has sufficient contrast with the Prime and finish coat.

F.4 Finish Coat

Remain within the minimum and maximum DFT limits as submitted by the manufacturer. Ensure the finish coat color matches the color standard required by the Contract.

Ensure the finished surface is uniform in color and free of visible lap marks and other blemishes.

F.5 Total Coating Thickness

Ensure the total Coating Thickness of the entire system remains within the minimum and maximum thickness limits defined by the manufacturer of the Coating System. If the Bridge Engineer finds total Coating Thickness deficient or excessive over any part of a Structure and if the Bridge Engineer does not require additional applications or removal of coating, the Department may apply a monetary deduction for the appropriate item of Work.

G Handling, Storage, and Shipping of Powder Coated Components

Do not damage the coated steel in the shop and field during shipping, erection, and construction of the Project. Do not move or handle the coated steel items until the coating cures and cools in accordance with the applicator's approved procedure. Use nylon straps, padded hooks, slings, or other non-metallic lifting devices to protect coated components or products during handling and loading. Use softeners and edge protection devices to protect the steel from binding chains. Use padded hooks and slings to hoist the coated components.

Store completed items in accordance with 1606, "Storage of Materials," and the following:

(1) Tag or permanently mark items before final storage. Include individual piece marks, Bridge number, Project number, manufacturer number, and the applicator job number in the identification markings.

(2) Locate the final storage area out of any Traffic Lanes and in an area capable of bearing the full weight of the members or items and stable enough to maintain bundles, members, or items within the supporting substrate. Inspect and store bundles, members, or items in one general location before final acceptance unless otherwise approved by the QAI or the Bridge Engineer.

Support individual items or bundles of coated products in transit in a manner that will prevent damage to the coating. Do not drop or drag individual items or bundles of coated products. Pad when shipping, bundling, or banding Materials to protect the components from direct contact with packaging Materials that may damage the coated products finish. Use softeners and Edge protection devices in conjunction with high-density foam or other acceptable packaging Materials at points of contact.

Any damaged coated surfaces, identified through either Quality Control or Quality Assurance inspections as being unacceptable, either after the application of the powder coating or during handling of the powder coated components, is subject to the provisions of 1512, "Unacceptable and Unauthorized Work" or will be repaired as described in the Powder Coating Applicators repair procedure.

H Coating Repair

H.1 Shop (prior to receiving at job site)

Any damaged coated surfaces, identified by the Bridge Engineer as being unacceptable is subject to the provisions of 1512, "Unacceptable and Unauthorized Work," and will be replaced or repaired. Submit a Non-conformance repair Plan to the Bridge Engineer for acceptance. Once accepted in writing by the Bridge Engineer, perform repairs using the accepted methods and procedures authorized by the Bridge Engineer.

Coating damage is classified in two extent types:

Type 1 – damage is any type of abrasion that caused a surface imperfection not exposing the galvanized surface or exposes an area of galvanized surface that is smaller than 1 square inch in size. This damage may be repaired in the shop using an accepted Non-conformance repair Plan as stated above (i.e. abrade the damaged area and apply an intermediate and finish coat per 2478, "Organic Zinc-Rich Paint System." (Note: Alkyd Enamels will not be allowed as a repair. Aerosol spray paint is not an acceptable repair procedure.)

Type 2 – damage is any type of surface imperfection that exposes the galvanized or steel surface larger than 1 square inch and/or exposed base metal in an area larger than 1/2 square inch. Repair this damage in the Shop using an accepted Non-conformance repair Plan.

H.2 Field (once received at the job site)

Any damaged coated surfaces, identified by the Engineer as being unacceptable is subject to the provisions of 1512, "Unacceptable and Unauthorized Work," and will be replaced or repaired. Submit a Non-conformance repair Plan to the Engineer for acceptance. Once accepted in writing by the Engineer, perform repairs using the accepted methods and procedures authorized by the Engineer.

Coating damage is classified in two extent types:

Type 1 – damage is any type of abrasion that caused a surface imperfection not exposing the galvanized surface or exposes an area of galvanized surface that is less than 1 square inch in size. This damage may be repaired in the field or the Shop using an accepted Non-conformance repair Plan as stated above (i.e. abrade the damaged area and apply an intermediate and finish coat per 2478, "Organic Zinc-Rich Paint System"). (Note: Alkyd Enamels will not be allowed as a repair. Aerosol spray paint is not an acceptable repair procedure.)

Type 2 – damage is any type of surface imperfection that exposes the galvanized surface larger than 1 square inch and/or exposed base metal in an area larger than 1/2 square inch. Remove sections of damaged rail from the site and repair in the Powder applicator's powder application facility. (Repair the damaged area utilizing an accepted Non-conformance repair Plan.)

2477.4 METHOD OF MEASUREMENT - BLANK

2477.5 BASIS OF PAYMENT

The Contract Unit Price for 2475, "Metal Railing," includes the cost of powder coating.

2478 ORGANIC ZINC-RICH PAINT SYSTEM

2478.1 DESCRIPTION

This Work consists of the following for shop or field full-system applications of Organic Zinc-Rich Paint Systems for new construction and recoating of existing structures:

(1) Surface preparations
(2) Providing and applying the coating
(3) Protecting and curing the coating
(4) Protecting pedestrians, vehicular traffic, and property against damage
(5) All Work Incidental to these operations

A Definitions

For the purpose of the Work specified in section 2478, "Organic Zinc-Rich Paint System," and 2479, "Inorganic, Zinc-Rich Paint System," the Department defines:

Coating System
The surface preparation and application of specific coating classifications (i.e., Inorganic Zinc-Rich, Organic Zinc-Rich, Polyurethane, Acrylic, Polyurea, Latex, Galvanize, Powder, etc.) of coating products to provide a film forming a unified whole for the purpose of corrosion protection and/or aesthetics.

Coating Thickness
The Dry-Film Paint Thickness (DFT) above the peaks of the blast profile.

Contact Surfaces
Those surfaces in the completed Structure that touch other surfaces.

Contractor
Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and applies the coatings.

Corner
The intersection of two surfaces.

Duplex Coating System
A system whereas galvanizing replaces the zinc-rich primer and subsequently intermediate and top coated in accordance with this Specification.

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.

Field Coating
The outdoor on-site coating of new or previously coated steel Structures before or after erection.

Hold Point
For field application of paints only: Puts a hold on any future Activities until an inspection is passed. Do not proceed without the written approval of the Bridge Engineer. The Department and the Contractor will use the “Start-up Checklist” and the “Daily Quality Assurance Check List” located on the MnDOT Bridge Construction website so that quality is assured.

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. A light coat of unspecified DFT used to prevent rust staining of steel substrates or temporarily inhibit corrosion.

Non-contact Surfaces
Surfaces that are not in direct contact with other surfaces.

Paint System
A set of interacting film forming paint Materials and products which combine to make up a complete Coating System.

Prime Coat
Application of a zinc-rich coating to a bare metal substrate.

Qualified
Holding appropriate documentation and officially on record as competent and experienced to perform a specified function or practice of a specific skill.

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.

Quality Control (QC)
The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality. The job foreman or production painter cannot be this person.

MnDOT Quality Manual (QM)
The formal written document prepared by the Contractor that describes the policies and procedures that ensure and verify that the coated structural steel component will satisfy the Contract requirements.

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.

Shop (in Shop coating)
The indoor facility where structural metals are prepared and coated.

Stripe Coat
A coating, of sufficient thickness to completely hide the surface being coated, on all Edges, corners, seams, crevices, interior angles, junctions of joining members, bolt heads, nuts and threads, weld lines, and similar surface irregularities. This coating shall be followed, as soon as practicable, by the application of the full Prime Coat to its specified thickness.

2478.2 MATERIALS

A Zinc-Rich Paint Systems 3520

2478.3 CONSTRUCTION REQUIREMENTS

A Contractor Qualifications and Documentation

A.1 Field Applicators

At least 30 Calendar Days prior to starting any painting Work submit a MnDOT Quality Manual (QM) meeting the requirements of 2478, “Organic Zinc-rich Paint System” and AASHTO/NSBA *Steel Bridge Collaboration S8.1 SSPC-PA 13, “*Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges,*”* to the Bridge Engineer for approval, including a method to provide the minimum requirements and frequencies in the QM as shown in 2478.3C.1, “MnDOT Quality Manual (QM) Requirements,” and Table 2478.3-1, and a custom proposal of how *SSPC PA 2,*”Procedure for Determining Conformance to Dry Coating Thickness Requirements” will be documented to the Bridge Engineer for acceptance in writing.

Perform the preparation and application of field applied coatings with staff meeting the requirements of The Society of Protective Coatings Certified Application Specialist (SSPS CAS) Level 2. One CAS Level 2 is required on sight overseeing the Work in each Work area up to a crew of 10 workers. Multiple Work areas will require an additional CAS for each area.

A.2 Shop Applicators

Before the start of Work, the supplier will be Qualified on *MnDOT’s Approved Suppliers for Fabricated Structural Metals Products* list as maintained by the Structural Metals Engineer on the Bridge Office website, or become Qualified. To become Qualified, the supplier is to submit a MnDOT Quality Manual (QM) to the Bridge Engineer for review and acceptance, at least 60 Calendar Days before beginning Work. The QM is to meet the requirements of the *MnDOT Supplier Qualification Standard* which will be the basis for acceptance by the Bridge Engineer. Upon acceptance of the QM, a supplier is Qualified and will be listed on the *MnDOT Approved Suppliers for Fabricated Structural Metals Products* list. In addition to routine inspections, the Bridge Engineer will audit suppliers with approved QMs on a biannual or annual basis or as otherwise directed by the Bridge Engineer to ensure the implementation of the QM.

The Department will invoke its Corrective Action Process if the routine inspections or audits indicate non-conformance. Any corrective actions deemed appropriate by the Bridge Engineer, are effective immediately and apply to any Work remaining on current and future Projects. If the Bridge Engineer determines that Work does not comply with the QM or that fabrication does not follow approved fabrication procedures, the Bridge Engineer will deem the Materials as non-conforming in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” If the Bridge Engineer finds non-conforming Work, direct the supplier to immediately correct the procedure and submit a written Nonconformance Report, containing data required by the Bridge Engineer to ensure compliance with the QM, Specifications, and drawings. Perform additional testing as required by the Bridge Engineer at no additional cost to the Department. For repeat offences or negligence, the Department will require corrective action of hiring a third-party Quality Control Inspector at no additional cost to the Department. The Contractor may obtain a copy of the Department’s Corrective Action Process from the Bridge Engineer.

B General

Provide Paint Systems listed on the *Approved/Qualified Products List* for Bridge structural steel coating, three Coat Systems (organic).

Deliver the paint to the site in the original unopened containers no greater than 5 gal. Do not alter the contents unless approved by the Bridge Engineer in writing. Package multi-component coatings in separate containers or kits.

Provide the Bridge Engineer with the following for each paint shipment:

(1) The manufacturer's Material Safety Data Sheets (MSDS)
(2) Material certifications
(3) Written instructions for mixing, handling, and application of the coatings

Ensure a manufacturer's technical representative with knowledge of the approved Paint System is available to assist during coating preparation and application.

For new construction, preserve or transfer erection markings to ensure legibility when erecting members. Provide removable markings or place markings at locations not visible in the completed Structure. Use marking Material that will not damage the Paint System.

If painting a Structure erected under a previous Contract, the Department will not require disassembly of portions of the Structure or removal of appurtenances to expose Contact Surfaces or otherwise inaccessible metal surfaces unless otherwise shown on the Plans or in the Special Provisions.

For new construction projects, paint Contact Surfaces with the zinc primer at the recommended DFT, except for surfaces completely sealed by:

(1) Welding
(2) Bolt heads
(3) Nuts and washers
(4) Embedment in concrete (ex. shear devices and anchorages)

Coat the top surfaces of beams and girders with a Mist Coat of primer.

Protect the environment and property as required by federal, State, and Department regulations.

Protect non-painted surfaces (concrete Bridge deck overhangs and vertical faces of abutments) that are adjacent to the painted surfaces from overspray, unless otherwise shown on the Plans or in the Special Provisions. The Bridge Engineer will allow up to 2 inches of overspray and may require the excessive over sprayed paint be removed, covered with a special surface finish, or wire wheeled from the adjacent surface(s).

Provide a system for inspection that will allow the Inspector to safely access the steel components. For safety systems that require temporary fastening to the steel to support the system, use fastening hardware that will not damage the paint. Repair damages as approved by the Bridge Engineer at no additional cost to the Department.

C Inspection

Perform QC inspections of the Shop and field painting in accordance with an approved QM.

The Department will appoint a Quality Assurance Inspector (QAI) as a Department representative to accept Work meeting the Contract requirements.

C.1 MnDOT Quality Manual (QM) Requirements

Provide the minimum requirements and frequencies in the QM as shown in Table 2478.3-1:

Table 2478.3-1
Coating Inspection Requirements

	Requirement	Frequency/Extent
General	Ambient temperature	Every 4 (field) hours; Every 8 (Shop) hours or at the start of each shift
	Dew point and relative humidity	Every 4 (field) hours; Every 8 (Shop) hours or at the start of each shift
	Surface temperature	Every 4 (field) hours; Every 8 (Shop) hours or at the start of each shift
	Date and time	Every 4 (field) hours; Every 8 (Shop) hors or at the start of each shift
	Piece mark or bundle	Every 4 (field) hours; Every 8 (Shop) hours or at the start of each shift
	Compressed Air Test *ASTM D4285**	Daily – when abrasive blasting or blow down operations are occurring
	DFT (each coat of paint)	*SSPC PA 2*‖
	Visual inspection (each coat of paint)	100 percent
Surface Preparation	Pre-clean per *SSPC-SP 1, Solvent Cleaning*	Each component to be Prime coated. Visually inspect 100 percent
	Abrasive blast clean per *SSPC-SP 10*†	Each component to be Prime coated
	Visually inspect per *SSPC VIS-1*‡	100 percent
	Soluble Salt Test	See Special Provisions
	Blast profile inspection per *ASTM D4417*#	Steel Girders – minimum of 3 locations per each blasted. Diaphragms – 3 locations minimum per each blasted. § Sole Plates – 3 locations minimum per each blasted. § Pedestrian Bridges** Railing‖‖ Bridge Truss – 3 location minimum for each 1000 square feet or the amount of truss blasted by each blasting nozzle in an 8 hour shift (whichever is less). Items not covered by this list shall have 3 documented profile locations for every 1000 square feet blasted.
Prime, Intermediate and Finish Coat	Batch number	Every paint kit
	Verification of surface cleanliness	Examine visually within 1 hour before prime painting. For field applications include a white cloth wipe test (nothing is transferred on to the cloth surface) – 5 locations, designated by the Engineer, minimum or more as requested by the Engineer
	Temperature of mixed product	When mixing components
	Proper mixing and straining	Every pot mix
	Induction time and reaction time	Every pot mix
	Pot life	Every pot mix
	Cure time	Each lot of work
	Cure Verification	Prior to the next coat application
	Proper use of Stripe Coats (Prime Coat only)	Visual, 100 percent of applicable areas, as specified in 2478.3F, "Paint Coats"
	Coating evaluation and repair	Visual, 100 percent of each element
	Recoat time	Each lot of Work and as recommended by the manufacturer

	Requirement	Frequency/Extent
	Adhesion (Final Coating System)	As required by the Bridge Engineer
	Coating System final evaluation and repair	Visual, 100 percent of each element

* *ASTM D4285, Standard Test Method for Indicating Oil or Water Compressed Air*
‖ *SSPC PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements*
† *SSPC-SP 10, Near-White Metal Blast Cleaning*
‡ *SSPC VIS-1 Guide and Reference Photographs for Steel Surfaces Prepared By Dry Abrasive Blast Cleaning*
\# *ASTM D4417, Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel*
§ For Inorganic Zinc-Rich Paint Systems: The amount of diaphragms or sole plates going through an automated blast machine at one time or the amount being blasted in an 8 hour shift.
** For organic Zinc-Rich Paint Systems: Minimum of 3 locations on each truss and a minimum of 3 locations on the floor beam. For Inorganic Zinc-Rich Paint Systems: Minimum of 3 readings on each truss and a minimum of 3 readings on the floor beam.
‖‖ For organic Zinc-Rich Paint Systems: Ten locations minimum for each 100 lineal feet of rail. For Inorganic Zinc-Rich Paint Systems: 3 readings minimum for each 100 lineal feet of rail.

In addition to the above requirements, include the following information in the field painting QM:

(1) Proof of SSPC QP 1 certification for field painting and that it is maintained throughout the painting portion of the Contract per *AASHTO/NSBA Steel Bridge Collaboration S8.1 SSPC-PA Guide 13*, *Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges*
(2) Copies of certifications of all CAS Level 2 employees on the job
(3) Product Data Sheets
(4) Manufacturer’s documentation stating that all personnel involved with the application of the paint were trained on mixing and application of the Coatings System
(5) Nonconformance Report form
(6) A custom proposal of how *SSPC PA 2* will be documented
(7) An initial color draw down sample on a Leneta chart per 2478.3F.5, “Finish Coats”
(8) Names of employees on the job including their titles
(9) Identify the following Hold Points for Department inspection and verification: abrasive blast profile and cleanliness, Stripe Coat, Prime Coat, intermediate coat, and finish coat

Provide written records meeting all Coating Inspection requirements to the Bridge Engineer upon request on an ongoing basis as the Work is being performed. For field applications, also provide complete written records within 5 Working Days from when the shift was completed to receive partial payment. Provide written records meeting all Coating Inspection requirements, in its entirety, at the completion of the job, prior to receiving final payment. The QAI or the Bridge Engineer will reject the Coating System or apply a monetary deduction per 1512, "Unacceptable and Unauthorized Work," if the Contractor did not adhere to the approved QM or provided inadequate documentation of adherence to the QM. Conduct subsequent testing with the QAI for the Bridge Engineer's approval, at no additional cost to the Department, to determine compliance.

D Surface Preparation

The QAI or Bridge Engineer will inspect the surface preparation as it is done, after its completion, or review the QM documentation, or any combination of the three. Notify the QAI or the Bridge Engineer at least 5 Working Days before beginning surface preparation.

D.1 Cleaning

D.1.a Solvent Cleaning

Clean areas containing organic and synthetic and other visible contaminants with solvent meeting the requirements of *SSPC-SP 1*, "Solvent Cleaning." Protect the adjacent environment and property while solvent cleaning.

D.1.b Abrasive Blasting

Abrasive blast clean surfaces to achieve a *SSPC-SP 10/NACE No. 2*, *Near-White Metal Blast Cleanin*g before applying Prime Coat. Use job site visual standards and *SSPC-VIS 1*, *Guide and Reference Photographs for Steel Surfaces Prepared by Abrasive Blast Cleaning*. Perform blast cleaning operations meeting the requirements of Minnesota MPCA Rules 7025.0200 through 7025.0380.

For Organic Zinc-Rich Paint Systems: Abrasive blast clean to achieve a profile range from 2.0 mils to 4.0 mils. Reblast clean surfaces when the surface profile is less than 2.0 mils. Provide a Nonconformance Report (NCR) as stated in the QM, to the QAI or Bridge Engineer if the profile exceeds 4.0 mils. Provide written documentation proving that the specified profile has been achieved.

For Organic Zinc-Rich Paint Systems: Abrasive blast clean to achieve a profile range from 2.0 mils to 3.5 mils. Reblast clean surfaces when the surface profile is less than 2.0 mils. Provide a Nonconformance Report (NCR), as specified in the QM, to the Bridge Engineer if the profile exceeds 3.5 mils. Provide written documentation proving that the specified profile has been achieved.

When recyclable blast media is used, assess the blast cleaning abrasives, prior to using, for the presence of conductive potential, ionic contaminants by determining the total concentration of water soluble conductive species using a conductivity test *ASTM D4940, Standard Test Metho*d for Conductimetric Analysis of Water Soluble Ionic Contamination of Blast Cleaning Abrasives.

D.1.b(1) Duplex System (shop)

Perform preparation of galvanized surfaces prior to application of paint in accordance with *SSPC SP16 Brush-off Blast Cleaning of Non-Ferrous Metals*, and *ASTM D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting*.

Inspect brush-off blasted surfaces for fins, tears, reduced DFTs that fall below the required minimum, or any other damage. Submit to the Bridge Engineer an NCR documenting all damage prior to repairing the surface.

D.1.c Post Blasting

After blast cleaning, remove blasting debris from steel surfaces using procedures that leave the surfaces free of moisture and contaminants. Remove the blasting residue from the containment area, specifically the floor area, to prevent dust from being airborne once painting process starts. Provide structural steel members free of surface defects, such as small seams, blisters, weld spatter, fins, laps, and tears. Perform grinding up to 1/32 inch or 5 percent of the Material thickness, whichever is less. Perform grinding parallel to the direction of the stresses. Remove surface defects and repair gouges before applying Prime Coat.

E Application of Paint

E.1 General

For Shop application of paint, submit documentation to the Quality Assurance Inspector (QAI) showing that the paint manufacturer's technical representative trained, all directly involved Shop personnel (including QC) on the proper mixing and application of the Coatings System for the Project. Make training curriculum available to the Bridge Engineer upon request.

Provide Prime, intermediate, and finish coats of paint in accordance with 2478.2A, “Zinc-Rich Paint Systems.” For Shop applied Duplex Coating System, the hot-dip galvanize coating replaces the liquid zinc-rich Prime Coat.

Do not start painting until the QAI or the Bridge Engineer approves the surface preparation and paint. Before applying paint, clean the surface of flash rust, dust, dirt, grease, oil, moisture, overspray, and other deleterious contaminants that will prevent the paint from adhering (Hold Point). For field painting applications, provide a white cloth Material to the QAI for cleanliness testing.

Apply paint to produce a smooth and uniform film free of runs, drips, sags, pinholes, blisters, mudcracking, and other deleterious conditions. Apply paint in accordance with manufacturer's printed instructions except as stated in this document.

For field applications:

(1) Apply paint by spray application only, unless a different application method is allowed in the Contract
(2) Rollers, daubers, brushes are not allowed to be used to apply paint, unless approved by the Engineer in writing

Do not apply paint to metal surfaces when weather conditions that the manufacturer’s literature defines as unsatisfactory are present, and when:

(1) The air temperature falls below 40°F
(2) Metal surface temperatures are less than 5°F above the dew point
(3) Water mist is in the air
(4) Metal surfaces are damp or frosted

Do not apply paint if other Work operations, wind, or traffic causes the air to carry dust, dirt, or sand onto the prepared or newly painted metal surfaces. Do not apply spray applied paint without protective shields that prevent scattering wet paint particles in areas where rebounding or blowing paint particles cause harm to persons, adjacent environment, or property. The QAI or Bridge Engineer will suspend spray painting operations if the Contractor does not properly control paint application.

Do not thin paint more than what is stated in the manufacturer’s written instructions. After mixing, strain the primer through a 30 – 60 mesh screen or a double layer of cheesecloth. Do not allow un-dispersed clumps of zinc to remain in the paint after mixing.

Before applying a subsequent coat of paint, perform the following:

(1) Cure the previous coat to the “recoat” time as defined in the manufacturer’s Product Data Sheet
(2) Screen or scrape smooth and repaint wrinkled, detached, distorted, scuffed, abraded areas

Remove dust or chalk-like deposits. Repair or replace defective previously applied paint coats as required by the Bridge Engineer and at no additional cost to the Department. Apply the subsequent paint coat within the maximum time interval recommended by the manufacturer. If the maximum time interval is exceeded, blast the areas to *SSPC-SP 10/NACE NO. 2*, “Near-White Metal Blast Cleaning,” and recoat at no additional cost to the Department.

Do not paint within 2 inches of the zones requiring field welding as shown on the Plans. Prepare and paint the heat affected areas after field welding, in accordance with this section.

When the Contract specifies Shop painting and the Contractor does not provide the specified coating(s) in the Shop, apply the paint coat(s) for the unpainted portion at the Project Site.

Submit paint repair procedures to the QAI or the Bridge Engineer for approval.

E.2 Spraying

Perform power spraying using a fine, even spray. The Contractor may brush out paint applied with spray Equipment to obtain uniform coverage and to eliminate wrinkling, blistering, sags, runs, and air holes if the brushing is done immediately. When spraying, maintain a “spray tip-to-surface” distance to achieve an even, wet coat, free of runs, drips, sags, overspray, and dry spray.

For Organic Zinc-Rich Paint Systems: When using conventional air spray, equip the air lines with approved water and oil traps. Use *ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air* to ensure the compressed air is oil and water free.

E.3 Rollers, Brushes, and Daubers

For field application, this entire section may only be used with written permission from the Bridge Engineer.

The Contractor may apply paint by rolling, brushing, or daubers in areas unsuitable for spray painting, such as small surface areas where over-spray would be excessive, and small areas requiring paint repair.

If using brushes, manipulate the paint under the brush to provide a smooth, uniform coating over the entire surface, including Corners and crevices. Perform final brush strokes horizontal and parallel to each other. Remove brush hairs on the paint surface.

The Contractor may use sheepskin or other approved daubers to paint surfaces inaccessible by spray or brush.

F Paint Coats

F.1 Measurement of Paint Thickness

The Department refers to “Dry Film Thickness” (DFT) when using the term “thickness” in this section. Use a properly calibrated thickness gage to measure the paint thickness and average thickness meeting, the requirements of *SSPC-PA 2, Measurement of Dry Coating Thickness with Magnetic Gages*. Measure paint thickness from the top of the peaks of the blast profile.

Perform painting operations as recommended by the manufacturer’s literature, unless otherwise specified in this section. If the manufacturer’s recommended DFT differs from the DFT in accordance with this section, submit a request in writing to the Engineer or Bridge Engineer before painting to approve the DFT deviation from the manufacturer’s written recommendations.

Refer to 2478.3J, “Paint Repair,” for deficient paint thickness.

F.2 Stripe Coats

Before applying Prime Coat, apply a Stripe Coat on the Edges, Corners, seams, crevices, interior angles, junctions of joining members, rivets or bolt heads, nuts and threads, weld lines, and similar irregularities. Ensure the Stripe Coat completely hides the surface to be covered. Apply the Prime Coat on top of the Stripe Coat before it is fully cured, to its specified thickness as defined in this section, and after the QAI or the Bridge Engineer accepts the stripe coat (Hold Point).

Apply the Stripe Coat per 2478.3E, “Application of Paint.”

F.3 Prime Coat

Apply the Stripe Coat and primer coat after preparing the surface in accordance with this section and as approved by the QAI or the Bridge Engineer and before the surface rusts.

Equip the paint pot with an agitator during spray painting Work. Provide an agitator or stirring rod capable of reaching within 2 inches of the bottom of the pot to keep the paint mixed during application.

For Organic Zinc-Rich Paint Systems: Apply Prime Coat to a DFT as stated in Table 2478.3-2, with no spot reading measuring less than the minimum primer DFT listed, unless the manufacturer requires otherwise. Remain within the maximum DFT limits as defined by the manufacturer.

Table 2478.3-2
Blast Profile / Paint Thickness Requirements for Primer

Blast Profile	Minimum Primer DFT	Average Primer DFT
2.0 – 3.0 mils	3.0 mils minimum	4.0 mils average
3.0 – 4.0 mils	4.0 mils minimum	5.0 mils average
>4.0 mils	Write a Nonconformance Report (NCR) or use a preapproved “Request for Deviation” as stated in your QM	Write a Nonconformance Report (NCR) or use a preapproved “Request for Deviation” as stated in your QM

For Inorganic Zinc-Rich Paint Systems: Apply Prime Coat to a DFT average of at least 4.0 mils with no spot reading measuring less than 3 mils, unless otherwise required by the Contract.

For Contact Surfaces of bolt splices, do not apply Prime Coat to a thickness greater than the manufacturer’s certified thickness for Class B slip co-efficient.

Apply the prime paint coat per 2478.3E, “Application of Paint,” (Hold Point).

F.4 Intermediate Coat

Apply the intermediate coat to a DFT of at least 3.0 mils after the Prime Coat cures to the “dry-to-topcoat,” as defined in the manufacturer’s Product Data Sheet. Remain within the maximum DFT limits as defined by the manufacturer.

Provide epoxy intermediate coat in a color that will contrast between the organic zinc-rich primer and the polyurethane topcoat.

Apply the intermediate paint coat to Prime Coated surfaces exposed in the completed Structure.

Apply the intermediate paint coat per 2478.3E, “Application of Paint,” (Hold Point).

F.5 Finish Coats

Apply the finish coat to a DFT of at least 2.0 mils (remain within the maximum DFT limits as defined by the manufacturer) after the intermediate cures to the “dry-to-topcoat,” as defined in the manufacturer’s Product Data Sheet. Ensure the finish coat color matches the color standard required by the Contract. Assure the supplied product meets the requirements of 3501, "Basic Requirements for Paints." Per 3501, "Basic Requirements for Paints," provide a color draw down sample on a Leneta chart per *ASTM D2805, Standard Test Method for Hiding Power of Paints by Reflectometry* to the Bridge Engineer. The Department requires an acceptable initial draw down sample prior to beginning any Work because color testing is the initial control for the quality of the product.

Apply the finish paint coat to intermediate coated surfaces exposed in the completed Structure. Ensure the finished surface is uniform in color and free of visible lap marks and other blemishes.

Apply the finish paint coat per 2478.3E, “Application of Paint,” (Hold Point).

Fillet seal crevices and cavities along the Edge of faying surfaces that are separated by 1/16 inch or more with an approved sealant that is listed on the *Approved/Qualified Products List* for Bridge “Structural Steel Coating Sealants” and apply per the coating manufacturer installation instructions. Do not seal the bottom Edge of vertical faying surfaces allowing the juncture to release trapped moisture. Ensure the sealant color is a match to the finish paint color by submitting a sample to the Department laboratory for color approval or utilize an approved clear caulk. Apply the caulk in a smooth manner (Hold Point).

F.6 Total Paint Thickness

Ensure the total paint thickness of the entire Paint System averages at least 10 mils for Organic Zinc-Rich Paint Systems and 9 mils for Inorganic Zinc-rich Paint Systems but remains in the maximum thickness limits defined by the manufacturer of the Paint System. If the Bridge Engineer finds total paint thickness deficient or excessive over any part of a Structure and if the Bridge Engineer does not require additional paint applications or removal of paint, the Department may apply a monetary deduction for the appropriate item of Work.

G Markings for Identification

Stencil the year of painting and the Specification numbers of the Prime, intermediate, and top coats in numerals 3 inches high on the interior surface of fascia beams, at the same Corner displaying the Bridge name plate and at the Corner diagonally opposite that Corner (example: 2020 2478).

G.1 Stenciling after Primer

When the primer is applied in the Shop, ensure the fabricator/painter stencils the name of the paint manufacturer and the primer product name applied in the Shop on the inside web of both fascia girders in characters 3 inches high and in a contrasting color compatible with the specified Paint System.

H Fasteners

All hardware, fasteners, anchorage nut, washer, and threaded rod stick out used to install metal railings in the field are not field painted.

I Handling, Storage, and Shipping of Painted Steel

Do not apply paint to members loaded for shipment except to apply touch-up paint as approved by the QAI or the Bridge Engineer.

Do not damage the painted steel in the Shop and field during shipping, erection, and construction of the Bridge and components. Do not move or handle the painted steel items until the coating dries in accordance with the manufacturer's data sheet. Use nylon straps, padded hooks, slings, or other nonmetallic lifting devices to protect coated components or products during handling and loading. Use softeners and Edge protection devices to protect the steel from binding chains. Provide padded hooks and slings to hoist the painted components.

Store completed items in accordance with 1606, “Storage of Materials,” and the following:

(1) Tag or permanently mark items before final storage. Include individual piece marks, Bridge number, Project number, manufacturer number, and the applicator job number in the identification markings
(2) Locate the final storage area out of any Traffic Lanes and in an area capable of bearing the full weight of the members or items and stable enough to maintain bundles, members, or items within the supporting substrate. Inspect and store bundles, members, or items in one general location before final acceptance unless otherwise approved by the QAI or the Bridge Engineer

Support individual items or bundles of coated products in transit in a manner that will prevent damage to the coating. Do not drop or drag individual items or bundles of coated products. Pad when shipping, bundling, or banding Materials to protect the components from direct contact with packaging Materials that may damage the coated products finish. Use softeners and Edge protection devices in conjunction with high-density foam or other acceptable packaging Materials at points of contact.

J Paint Repair

The Contractor may use a “Tooke Gauge” to perform a destructive test to measure the DFT, at no additional cost to the Department, if it is not possible to satisfactorily determine the coating thickness of any paint coat after application. Repair the destructively tested area as approved by the Bridge Engineer and at no additional cost to the Department. Do not perform mechanical grinding to reduce paint thickness. Completely remove and recoat the Paint System with deficient or excessive paint thickness, as defined in this section, for Prime, intermediate, or topcoat if directed by the Bridge Engineer.

Submit paint repair procedures to the Bridge Engineer in writing for acceptance.

2478.4 METHOD OF MEASUREMENT

The Engineer will make area calculations. The Engineer will not make allowance in area calculations for actual areas of rivets and bolt heads, curved surfaces of welds, radii, or Corners.

A Shop Painting

The Engineer will measure Shop painting required by the Contract based on the area of acceptable paint coverage on non-contact areas, as computed from the dimensions shown on the Plans. The Engineer will not include contact areas in the measurement for payment.

B Field Painting for New Construction

The Engineer will measure field painting in the bolted field splice areas of newly constructed Shop painted steel based on the field splice area of acceptable paint coverage as shown on the Plans. The Department will consider the cost of paint repairs to correct damage from field storage or erection with the relevant Contract Unit Prices for structural steel.

C Field Painting of an Existing Bridge

The Engineer will measure field painting of structural steel on the basis of the area of acceptable paint coverage, as computed from the dimensions as shown on the Plans for the Structure.

2478.5 BASIS OF PAYMENT

A Shop Painting

The Contract square foot for Organic Zinc-Rich Paint (Shop) includes the costs providing and applying an acceptable Shop applied Paint System, including necessary repairs to the paint coating that occur before unloading at the Project storage site.

B Field Painting of Shop Painted Components

The Contract square foot price for Organic Zinc-Rich Paint System (Field) includes the costs of preparing and applying field applied Paint Systems to Shop primed bolted splice areas.

C Painting of Existing (Old) Components or Structures

The Contract square foot price for Organic Zinc-Rich Paint System (Old) includes the costs of surface preparation, providing, and applying Coating System to existing structural steel.

D Schedule

The Department will pay for Organic Zinc-Rich Paint System on the basis of the following schedule:

Item No.	Item	Unit
2478.518	Organic Zinc-Rich Paint System (Shop)	square foot
2478.518	Organic Zinc-Rich Paint System (Field)	square foot
2478.518	Organic Zinc-Rich Paint System (Old)	square foot

2479 INORGANIC ZINC-RICH PAINT SYSTEM

2479.1 DESCRIPTION

This Work consists of the following for new Work where the application of Inorganic Zinc-Rich Primer is done in the Shop and where field applied intermediate and top coating is desired:

(1) Surface preparations
(2) Providing and applying the coating
(3) Protecting and curing the coating
(4) Protecting pedestrians, vehicular traffic, and property against damage
(5) All Work Incidental to these operations

A Definitions 2478.1A

2479.2 MATERIALS

A Zinc-Rich Paint Systems 3520

Provide paint systems listed on the *Approved/Qualified Products List* for Bridge “Structural steel coating, three coat systems (inorganic).”

2479.3 CONSTRUCTION REQUIREMENTS 2478.3

2479.4 METHOD OF MEASUREMENT

The Engineer will make area calculations. The Engineer will not make allowance in area calculations for actual areas of rivets and bolt heads, curved surfaces of welds, radii, or Corners.

The Engineer will measure painting of the structural steel by the square foot based on the area of acceptable paint coverage on non-contact areas as computed from the dimensions as shown on the Plans. The Engineer will not include contact areas in the measurement for payment.

2479.5 BASIS OF PAYMENT

A Shop Painting

The Contract square foot price for Inorganic Zinc-Rich Paint System (Shop) includes the cost of providing paint product for the primer and applying the primer in accordance with this section and 2402, "Steel Bridge Construction."

B Field Painting

The Contract square foot price for Inorganic Zinc-Rich Paint System (Field) includes the cost of providing and applying the paint product for the intermediate and finish coats of the approved paint system. The Department will include the cost of paint repairs to correct damage from field storage or erection with the relevant Contract Unit Price for structural steel.

C Shop and Field Painting

The Contract square foot price for Inorganic Rich Paint Systems (Shop and Field) includes the costs of surface preparation, providing, and applying Shop and Field Coatings. The Department will include the cost of paint repairs to correct damage from field storage or erection in the relevant Contract Unit Price for structural steel.

D Schedule

The Department will pay for Inorganic Zinc-Rich Paint System on the basis of the following schedule:

Item No.	Item	Unit
2479.518	Inorganic Zinc-Rich Paint System (Shop)	square foot
2479.518	Inorganic Zinc-Rich Paint System (Field)	square foot
2479.518	Inorganic Zinc-Rich Paint System (Shop and Field)	square foot

2481 WATERPROOFING

2481.1 DESCRIPTION

This Work consists of waterproofing joints.

2481.2 MATERIALS

A Membrane Waterproofing System 3757

2481.3 CONSTRUCTION REQUIREMENTS

A General

Remove form ties, fill cavities with mortar, and remove sharp protrusions before waterproofing. Before applying the primer, ensure the concrete has cured for 72 hours and is clean, dry, smooth, and free of voids. Clear the concrete of dust and other loose Material immediately before applying the primer.

Apply the waterproofing system in dry, fair weather when the air temperature is above 40°F.

Protect waterproofing against damage during succeeding construction operations. Repair damaged waterproofing as approved by the Engineer, at no additional cost to the Department.

B Membrane Waterproofing System

Provide a self-adhering strip of waterproofing membrane at least 12 inches wide listed on the *Approved/Qualified Products List* for the membrane waterproofing system. Prime the surface on the joint as recommended by the manufacturer. Center the membrane on the joint. Provide polyethylene sheeting with a thickness of 4 mils and provide rubberized asphalt with a Nominal thickness of 0.06 inches, for a total Nominal thickness of 0.06 inches. Ensure the face of the rubberized asphalt opposite the face bonded to the sheeting includes a removable covering. Allow the removable covering to remain on the membrane until placement of the membrane.

The Contractor may make splices in the joint waterproofing membrane using an overlap of at least 6 inches at the splice. For splices on vertical face joints, ensure the upper strip overlays the lower strip.

2481.4 METHOD OF MEASUREMENT

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

2481.5 BASIS OF PAYMENT

The Department will pay for joint waterproofing only if the Contract contains a specific Pay Item for waterproofing. If the Contract does not specify a Pay Item for waterproofing, the Department will include the cost of Joint waterproofing with other relevant Contract Unit Prices.

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

Item No.	Item	Unit
2481.503	Joint Waterproofing	linear foot

Miscellaneous Construction

2501 PIPE CULVERTS

2501.1 DESCRIPTION

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

2501.2 MATERIALS

A Pipe

Provide one of the following types of Culvert pipe meeting the lowest strength class specified in the referenced Specification, unless otherwise shown on the Plans or specified in the Special Provisions. Provide special fabrication or jointing details as shown on the Plans. Provide Culvert pipe with the coating type shown on the Plans or specified in the Special Provisions.

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

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

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

A.4 Polypropylene (PP) **3246**

A.5 Reinforced Concrete (RC) **3236**

A.6 Polymeric Coated Corrugated Steel (PC-CS) **3229**

A.7 Corrugated Aluminized Steel (CAS) **3222**

A.8 Polyvinyl Chloride (PVC) **3248**

B **Structural Plate**

C **Aprons**

Provide aprons of the type required by the Contract. The Contractor may provide and attach galvanized steel aprons to corrugated steel, corrugated polyethylene, polyvinyl chloride, polypropylene, and polymeric coated corrugated steel pipe, unless otherwise specified on the Plans. Do not connect galvanized steel products to aluminum or aluminized steel products. Use GS for smooth galvanized steel aprons and CS for corrugated galvanized steel aprons as shown on Plate 3128.

F **Pipe Joint Sealer Materials**

2501.3 CONSTRUCTION REQUIREMENTS

Install pipe Culverts in accordance with the following requirements:

A **General**

Excavate, construct foundations, backfill, and compact Culvert(s) in accordance with the Plans, 2451 “Structure Excavations and Backfills,” and the following:

Remove and replace unsuitable foundation Materials encountered at or below the foundation elevation using suitable replacement Materials as directed by the Engineer. Install the replacement Material in Layers 6 inches thick per 2106, “Excavation and Embankment – Compacted Volume Method.”

Compact Materials used for bedding and foundation backfill in accordance with the Plans and 2106, “Excavation and Embankment – Compacted Volume Method.”

B Entrance Culverts

The Contractor may install entrance Culverts without standard bedding unless shown in the Plans or installing plastic pipe. Backfill using Material meeting 1103, “Definitions: Select Grading Material,” and compact per 2106, “Excavation and Embankment – Compacted Volume Method.”

C Laying Pipe

C.1 General

Lay pipe to the line and grade shown in the Plans.

Terminate pipes that connect with inlet Structures flush with the inside of the Structure wall. At Culvert connections with an existing inlet Structure, make a suitable connection as approved by the Engineer through the wall of the inlet Structure.

Jack Culverts through the existing earth Structure into position as shown on the Plans or as approved by the Engineer. Ensure the flow line elevation at the starting point for jacking is within 0.1 feet of the staked grade. Do not reverse the flow line grade at any point. Ensure the line and grade at any point within the pipe does not vary by greater than 0.5 feet from the line and grade designated on the Plans.

Provide any additional cover required to avoid damage to the pipe during construction. Maintain adequate cover until paving is completed, or until the installation is accepted by the Engineer if paving is not required. Repair or replace pipe damaged by Contractor operations to the satisfaction of the Engineer, at no additional costs to the Department.

C.2 Metal Culvert

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

Provide backfill Material in accordance with the Plan, modified to 100 percent passing the 3-inch Sieve within 2 foot of the pipe.

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

Use approved fasteners, as defined in the applicable Materials Specifications, to assemble structural plate Culverts as required by the manufacturer. Tighten bolts after assembly to a torque of 100 lbf ft to 300 lbf ft. Provide a calibrated torque wrench to demonstrate the adequacy of the bolt tightening, as approved by the Engineer.

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

C.3 Concrete Culvert

Lay concrete pipe with the female end of each section upgrade. Tightly join the pipe sections so that the interior of the pipe sections abut each other.

Use preformed rubber or bituminous mastic elastic joint sealer Material to provide flexible water-tight joint seals for concrete pipe. Where the pipe is designed to accommodate preformed gasket type seals, seal the joints with the preformed gasket as shown on the Plans and meeting the performance requirements of 3726, “Preformed Gasket Seals for Concrete Pipe.” Keep gaskets and joint surfaces clean and free from soil during installation. Follow manufacturer’s recommendation for fitting or coupling assembly and installation. Use a lubricant, if required, that will not deteriorate the gasket and pipe Materials.

Where the pipe is not required to accommodate preformed gasket type seals, seal the joints with bituminous mastic and a full circumferential wrap of geotextile Material extending at least 1 foot on each side of the joint. Secure the circumferential wrap against the outside of the pipe by metal or plastic strapping or by other methods approved by the Engineer.

Apply mastic joint sealer Materials as recommended by the manufacturer. Wipe joints clean on the inside after sealing.

Plug lifting holes with a precast concrete plug, sealed and covered with mastic or mortar.

Use approved fasteners shown on *Standard Plate 3145* to tie together concrete Culvert sections unless otherwise shown on the Plans or specified in the Special Provisions.

Provide backfill Material in accordance with the Plan, modified to 100 percent passing the 3-inch Sieve within 2 feet of the pipe.

C.4 Plastic Culvert

Follow bedding, backfill, and trench width requirements shown in Plan. If cover over plastic pipe modified from what is shown in the Plan, follow plastic pipe minimum cover and maximum fill height requirements in the *Drainage Manual*.

Provide backfill Material in accordance with the Plan, modified to 100 percent passing the 1-inch Sieve within 2 feet of the pipe. Use the embedment Material to provide 1 foot minimum of fill over the pipe for a trench width as specified by the Contract.

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

Place pipes on the bedding starting at the downstream end with the female end of each section upgrade.

Make connections with bell and spigot joints using an elastomeric rubber seal (gasket) to provide water-tight joints that do not allow soil, Silt, or water to migrate through the joint. Install joints so connected pipe sections form a continuous surface free of irregularities in the flow line. Tightly join the pipe sections so that the interior of the pipe sections abut each other. Keep gaskets and joint surfaces clean and free from soil during installation. Follow manufacturer's recommendation for fitting or coupling assembly and installation. Use a lubricant, if required, that will not deteriorate the gasket and pipe Materials.

Before allowing vehicles or heavy construction Equipment to travel over the pipe trench, maintain a minimum cover depth of Material above the pipe of at least 2 feet and meeting the requirements of *AASHTO LRFD Bridge Construction Specifications*, Section 30, Table 30.6-1.

Perform deflection testing of all plastic pipe at least 30 Calendar Days after installation. Remove obstructions such as sediment, standing water or safety grates that would interfere with deflection testing. Dewatering and additional Work associated with preparing for and performing deflection testing is included in the bid price of the pipe.

Evaluate the pipe to determine if the specific internal diameter of the barrel has deflected more than 5 percent. Use the following methods to perform the deflection test unless specified in the Plan:

(1) Visual inspection alone is not allowed for deflection testing.

(2) Use a 9-point mandrel approved by the Engineer to perform deflection testing for pipes. Pull the mandrel through the pipe using non-mechanical means.

(3) Direct measurements cannot be used for deflection testing unless specified in the Plans and approved by the Engineer. Direct measurements can only be used on pipes with an inside diameter of 30 inches or greater. If the Department allows direct measurements, the Engineer must take measurements at randomly select locations, but at a minimum once every 10 feet throughout the pipe length and at the pipe ends. Visually inspect the pipe and take additional measurements at any location of observed anomaly or deflection. Ensure personnel making direct measurements meet confined space entry requirements in accordance with 1706, “Employee Health and Welfare.”

(4) Laser scan inspection (laser ring) can be used to perform deflection testing when specified in the Plans and approved by the Engineer.

The Engineer will not accept pipe that has a deflection of more than 5 percent or is damaged. Remove unacceptable pipe and reinstall new pipe or reuse undamaged pipe. Retest the relaid pipe for 5 percent deflection at least 5 Calendar Days after embedment Material is installed to grade.

Send deflection testing results to the Hydraulic Engineer with the SP number, pipe location, Material type, size, date built, date tested, and results from the mandrel test or other deflection test.

C.5 Extending In-Place Culverts

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

Follow backfill and bedding requirements for Culvert Material type.

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

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

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

D Backfilling Excavations

Backfill excavations to the required extent shown on the Plans and at the appropriate time. Uniformly distribute suitable backfill Materials in 6 inch Layers. Compact backfill in accordance with the Plans and 2106, “Excavation and Embankment – Compacted Volume Method,” before placing successive Layers.

Within the Road core, if the Contract does not specify special backfill Materials, use Materials meeting 3149.2D.1, “Granular Backfill,” placed within 18 inches of the sides and 12 inches above the top of the Structure (note that plastic Culverts require 1 inch minus Material, regardless of Culvert location). For the remainder of the backfill, use embankment Material meeting 1103, “Definitions: Select Grading Material.” If outside the Road core, use suitable Material meeting 1103, “Definitions: Select Grading Material.”

Do not place backfill Material on a frozen foundation or when the Material may freeze during the placement or compaction Work.

Step the sides of the excavation, if steeper than 1:4 and if potential wedging action of the backfill may be detrimental to the Structure. If the Contract does not require specific maximum dimensions for the excavation, the Contractor may enlarge the excavation and flatten the side slopes for convenience of backfill and compaction operations, at no additional cost to the Department.

Backfill uniformly in horizontal Layers throughout the excavation area. Maintain the sides of the excavation and prevent voids in the backfill when removing shoring or bracing from the excavation.

E Culvert Appurtenances

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

F Induced Trench Installation

Construct backfill over the Culvert, if shown on the Pans and in accordance with the following:

Construct the embankment in accordance with 2106, "Excavation and Embankment – Compacted Volume Method," 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 1 foot. When using 2106.3G.1, "Specified Density" method, compact the embankment to a density not less than 100 percent of Maximum Density.

Excavate a trench to a level 1 foot above the top of the Culvert, for the width and length of the pipe, and with vertical sides. Loosely fill the trench with highly-compressible clay soil before constructing the remaining embankment in accordance with 2106, "Excavation and Embankment – Compacted Volume Method."

G Culvert Cleaning

Clean sediment and debris from Culvert(s) before final acceptance.

2501.4 METHOD OF MEASUREMENT

A Culvert Excavation

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

B Culvert Pipe

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

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

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

Where pipe options are allowed, measurement will be made by length and type of pipe indicated on the Plan, regardless of the type of Material installed. No adjustments will be made for any additional Work required by the Contractor based on choice of Material.

C Culvert Appurtenances

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

The Contract Unit Prices for pipe Culverts will include the cost of cast-in-place concrete Work.

D Granular Materials

The Engineer will measure granular Materials for special backfill or bedding in accordance with 2451.4B, “Granular Materials,” unless specified otherwise in the Plan.

2501.5 BASIS OF PAYMENT

The Contract Unit Price for Culvert pipe of each size, type, kind, and strength class includes the costs of providing and installing the pipe complete in-place as required in the Contract, except as otherwise specified in this section.

The Contract Unit Prices for plastic pipe Culverts will include the cost of deflection testing, dewatering, and buoyancy protection as required by the Plan but not designated under other items. Payment will not be made until proof of adequate deflection test is provided.

The Department will separately pay for aprons, safety aprons and grates, safety grates, flap gates, dissipator rings, diaphragms, and other specially designed and identified appurtenant items by type, size, and number of units incorporated in the Structures as shown on the Plans. The Contract Unit Price for these items includes the cost of providing and installing the items complete in-place.

The Department will separately pay for granular Materials for special backfill or bedding in accordance with 2451.5, “Structure Excavations and Backfills, Basis of Payment.”

The Department will separately pay for Culvert excavation at the Contract Unit Prices included in the Contract in accordance with 2451.5, “Structure Excavations and Backfills, Basis of Payment.” If not included in the Contract, the Department will include excavating costs in the Contract Unit Prices for Culvert pipe and appurtenant items.

Surplus excavated Materials not used for backfill become the property of the Contractor. Dispose of surplus Material in accordance with the disposal form submitted to and approved by the Engineer. The Contract Unit Price for the relevant Culvert Contract Item includes the costs associated with the disposal of surplus Material.

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

The Department will pay for installing Culvert Materials provided by the Department under the applicable installation items shown in the Contract. The Contract Unit Prices for installing Culvert Materials provided by the Department include the cost of Work and additional Materials required for the installation complete in-place, except for Extra Work or Work designated under other items.

If the Engineer allows installation by the jacking method and the Contract does not contain a relevant Contract Item, the Department will pay for a jacking installation on the basis of Contract Unit Prices relevant for the trenching method.

The Contract Unit Price for the relevant pipe Contract Item includes the cost of Culvert cleaning, except when specifically designated under other items.

The Department will identify when pipe Material options are allowed in the Plans. Payment will be made by the length and type of pipe indicated on the Plan, regardless of the type of Material installed. The Contractor will include the costs associated with using an alternative, such as differences in installation requirements including deflection testing, trench width, or embedment Material Specifications, and quantities in the Contract Unit Prices of the relevant pipe Pay Items. No adjustments will be made for any additional Work required by the Contractor based on the choice of Material.

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

Item No.	Item	Unit
2501.502	___" ‖ Pipe Apron	each
2501.502	A-S Diaphragm for ‡ Pipe	each
2501.502	Flap Gate for ‡ Pipe	each
2501.502	___" Span ‖ Pipe-Arch Apron	each
2501.502	A-S Diaphragm- for ‡ Pipe-Arch	each
2501.502	___" ‖ Elliptical Apron	each
2501.502	___" High ‖ Cattle Pass Transition Section	each
2501.502	___ " High ‖ Cattle Pass Apron	each
2501.502	___" ‖ Safety Apron and Grate Design §	each
2501.502	___" ‖ **	each
2501.502	Install **	each
2501.502	___" RC Dissipator Ring	each
2501.503	Install **	linear foot
2501.503	___" ‖ Pipe Culvert †	linear foot
2501.503	___" Span ‖ Pipe-Arch Culvert †	linear foot
2501.503	___" ‖ Elliptical Pipe Culvert #	linear foot
2501.503	___" High ‖ Cattle Pass Culvert †	linear foot
2501.503	___" ‖ Struct Plate Pipe Culvert †	linear foot
2501.503	___" Span ‖ Struct Plate Pipe-Arch Culvert †	linear foot
2501.503	___" ‖ Pipe Culvert Design § †	linear foot
2501.503	___" Span ‖ Pipe-Arch Culvert Design § †	linear foot
2501.507	Culvert Excavation Class *	cubic yard

* Specify Class U, E, or R only – See 2451.3B.2, "Types"
‖ Specify Kind – See 2501.2, "Materials," if alternatives are allowed do not specify kind
† Specify Strength Class, if other than minimum requirement
‡ Specify size and kind
# Specify HE or VE, and Strength Class, if other than minimum requirement
§ Give Standard Plate number for special pipe or joint designs
** Specify item name

2502 SUBSURFACE DRAINS

2502.1 DESCRIPTION

This Work consists of constructing subsurface drains and installing plant-fabricated pipe and appurtenant Materials:

2502.2 MATERIALS

Provide perforated pipe except where unperforated is required.

Provide fittings connecting multiple lengths of drain pipe made of the same Material as the pipe.

A	**Medium Filter Aggregate**	**3149.2I.1**
B	**Fine Filter Aggregate**	**3149.2I.2**
C	**Drain Pipe and Fittings**	
C.1	**Thermoplastic (TP)**	**3245**
C.2	**Corrugated Polyethylene Drainage Tubing (PE)**	**3278**
D	**Discharge Pipe, Radial Connecting Pipe, and Fittings**	**3245**
E	**Preformed Pavement Marking Tape**	**3354**
F	**Geotextile, Type 1**	**3733**
G	**Precast Concrete Headwall**	***Standard Plate 3131***
H	**Flexible Transition Couplings**	***ASTM C1173***

2502.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Excavation, Bedding and Laying Drains General

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

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

Do not compact greater than 12 inches of backfill in any one Layer. After compaction and leveling, extend the filter Aggregate up onto the adjacent pavement as shown on the Plans.

After placing the drain and discharge pipe, do not allow construction Equipment to travel over the drain or discharge pipe until the system is covered.

Allow the drain to remain open and operational after installation to prevent water from collecting in the pipe.

Excavate the trench to the lines and grades as shown on the Plans.

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

Place drains constructed in conjunction with bituminous pavement after placement of the non wearing course(s) and before the wearing course.

Construct drains before placing the additional Aggregate base in the Shoulder area.

Use cement solvent type joints unless otherwise indicated. Flexible transition couplings are allowed with the Engineer’s approval.

Close upgrade ends of subdrain pipe with caps. Use wyes or bends at junctions and turns suitable for cleaning and inspection.

Use 3A grout for connecting to a storm sewer or basin.

Remove rock encountered within the excavation to a width of at least the Nominal pipe width plus 2 times the pipe diameter or the Plan width whichever is greater and to a depth of at least 1 pipe diameter below the bottom of the pipe.

No stone larger than 1 inch is allowed in the trench.

Line the bottom of the drainage trench with geosynthetic as required in the Plan. On the pavement side of the trench, terminate the geosynthetic within the Aggregate base. Do not extend the geotextile up onto the PASB, OGAB, DSB, PASSRC or allow it to fall below the bottom of the Aggregate base. On the side of the trench farthest from the pavement, the Contractor may terminate the geotextile within or above the Aggregate base, but not below it.

Place pipe on a minimum 0.2 percent grade or as shown on the Plan. If pipe grades do not follow the Roadway profile at a constant depth, provide and use laser grade control Equipment to place pipe.

Follow pavement grades at the depth shown on the Plans when placing pipes in trenches. Properly align the pipe in the cradle before placing the backfill when separate operations are used to place the pipe and backfill.

Bed trench with Material as specified in the Plans and compact meeting the requirements 2106.3G.2, “Quality Compaction.”

Excess Materials become the property of Contractor. Dispose of excess Materials per 2104.3D.3, “Disposal Outside Right-of-way.”

Where a drain connects with a Structure or catch basin, construct a connection that does not leak through the wall of the Structure.

Terminate drainage discharge pipe at a precast concrete headwall, per *Standard Plate 3131*.

A.1.a Excavation, Bedding, Laying Drains, and Connecting TP Pipe

Place pipe in an open trench.

Shape the bedding foundation with the required Material to fit at least the lower 30 percent of the outside circumference of the pipe.

Lay drains to line and grade shown on the Plans and with the perforations down.

Use a rubber or plastic gasket cast into the headwall.

A.1.b Excavation, Bedding, Laying Drains, and Connecting PE pipe

Use a trencher capable of cutting the trench to the Plan dimensions, shaping the trench bottom to cradle the lower 1/3 of the pipe, laying the pipe and backfilling with Plan required Aggregate in a simultaneous and continuous operation.

Do not plow.

If the off-set between the tracks or tires of the trencher is greater than 6 inches, use a self-leveling trenching machine.

Provide trenching Equipment designed and operated to prevent the excavated Material from falling back into the trench. If the trench sides are sloughing or caving in, use a shield to place the backfill.

Use couplers for joints unless otherwise indicated.

A.2 Geosynthetics

Install geosynthetics as shown in the Plans in conformance with 2108, "Geosynthetic Construction Materials."

If required per the Plans, wrap perforated pipe with factory-seamed or factory-produced continuous knit weave geotextile. Place the fabric seam at the top of the pipe, opposite the perforations. For seams at fittings or connectors, mechanically fasten or overlap the adjoining geotextiles at least 6 inches.

A.3 Backfill and Compaction

For perforated pipe installations, if Plan does not designate Material type, backfill with Material meeting 3149.2I.2, "Fine Filter Aggregate."

Moisten the Aggregate for compaction.

Do not use the tire-rolling method to compact the backfill.

Do not use stones greater than 1 inch for backfilling.

Meet the requirements of 2106.3G.2, "Quality Compaction."

For fine filter Aggregate backfill, meet a DPI of 75 millimeter per hammer blow when using a Dynamic Cone Penetrometer (DCP).

A.4 Drain Discharge

A.4.a Precast Concrete Headwall

Place concrete headwalls on discharge pipes before the end of the construction season.

Place precast concrete headwall outlet inverts 12 inches above ditch grades unless otherwise noted in the Plan.

Place the uppermost point of the headwall flush with the in-slope at a downward grade of at least 2 percent.

Shape the side slopes adjacent to the headwall to conform to the sides and toe of the headwall.

Compact the soils around and under the concrete headwall to meet 2106.3G.2, "Quality Compaction."

If headwalls are not required:

(1) Mark discharge points to locate in the future
(2) Screen the drain opening with a rodent shield
(3) Leave screened pipe ends open and free-flowing

A.4.b Discharge Pipe

Provide the same diameter of discharge pipe as the pipe.

Use connection and coupling methods approved by the Engineer.

Construct the discharge pipe to the drain outlet while constructing the drains. Place the discharge pipe and the drains at right angles to the Roadway centerline. Connect the discharge pipe to the headwall.

Solvent or gasket joint into a TP coupling cast into the headwall.

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

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

(1) Cradle the pipe invert
(2) Compact soil adjacent to and above the pipe to prevent crushing the pipe
(3) Compact the backfill soil in accordance with 2106.3G, “Compacting Embankments and Backfills”

Use compaction Equipment capable of compacting the Material in the drain trench without compacting the adjacent soils. Use backfill Layer uncompacted thicknesses no greater than 6 inches.

Correct Shoulder settlement above the discharge pipe as directed by the Engineer and at no additional cost to the Department.

Replace crushed or deformed discharge pipes or connections at no additional cost to the Department.

If drains discharge to storm sewers, place the drain invert from 6 inches to 12 inches above the sewer invert using a connection method approved by the Engineer at no additional cost to the Department.

Establish turf in accordance with specification 2575.3L, “Turf Establishment,” concurrent with drain outlet installation.

A.5 Quality Assurance Testing and Clean Out

The Engineer will perform inspections using a probe mounted on the end of a flexible fiberglass rod 4 inches long and with a diameter of 1 Nominal pipe size smaller than the drain pipe being inspected.

The Engineer will conduct the inspection through the discharge pipe, radius connection, and at least 3 feet into the main drainage line. Clean or repair inoperative discharge pipe and connections as approved by the Engineer. Replace crushed or deformed pipes or connections at no additional cost to the Department.

A.6 Maintenance during Construction

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

A.7 Marking Outlet Locations

Permanently mark the locations of outlets with a 6 inch by 18 inch strip of white marking tape in accordance with 3354, "Preformed Pavement Marking Tape." Place the tape at the outside edge of the bituminous Shoulder, at right angles to the Roadway, and roll the tape into the Shoulder while the bituminous pavement surface temperature is from 120°F to 150°F. If 2 runs of drain pipe come together at a low point and discharge via a "Y" to a single outlet, place 2 markings side-by-side with a 6 inch spacing. For locations with no bituminous Shoulder, place the tape on the bituminous pavement or spray a white paint strip on concrete pavements.

B Subcut Drain Specific Requirements

The Contractor may directly connect subcut drains to permanent drainage Structures or outlet the drains to the ditch using a discharge pipe and headwall. Maximum spacing of Structures is 800 feet. Make connections to drainage Structures as approved by the Engineer. Place discharge outlets at low points and spaced no greater than 500 feet apart.

B.1 Design Option One

Place perforated TP pipe in the bottom of the subcut in accordance with the design typical in the Plans. Place 12 inches of backfill above the pipe before compacting.

Provide pipe with either bell and spigot or sleeve couplings and either gasket or solvent joints. Mark the fitting insertion line on the ends of the bell or sleeve.

Maximum angle is 22 1/2 degrees when connecting to drainage Structures.

B.2 Design Option Two

Place perforated PE pipe after partially or totally backfilling the subcut.

Backfill and compact as shown in the Plan.

Perform the trenching operation after placing and compacting at least 24 inches of subcut backfill. If trenching after completely backfilling the subcut, only backfill the lowermost 24 inches of the trench. Backfill the remaining trench with the same Material used for the subcut.

C Pavement Edge Drain Specific Requirements

Place edge drain adjacent to new concrete pavements after constructing the pavement. Run the trenching head tight against the pavement to completely excavate adjacent soil.

Place the edge drains before pavement cracking when cracking in-place PCC pavement.

Place the drains before excavating the widening-trench for edge drains placed in conjunction with pavement widening. Use an approved device on the trenching machine to ensure that the pipe is located at the design distance from the edge of the in-place pavement. After compaction, ensure the backfill in the drain extends at least 4 inches above the bottom of the pavement widening trench.

When placing edge drains adjacent to new bituminous pavement, construct the edge drain after placing the non wearing courses, but before placing the wearing course. For new and retrofit bituminous construction, ensure the trenching head continuously intercepts and cuts-off the roll-over portion of at least the lower bituminous pavement course.

D Interceptor Drains Specific Requirements

Construct 4 inch to 6 inch Aggregate-filled interceptor drains at the end of each pavement joint and at mid-panel cracks, or at other major cracks as designated by the Engineer.

Interceptor drains must be installed before placing a stress relief Layer or any other overlaying Work.

Cut trenches normal to the pavement edge centered on the joint or crack.

Cut trenches 2 inches deeper than the adjacent pavement and running the full-depth from the in-place pavement edge to at least 4 inches beyond the edge of the unbonded concrete overlay.

Clean soil or debris from the exposed pavement crack or joint before backfilling the trench. The Engineer will approve the method and extent of joint/crack cleaning.

Backfill any void space to the top of the trench with fine filter Aggregate.

2502.4 METHOD OF MEASUREMENT

A Drainage System

The Engineer will measure drainage system on a lump sum basis. No measurement will be made of any individual subsurface drain item.

B Precast Concrete Headwalls

The Engineer will measure Precast concrete headwalls on an each basis.

C Interceptor Drains

The Engineer will measure Interceptor drains on an each basis.

D Subsurface Drains

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

The Engineer will measure drain and discharge pipes by installed length along the centerline of the pipe. The Engineer will begin and end measurement at the pipe end at free outlets, at the point of junction with in-place pipe, or at the center of Structures, catch basins, or multiple junction points.

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

2502.5 BASIS OF PAYMENT

The Contract Unit Prices for subsurface drains and outlets of each size, type, kind, and strength class includes the cost of pipe, geotextiles, excavation, and backfill.

For subcut drains, if the Plan includes both Option 1 and Option 2, the Contractor may select either option and the Pay Item will be 4” Perforated TP pipe drain.

Payment for Interceptor drains under the Contract bid item includes cutting the trench, cleaning joint and crack face, furnishing and compacting Aggregate, and other associated Work.

The Contract Unit Price for Precast concrete headwall includes the cost of the headwall, connecting the pipe, couplings, rolled erosion prevention product and seed, marking outlet location, inspecting, and other associated Work. For required sodding, the Engineer will include the cost of the sod with relevant Contract Pay Items.

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

Item No.	Item	Unit
2502.501	Drainage System Type (____)	lump sum
2502.502	___" Precast Concrete Headwall	each
2502.502	Interceptor Darin	each
2502.502	Install *	each
2502.503	___" Perf ‖ Pipe Drain †	linear foot
2502.503	Install ___" †	linear foot
2502.503	___" * Pipe Drain †	linear foot

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

2503 PIPE SEWERS

2503.1 DESCRIPTION

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

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

2503.2 MATERIALS

A Pipe

Provide one of the following types of sewer pipe as specified or allowed as an option on the Plans or in the Special Provisions. Use pipe meeting the lowest strength class specified or greater, as shown on the Plans or specified in the Special Provisions. Perform special fabrication or jointing as shown on the Plans. Provide pipe sewers with the coating type shown on the Plans or specified in the Special Provisions.

A.1 Reinforced Concrete (RC) **3236**

A.2 Corrugated Aluminum (CA) **3225**

A.3 Corrugated Steel (CS) **3226**

A.4 Corrugated Aluminized Steel (CAS) **3222**

A.5 Corrugated Polyethylene (CP) **3247**

A.6 Polypropylene (PP) **3246**

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

A.8 Polyvinyl Chloride (PVC) **3248**

B Flap Gates **3399**

C Pipe Joint Sealer Materials

C.1 Preformed Rubber, Type A **3726**

C.2 Bituminous Mastic **3728**

D Granular Materials **3149**

2503.3 CONSTRUCTION REQUIREMENTS

A General

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

B Excavation

For locations with cover over the top of the pipe at least 15 feet, ensure the excavation dimensions meet the following:

(1) For the portion of the required excavation below a point 1 feet above the top of the pipe, provide nearly vertical side slopes
(2) Excavate the width of the trench meeting the requirements specified in Table 2503.3-1:

Table 2503.3-1
Maximum Trench Width for Pipe Sewer

Pipe Diameter, inch	Maximum Trench Width*
< 42	Outside diameter plus 24 inches
42 – 54	1.5 times outside diameter
> 54	Outside diameter plus 36 inches
* 1 foot above pipe	

If the Contractor excavates the trench to a width greater than the values specified in Table 2503.3-1, the Engineer may direct the Contractor to provide a higher class of bedding, a higher strength pipe, or both, than that required by the Contract, at no additional cost to the Department.

C Laying Pipe

C.1 General

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

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

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

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

Provide any additional cover required to avoid damage to the pipe during construction. Maintain adequate cover until paving is completed, or until the installation is accepted by the Engineer if paving is not required. Repair or replace pipe damaged by Contractor operations to the satisfaction of the Engineer, at no additional costs to the Department.

C.2 Metal Sewer Pipe

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

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

C.3 Concrete Sewer Pipe

Lay concrete pipe with the female end of each section upgrade. Tightly join the pipe sections so that the interior of the pipe sections abut each other.

Use preformed rubber or bituminous mastic elastic joint sealer Material to provide flexible water-tight joint seals for concrete pipe. Where the pipe is designed to accommodate preformed gasket type seals, seal the joints with the preformed gasket as shown on the Plans and meeting the performance requirements of 3726, “Preformed Gasket Seals for Concrete Pipe.”

Keep gaskets and joint surfaces clean and free from soil during installation. Follow manufacturer’s recommendation for fitting or coupling assembly and installation. Use a lubricant, if required, that will not deteriorate the gasket and pipe Materials.

Where the pipe is not required to accommodate preformed gasket type seals, seal the joints with bituminous mastic and a full circumferential wrap of geotextile Material extending at least 1 foot on each side of the joint. Secure the circumferential wrap against the outside of the pipe by metal or plastic strapping or by other methods approved by the Engineer.

Apply mastic joint sealer Materials as recommended by the manufacturer. Wipe joints clean on the inside after sealing.

Plug lifting holes with a precast concrete plug, sealed and covered with mastic or mortar.

Use approved fasteners shown on *Standard Plate 3145* to tie together concrete pipe sections unless otherwise shown on the Plans or specified in the Special Provisions.

Provide backfill Material in accordance with the Plan, modified to 100 percent passing the 3-inch Sieve within 2 feet of the pipe.

C.4 Plastic Sewer Pipe

Follow bedding, backfill, and trench width requirements shown in the Plan. If cover over plastic pipe is modified from what is shown in the Plan, follow plastic pipe minimum cover and maximum fill height requirements in the *Drainage Manual*.

Provide embedment Material in accordance with the Plan, modified to 100 percent passing the 1-inch Sieve within 2 feet of the pipe. Use the embedment Material to provide 1 foot of fill over the pipe and fill for a trench width as specified by the Contract.

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

Place pipes on the bedding starting at the downstream end of the pipe installation with the female end of each section upgrade.

Make connections with bell and spigot joints using an elastomeric rubber seal (gasket) to provide water-tight joints that do not allow soil, Silt, or water to migrate through the joint. Install joints so connected pipe sections form a continuous surface free of irregularities in the flow line. Tightly join the pipe sections so that the interior of the pipe sections abut each other. Keep gaskets and joint surfaces clean and free from soil during installation. Follow manufacturer’s recommendation for fitting or coupling assembly and installation. Use a lubricant, if required, that will not have deteriorating effects on the gasket and pipe Materials.

Before allowing vehicles or heavy construction Equipment to travel over the pipe trench, maintain a minimum cover depth of Material above the pipe of at least 2 feet and meeting the requirements of *AASHTO LRFD Bridge Construction Specifications*, Section 30, Table 30.6-1.

Perform deflection testing of all plastic pipe at least 30 Calendar Days after installation. Remove obstructions including sediment, standing water, or other obstructions that would interfere with mandrel testing prior to deflection testing. Dewatering and additional Work associated with preparing for and performing deflection testing is included in the bid price of the pipe.

Evaluate the pipe to determine if the specific internal diameter of the barrel has deflected more than 5 percent. Use the following methods to perform the deflection test unless otherwise specified in the Plan:

(1) Visual inspection alone is not allowed for deflection testing.
(2) Use a 9-point mandrel approved by the Engineer to perform deflection testing for pipes with an inside diameter 2 feet or smaller. Pull the mandrel through the pipe using non-mechanical means.
(3) Direct measurements cannot be used for deflection testing unless specified in the Plans and approved by the Engineer. Direct measurements can only be used on pipes with an inside diameter of 30 inches or greater. If the Department allows direct measurements, the Engineer must take measurements at randomly select locations, but at a minimum once every 10 feet throughout the pipe length and at the pipe ends. Visually inspect the pipe and take additional measurements at any location of observed anomaly or deflection. Ensure personnel making direct measurements meet confined space entry requirements in accordance with 1706, “Employee Health and Welfare.”
(4) Laser scan inspection (laser ring) can be used to perform deflection testing when specified in the Plans and approved by the Engineer.

The Engineer will not accept pipe that has a deflection of greater than 5 percent or is damaged. Remove unacceptable pipe and install new pipe or reuse undamaged pipe. Retest the relaid pipe for 5 percent deflection after at least 5 Calendar Days after embedment Material is installed to grade.

Send deflection testing results to the Hydraulic Engineer with the SP number, pipe location, material type, size, date built, date tested, and results from the mandrel test or other deflection test.

D Backfill

Backfill sewer installations as shown on the Plans and in accordance with 2451, “Structure Excavations and Backfills.”

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

E Installation by Jacking

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

F Cleanout

Clean sediment and debris from sewers before final acceptance.

2503.4 METHOD OF MEASUREMENT

A Excavation

The Engineer will measure excavation specified or directed as Extra Work in accordance with 2451.4, “Structure Excavations and Backfills, Method of Measurement,” for prefabricated Structures.

B Sewer Pipe

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

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

The Engineer will measure pipe transition sections as pipe of the larger or more costly size except for special sections designated by the Contract for measurement as a unit.

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

Where pipe options are allowed, measurement will be made by length and type of pipe indicated on the Plan, regardless of the type of Material installed. No adjustments will be made for any additional Work required by the Contractor based on choice of Material.

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

C Sewer Appurtenances

The Engineer will separately measure flap gates and other specially identified appurtenant items of each design by the number of units of each type and size incorporated in the sewer Structures.

D Granular Materials

Standard bedding and backfill is not measured but is included in the cost of the relevant sewer Pay Items unless identified otherwise in the Plan.

2503.5 BASIS OF PAYMENT

The Contract Unit Price for the Contract Items for sewer pipe of each size, type, kind, and strength class include the costs of providing and installing the pipe complete-in-place as required by the Contract, except as otherwise specified in this section.

The Contract Unit Prices for Plastic pipe sewers will include the cost of deflection testing and buoyancy protection as required by the Contract.

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

The Department will pay for installing Department-provided sewer Materials including Work and additional Materials used to complete the sewer installation by the relevant install only Contract Pay Item, except for “Extra Work” or Work included in other relevant Contract Pay Items.

The Department will include the cost of granular Materials for bedding and backfill with the relevant sewer Pay Items unless specified otherwise in the Plan.

The Contract Unit Price for the relevant sewer Contract item includes the costs associated with the disposal of surplus Material associated with sewer installation.

If the Engineer approves of sewer pipe installation by the jacking method and Contract Item does not exist, the Department will pay for a jacking installation on the basis of Contract Unit Prices relevant for the trenching method.

The Department will include the cost of aprons required in connection with the sewer construction with relevant Pay Items in accordance with 2501.5, “Pipe Culverts, Basis of Payment.”

The Department will pay for required excavation greater than 1 foot below the bottom of the pipe as shown on the Plans as Extra Work in accordance with 1402, “Contract Revisions.”

If the Plans do not include a Contract Pay Item, the Department will pay for the removal of ledge rock or rocks larger than 1/2 cubic yard in volume from the excavation as Extra Work in accordance with 1402, “Contract Revisions.”

The Department will identify when pipe Material options are allowed in the Plans. Payment will be made by length and type of pipe indicated on the Plan, regardless of the type of Material installed. The Department will include the costs associated with using an option, such as differences in installation requirements including deflection testing, trench width, bedding Material Specifications and quantities in the Contract Unit Prices of the relevant pipe Pay Items. No adjustments will be made for any additional Work required by the Contractor based on choice of Material.

The Department will include the cost of trench excavation with the relevant Contract Pay Item for sewer installation.

The Contract Unit Price for the relevant pipe Contract Item includes the cost of pipe cleaning except when specifically designated under other items.

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

Item No.	Item	Unit
2503.502	Flap Gate for † Pipe	each
2503.502	Install §	each
2503.503	Install §	linear foot
2503.503	___” * Pipe Sewer ‖	linear foot
2503.503	___” Span* Pipe-Arch Sewer ‖	linear foot
2503.503	___” Span* Elliptical Pipe Sewer ‡	linear foot
2503.503	___” * Pipe Sewer Design# ‖	linear foot

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

2506 MANHOLES AND CATCH BASINS

2506.1 DESCRIPTION

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

For the purpose of the Work specified in section 2506, “Manholes and Catch Basins,” the Department defines precast concrete median drains as casting assemblies.

2506.2 MATERIALS

A Concrete **2461**

Use 3G52 concrete.

B Mortar

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

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

B.3 Mortar Sand **3128**

C Clay Brick **3612**

D Concrete Brick **3616**

E Concrete Masonry Units **3621**

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

G Precast Concrete **2462**

Use 3W8X concrete.

H Reinforced Concrete Pipe **3236**

I Corrugated Steel Pipe **3226**

J Metal Drainage Castings **3321**

K Concrete Drainage Castings **3622**

L Granular Material **3149**

M Corrugated Aluminum Pipe **3225**

N Corrugated Aluminized Steel (Type 2) **3222**

2506.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Combination Construction

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

A.2 Intercepting Existing Facilities

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

A.3 Abandoned Pipes

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

A.4 Excavation, Bedding, and Backfill

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

A.5 Inspection Before Construction

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

A.6 Temperature Restrictions

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

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

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

Do not use masonry units or Aggregate in temperatures 32°F or less, except as directed by the Engineer.

Maintain concrete and mortar mixes at a temperature from 50°F to 90°F until incorporated into the Work.

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

B Cast-in-Place Concrete

Install cast-in-place Structures in accordance with 2411, “Minor Concrete Structures,” and the Plans.

C Masonry

Provide masonry in accordance with the requirements in this section if at least part of the Structure is constructed using clay brick or concrete masonry units. For the purpose of the Work specified in 2506, “Manholes and Catch Basins,” The Department defines “unit” as the brick or concrete block unless otherwise qualified in this section.

Do not moisten concrete masonry Units before placement in the Work. Moisten all other types of masonry Units before placement.

Place Units in a full mortar bed, in horizontal courses, using the “shove joint” method, as described in this section. Fill joints with mortar. Strike joints on the inside of the Structure, providing a joint width no greater than 0.5 inch wide. Plaster the outside of the Structure with mortar to a smooth surface.

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

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

(1) In circular type Structures, lay the bricks flat and radially with the ends exposed on the inside of the Structure. Where the thickness of the wall is greater than the length of one brick, the Contractor may lay the outside bricks circumferentially using full header construction in at least each sixth course.

(2) In rectangular type manholes, lay the bricks in regular courses of stretchers using full header construction in at least each sixth course. Do not use bats or spalls except for shaping around openings or for finishing out a course. When shaping around openings or finishing out a course, place full bricks in the corners and the bats in the interior of the course. Ensure the least dimension of the exposed faces of bats is at least 50 percent of the width of a brick.

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

D Sectional Concrete

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

Install cover for a 4020 Structure on a full mortar bed according to *Standard Plate 4020*.

E Pipe

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

F Castings

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

Place a 4 inch thick concrete encasement around the outside of the manhole or catch basin as detailed in *Standard Plate 4026*. Place this encasement at the time of final casting placement.

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

G Adjusting Frame or Ring Castings

Provide vertical adjustment of access castings made to the planned elevation on the Structure. Meet the criteria that full support for the casting is obtained above the cone section and ensure that Structure construction above the cone does not exceed 6 inches, not including the frame. Use no more than 3 adjusting rings. Limit thickness of each adjusting ring to 6 inches or less. If these criteria cannot be met by vertical adjustment Work, reconstruct the Structure.

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

H Reconstructing In-Place Structures

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

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

I Backfilling

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

Excavated Materials not required for backfill shall become the property of the Contractor. Dispose of the excavated Material off the Right-of-way in accordance with 2106, "Excavation and Embankment – Compacted Volume Method," at no additional cost to the Department.

J Cleaning

Clean sediment and debris from manholes and catch basins before final acceptance.

2506.4 METHOD OF MEASUREMENT

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

A Constructing Drainage Structures

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

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

If the Plans specify the measurement of each Structure complete in-place, the Engineer will separately measure drainage Structures of each design as individual units complete in place, including any castings provided and installed.

B Reconstruction

The Engineer will measure reconstruction to the nearest 0.1 feet, of the height from the bottom of the reconstructed portion to the bottom of the newly set casting, regardless of type.

C Castings

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

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

The Engineer will not measure castings for Structures measured as a Unit. The Engineer will consider all castings required for an individual Structure as one assembly.

D Adjusting Castings

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

2506.5 BASIS OF PAYMENT

The Contract Unit Price for constructing or reconstructing drainage Structures includes all costs for completing the Work, including the cost of excavation, except for the cost of specific Contract Items, in accordance with the following:

(1) The Department will pay for excavation in ledge rock and the removal of boulders or detached rocks with a volume greater than 0.5 cubic yard as Extra Work in accordance with 1402, “Contract Revisions,” unless the existence of the rock is shown on the Plans.

(2) The Contract Unit Price for reconstructing drainage Structures includes the cost of removing the existing casting, but does not include placement of a casting on the reconstructed Structure.

(3) The Contract Unit Price for reconstructing drainage Structures includes the costs of removing and replacing all or a portion of the Structure as shown on the Plans, adjacent pavement Aggregate base, and excavation if, except for the Structure construction, the surface would not otherwise have been disturbed. The Department will pay for the cost of this Work at the Contract Unit Price based on the area to the nearest 0.1 square yard within a rectangle with sides that lie 1.5 feet outside the Structure limits. The Department will include the cost of removing and replacing pavement outside of these limits or for replacing any other type of surfacing with other applicable Pay Items.

(4) The Contract Unit Price for drainage Structure construction by the Structure as individual units complete in-place includes the cost of providing and installing any castings required.

(5) The Contract Unit Price for adjust frame and ring castings will include the cost of the removing and replacing concrete surfacing in connection with the item of adjust frame and ring castings.

(6) The casting encasement detailed in *Standard Plate 4026* will be placed at the time of final casting placement, with no additional cost to the Department.

(7) The Department will pay for granular Materials for special bedding or backfill in accordance with 2451.5, “Structure Excavations and Backfills, Basis of Payment.”

(8) The Contract Unit Price for Adjust frame and ring casting includes the cost of salvaging and installing the in-place casting; removing deteriorated rings; and providing and installing all sewer blocks, bricks, rings and grout necessary to raise or lower in-place castings to the elevation shown on the Plans or directed by the Engineer.

The Department will pay for manholes and catch basins as drainage Structures on the basis of the following schedule:

Item No.	Item	Unit
2506.502	Construct Drainage Structure Design ___	each
2506.502	Casting Assembly	each
2506.502	Install Casting	each
2506.502	Adjust Frame and Ring Casting	each
2506.503	Construct Drainage Structure Design ___	linear foot
2506.503	Reconstruct Drainage Structure	linear foot

2507 CULVERT LINER

2507.1 DESCRIPTION

This Work consists of lining Culvert pipe by inserting a polyethylene (PE) liner inside an in-place Culvert.

2507.2 MATERIALS

A Pipe

Provide one of the following types of liner as shown on the Plans or specified in the Special provisions:

2507.3 CONSTRUCTION REQUIREMENTS

A General

The Department will specify the diameter or span of the in-place pipe to be lined in the Contract item. Follow liner dimensions as shown on the Plans and as specified by the Special Provisions. Use a liner and grout method that has adequate space between the in-place pipe and liner to grout the annular space.

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

The Department will consider any damaged liner to be unacceptable. Unacceptable liner includes but is not limited to liner that is damaged during handling or installation, or rejected because it does not meet Plan requirements.

B Installing Liner

B.1 General

Inspect the interior of the in-place pipe to identify conditions which may prevent proper installation and to confirm that the liner and installation method proposed by the Contractor are adequate for existing site conditions.

Use jet rodding Equipment, hydro-mechanical methods or other methods approved by the Engineer to clean and dry the in-place pipe before inserting the liner. Remove or repair all obstructions that would prevent installation or damage the liner during installation. Remove debris or other Materials from the in-place pipe to prevent the inserted liner from resting on or against, or be irregularly supported by, these Materials.

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

Use fasteners, blocks, or multiple grout Layers to secure liners equal to or greater than 2 feet in diameter to the invert of the in-place pipe to prevent the liner from floating during the grouting operations.

B.2 Inserting Liner

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

B.2.a Pull Technique

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

B.2.b Push Technique

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

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

B.3 Pipe Joints

Use heat fusion or grooved press-on joints approved by the Engineer to join PE liner meeting requirements of *ASTM F714 (DR 32.5)*, *Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter*. Heat fuse liner joints as recommended by the liner manufacturer, using an experienced operator of the heat fusion Equipment.

Use a threaded joint to join liner segments of closed-profile PE liner with an *ASTM D3350*, *Standard Specification for Polyethylene Plastic Pipe and Fittings Material*, cell classification of 345464C as approved by the Engineer.

C Grout

Block off Culvert ends before filling the annular space between the liner and the in-place pipe. Provide CLSM Low Density or CLSM High Density grout in accordance with 2519, “Cellular Concrete Grout – Controlled Low Strength Material,” and as shown on the Plans or as required by the Contract. Use CLSM High Density grout if the Plans or the Contract do not specify the grout type. Do not allow grouting pressure to exceed the external hydrostatic collapse resistance of the liner.

D Culvert Cleaning

Clean sediment and debris from lined pipe before final acceptance.

2507.4 METHOD OF MEASUREMENT

A Pipe Liner

The Engineer will measure liner by length, as determined by summation of the Nominal laying lengths of the individual liner sections incorporated in each lined pipe. The Engineer will separately measure Culvert pipe liner by size, type, and kind in accordance with the Contract Items. The size is the diameter or span of the in-place pipe being lined.

B Culvert Appurtenances

The Engineer will separately measure aprons or other appurtenances required to the installation of the liner in accordance with 2501, “Pipe Culverts.”

C Grout

The Engineer will measure grout in accordance with 2519, “Cellular Concrete Grout – Controlled Low Strength Material.”

2507.5 BASIS OF PAYMENT

The Contract linear foot price for Lining culvert pipe will include the cost of excavating, cleaning, inserting the liner, backfilling, and providing liner, fittings, seals, and joint system. This cost includes cleaning and repair activities required to prepare the in-place pipe prior to inserting the liner and cleaning the lined pipe before final acceptance.

The Department will pay for grouting with the Contract Unit Price for CLSM Low Density, or CLSM High Density, as shown on the Plans and in accordance with 2519 “Cellular Concrete Grout – Controlled Low Strength Material.”

The Department will pay for Culvert appurtenances in accordance with 2501, “Pipe Culverts.”

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

Item No.	Item	Unit
2507.503	Lining Culvert Pipe ___"	linear foot

2511 RIPRAP

2511.1 DESCRIPTION

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

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

2511.2 MATERIALS

A Riprap Materials.. 3601

B Filter Materials

B.1 Granular Filter 3601

B.2 Geotextiles 3733

C 3AGrout... 2461

2511.3 CONSTRUCTION REQUIREMENTS

A General

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

Excavate and shape the foundation for the riprap, with or without filter Material, to the cross-sections as shown on the Plans. Compact loose foundation Material before placing the riprap or filter Material.

Place a Layer of riprap on a filter Material, at the thickness required by the Contract.

Grout riprap as required by the Contract. Fully grouted riprap is not allowed in public waters.

B Filter Material

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

B.1 Granular Filter

Spread granular filter Material to a minimum thickness of 6 inches over the prepared foundation, or as required by the Contract. Deposit granular Material, placed under water, directly on the foundation using a bucket or similar container. Do not discharge the granular Material above the water surface.

B.2 Geotextiles

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

Place the fabric with the longest dimension parallel to the direction of water flow. If using fabric that is not seamed, overlap splices and joints at least 18 inches, for installations above water. When fabric is installed underwater overlap splices and joints at least 36 inches. Provide shingled joint laps in the flow direction and from top to bottom of a slope to direct water flow over the joint without undermining the geotextile filter. The Contractor may sew multiple fabric pieces together, as specified in 3733, “Geosynthetic Materials,” in lieu of joint overlapping. Bury the upgrade edges of the fabric a minimum of 6 inches to direct water flow over the fabric and prevent undermining. If not seamed, place washered steel pins, edge stakes, stones, or other Material at locations and in quantities as approved by the Engineer, to prevent movement of the geotextile filter during placement of the riprap.

Do not dump stone at the top of the slope and roll stone down the slope. If placing stones directly on the geotextile filter, do not operate Equipment on top of the stones after placement. Do not operate construction Equipment directly on top of the geotextile.

Do not use geotextile filter Material under hand placed or grouted riprap, unless otherwise required by the Contract.

The Contractor may place geotextile filter on slopes no steeper than 1:3. For slopes steeper than 1:3, retrench the geotextile at least every 15 feet or as required by the Contract. Do not use geotextile filter on slopes steeper than 1:2.

C Riprap Stone

Do not drop stones on the fabric from a height greater than 1 foot unless the fabric is covered with a 6 inch thick granular cushion course. If covered, the Contractor may drop riprap stones from a height no greater than 3 feet.

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

Before placement of riprap stone on geotextile, the Engineer may require the Contractor to demonstrate that the placement methods will not damage the fabric. The Engineer may order the removal of at least 4 square yard of riprap to inspect for fabric damage in accordance with 1511, “Inspection of Work.”

C.1 Random Riprap

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

Wash riprap clean before placing underwater.

C.2 Hand-Placed Riprap

Embed the stones for hand-placed riprap in the foundation Material, with the axis of the stone that most nearly approximates the Contract-required thickness of riprap laid perpendicular to the foundation slope. Lay stones with the least practicable space between them. Position the stones to stagger the joints up the slope. Place each stone to allow the foundation Material and adjacent stones to carry its mass.

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

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

Wash riprap clean before placing underwater.

D Grouting

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

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

E Thickness Requirements

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

F Quality Control (QC)

For riprap meeting 3601.3A, “Riprap Gradation Test Methods Using D_{85},” and 3601.3B, “Riprap Gradation Test Method Using Wolman Count,” refer to the requirements in the *Schedule of Materials Control*.

For riprap meeting 3601.2C, “Gabions and Revet Mattresses,” 3601.2D, “Granular Filter Under Class I Riprap,” and 3601.2E, “Granular Filter Under Other Riprap, Gabion, and Revet Mattress,” provide certification using *Form G&B-104b*, found on the MnDOT Grading and Base website.

G Quality Assurance (QA)

The Department will inspect the Material for compliance to the requirements of 3601, “Riprap Material.” Obtain the Engineer’s approval of the quality of the stone before delivering the stone to the Project. The Engineer will inspect the stone for compliance to the gradation requirements after delivery of the stone to the Project.

G.1 Riprap meeting 3601.2A, “Random Riprap,” 3601.2B, “Hand-placed Riprap,” or 3601.2C, “Gabions and Revet Mattresses,”

For gradation compliance, the Engineer may use either:

(1) Visual inspection
(2) The D85 test, test method 5-692.210, listed in the *Grading and Base Manual* and *Form G&B-108a*, found on the MnDOT Grading and Base website

If the Contractor disagrees with the results of the Engineer’s visual check or the D85 results, the Contractor will test the gradation, under the supervision of the Engineer, using one of the following methods:

(1) Wolman Count Method. Test method 5-692.211 in the *Grading and Base Manual*. Record and submit results using *Form G&B-108b*, found on the MnDOT Grading and Base website,
(2) FHWA Hydraulic Toolbox, Test method 5-692.212 in the *Grading and Base Manual*. Record and submit results using *Form G&B-108a*, found on the MnDOT Grading and Base website, or
(3) WipFrag or an alternative image analysis software, approved by the Engineer. Record and submit results using and submit *Form G&B-108a*, found on the MnDOT Grading and Base website.

G.2 Granular Filter meeting 3601.2D, "Granular Filter Under Class I Riprap," or 3601.2E, "Granular Filter Under Other Riprap, Gabion, and Revet Mattress"

For gradation compliance, the Engineer may use either visual inspection or perform gradation per *Laboratory Manual*.

G.3 Carbonate Quarry Riprap

The Department will sample for insoluble residue and test per the *Laboratory Manual*.

2511.4 METHOD OF MEASUREMENT

A Riprap

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

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

B Filter Materials

If measuring filter Materials by weight, the Engineer will calculate the weight based on Scale tickets of Material delivered and placed within the staked areas.

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

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

2511.5 BASIS OF PAYMENT

The Contract Unit Price for riprap of each type and class includes the cost of providing the Materials, excavating and preparing the foundations, and placing the riprap stone, grouting, and filter Materials as required by the Contract.

The Department will pay for filter Materials of the type specified, if included in the Contract.

The Department will pay for riprap and filter Material on the basis of the following schedule:

Item No.	Item	Unit
2511.504	Geotextile Filter Type *	square yard
2511.507	Random Riprap Class ___‖	cubic yard
2511.507	Hand-placed Riprap	cubic yard
2511.507	Grouted Riprap	cubic yard
2511.507	Granular Filter	cubic yard
2511.509	Random Riprap Class ___‖	ton
2511.509	Granular Filter	ton

* Specify Type – 3, 4, or 7. See 3733, "Geosynthetic Materials"

‖ Specify Class – See 3601.2A.1, "Sizing Requirements"

2512 GABIONS AND REVET MATTRESSES

2512.1 DESCRIPTION

This Work consists of constructing gabions and revet mattresses.

2512.2 MATERIALS

A Riprap Materials ... 3601

B Filter Materials

B.1 Granular Filter ... 3601

B.2 Geotextiles ... 3733

C Gabions and Revet Mattresses Materials ... 3602

2512.3 CONSTRUCTION REQUIREMENTS

A General... 2511.3

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

Provide and place filter Material, unless otherwise required by the Contract.

Provide and place gabions and revet mattresses.

B Filter Material

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

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

C Baskets and Fasteners

C.1 Documentation

Provide the following:

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

C.2 Construction

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

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

Place and fasten the diaphragms in the baskets to the side and bottom mesh to create cell dimensions no greater than 3 feet.

Fasten adjoining empty baskets together at their perimeters.

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

Fill cells in 1 foot Layers. Fill cells no greater than 1 foot in one Layer. Fill cells no greater than 18 inches in 2 equal Layers. Do not fill cells greater than 1 foot higher than stone Layers in adjacent cells or baskets.

For twisted wire gabions, place horizontal connecting wires on top of the stone Layer in both directions if no supporting basket exists, to prevent the sides from bulging. For welded wire gabions, install preformed stiffeners across the corners of the gabions before filling. Provide 2 rows of stiffeners, 4 per cell, for the front face and the side faces. Provide a single row of stiffeners, 2 per cell, on the back face. The Department will not require stiffeners in interior cells. Provide preformed stiffeners with a Nominal length of 18 inches. Hook the stiffeners at crossing wires. The Contractor may use lacing wire as a stiffener.

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

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

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

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

C.3 Fasteners

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

C.3.a Lacing Wire

Place lacing wire at each joint alternating single and double loops every 3 to 6 inches.

C.3.b Alternative Fastener

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

D Acceptance

The Engineer may consider the Work unacceptable if visible baskets vary by greater than 6 inches from the profile or alignment as shown on the Plans or as directed by the Engineer.

2512.4 METHOD OF MEASUREMENT

A Gabions and Revet Mattresses

The Engineer will measure Gabions and Revet mattresses by volume based on the Nominal basket dimensions and the number of baskets incorporated into the Work.

B Filter Materials

The Engineer will measure filter Materials in accordance with 2511.4B, “Filter Materials.”

2512.5 BASIS OF PAYMENT

The Contract Unit Price for both Gabions and for Revet mattresses include the cost of providing the Materials as required by 3601, “Riprap Material,” and 3602, “Gabions and Revet Mattresses Materials,” excavating and preparing the foundations, providing and installing filter Materials, and constructing and filling the Gabions and revet Mattresses.

The Department will separately compensate for filter Materials if the Contract contains the relevant Contract Items as listed in 2511, “Riprap.”

The Department will pay for Gabions and Revet mattresses on the basis of the following schedule:

Item No.	Item	Unit
2512.507	Gabion	cubic yard
2512.507	Revet Mattress	cubic yard

2514 SLOPE PAVING

2514.1 DESCRIPTION

This Work consists of paving embankment slopes and waterways with Portland cement concrete or crushed Aggregate to provide erosion protection.

2514.2 MATERIALS

A Concrete 2461

Provide concrete meeting the requirements for Mix Designation 3F52, except that the Contractor may adjust the slump requirement as approved by the Engineer.

B Reinforcement Bars 3301

Provide reinforcement bars meeting the following requirements:

(1) Either Grade 40 or Grade 60
(2) Deformed billet steel
(3) Meeting the requirements of *ASTM A615*, *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*

C Preformed Joint Filler 3702

D Bituminous Material 3151

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

E Aggregate

Provide Aggregate for stabilized slope paving in accordance with Table 2514.2-1 for gradation class CA-1, CA-2, or CA-3, and in accordance with the quality requirements in 3137.2D, “Quality.”

Table 2514.2-1
Coarse Aggregate Fraction Size,
percent by weight passing square opening Sieves

	Aggregate Designation		
	CA-1	**CA-2**	**CA-3**
2 inch	100	100	—
1 1/2 inch	80 – 100	90 – 100	100
1 1/4 inch	—	—	85 – 100
1 inch	—	—	—
3/4 inch	5 – 30	5 – 35	5 – 35
5/8 inch	—	—	—
1/2 inch	—	—	—
3/8 inch	—	—	—
No. 4	0 – 5	0 – 5	0 – 5

2514.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Prepare the foundation to the dimensions and elevations shown on the Plans or as directed by the Engineer. Excavate the high spots, and fill and compact low spots of the foundation to meet the elevation and slope requirements. Prepare the foundation with a uniform density meeting 2106.3G.2, “Quality Compaction.”

For rough grading performed by others under another contract, if the Engineer determines that a Material shortage or excess exists to construct the planned foundation elevations, the Engineer may require one of the following to achieve acceptable foundation elevations:

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

B Stabilized Aggregate Slope Paving

Use mechanical or hand methods to deposit, spread, consolidate, and shape the Aggregate to provide a uniform depth and density and to produce a uniform surface appearance. Apply liquid asphalt at a rate of 1.8 gallons per square yard and only when the ambient air temperature is at least 40°F. Apply emulsified asphalt at a rate of 2.5 gallons per square yard and only when the ambient air temperature is at least 50°F. Ensure bituminous Materials penetrate to a depth of at least half the thickness of the Aggregate slope paving as shown on the Plans. Protect adjacent structure surfaces from bituminous splatter.

C Concrete Slope Paving

Construct concrete slope paving in accordance with 2401, “Concrete Bridge Construction.” Place, consolidate, strike-off, and hand float the concrete to provide a dense pavement relatively free of voids and cavities, and to produce a uniform surface appearance. Set and support side forms and finish the concrete so surfaces do not deviate from a true plane and the grade shown on the Plans by greater than ±1/2 inch. Place metal reinforcement and preformed filler Material as shown on the Plans. Support the metal reinforcement and preformed filler Material as shown on the Plans to maintain correct position during concrete placement.

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

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

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

After the final floating, finish edges not formed with v-strip inserts with an edging tool and cut panel lines with grooving tools. The Contractor may saw the panel lines as directed by the Engineer. Float edging and grooving flange trails to secure uniform surface appearance.

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

2514.4 METHOD OF MEASUREMENT

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

2514.5 BASIS OF PAYMENT

The Contract Unit Price for slope paving of each type includes the cost of constructing the Work complete in-place.

The Department will pay for the cost of providing and placing additional Material, or the removal and outside disposal of excess Material requiring loading and hauling, directed by the Engineer, as Extra Work in accordance with 1402, "Contract Revisions." The Department will include the cost of excess Material disposed on areas adjoining the slope paving without loading and hauling, as directed by the Engineer, with the Contract Unit Prices for slope paving.

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

Item No.	Item	Unit
2514.504	Concrete Slope Paving	square yard
2514.504	Stabilized Aggregate Slope Paving	square yard

2515 REVETMENT SYSTEMS

2515.1 DESCRIPTION

This Work consists of providing and placing a protective covering for earth slopes, river channels, vehicle accesses, spillways, and susceptible soil erosion areas.

2515.2 MATERIALS

A Precast Articulated Concrete **3604**

B Geotextiles **3733**

C Bedding Material **3149**

D Concrete **2461**

E Concrete Armor Units **3608**

2515.3 CONSTRUCTION REQUIREMENTS

A General

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

B Subgrade Preparation

Prepare the subgrade per 2112, “Subgrade Preparation.” Provide subgrade Material free of stones, sticks, and other debris or irregularities that might puncture the geotextile fabric or create other system failures. If the system is subject to vehicle loading, install a geogrid for extra support, as shown on the Plans.

C Bedding Material

Provide bedding Material consisting of at least 6 inches spread evenly over the compacted Subgrade, made from one of the following Materials:

(1) Select Grading Material per 1103,”Defintions: Select Grading Material”
(2) Granular Material per 3149.2B, “Granular and Select Granular Materials”
(3) Granular Bedding per 3149.2F, “Granular Bedding”

Compact the Bedding Material per 2106.3G.2, “Quality Compaction.”

D Geotextile Filter

Place Type 3 geotextile per 3733, “Geosynthetic Materials,” as a filter under the revetment systems unless otherwise required by the Contract. Place the geotextile filter Material on the entire area supporting the revetment system. Secure the geotextile Material with 6-inch steel pins or staples, unless otherwise shown on the Plans. If installing anchors, cut the geotextile to allow the anchors to penetrate the geotextile.

Place and compact prepared Subgrade and bedding Material, and place geotextile Material without tearing, puncturing, or shifting the fabric. Place a 1-inch sand Layer on the geotextile fabric before placing the block.

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

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

E Precast Articulated Concrete

E.1 Articulated Block Mat

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

E.2 Articulated Interlocking Block

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

E.3 Clamps

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

E.4 Anchors

Install anchors at 8-foot intervals at lead edge and around perimeter of the revetment system, and as shown on the Plans, as specified by the manufacturer, or as directed by the Engineer. Embed anchors at least 3.5 feet deep. Fasten the exposed cables of the concrete mats to the anchors driven into the anchor trench.

F Concrete Armor Units

Place concrete armor units so not to tear the geotextile. Embed and entrench at least one block into the ground at the toe with compacted fill Material. Begin placement of the system at the toe termination trench and proceed up the slope and as per manufacturer’s recommendations.

G Filling and Vegetation

If vegetation is shown on the Plans, fill voids of the revetment system with screened common topsoil borrow per 3877, “Topsoil Material,” 35-241 seed mix per 3876, “Seed,” and category 30 rolled erosion prevention product per 3885, ”Rolled Erosion Prevention Products,” unless otherwise shown on the Plans. Perform filling and vegetation after the Engineer completes inspection of any required clamping and anchoring systems.

2515.4 METHOD OF MEASUREMENT

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

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

The Engineer will measure concrete armor units by surface area covered by each size provided, installed, and accepted by the Engineer, including the buried portions, using the outermost extremity of the units as required by the Contract. On small Projects, the Engineer will accept concrete armor units by the number of complete units assembled and installed as required by the Contract.

2515.5 BASIS OF PAYMENT

The Contract Unit Prices for revetment systems include the cost of excavating and preparing the foundations, providing system Materials, geotextile filter, base, and bedding Materials, grouting, clamping, and anchoring.

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

Item No.	Item	Unit
2515.502	Concrete Armor Units ____ (size)	each
2515.504	Articulated Block Mat Open Cell Type ___	square yard
2515.504	Articulated Block Mat Closed Cell Type ___	square yard
2515.504	Articulated Interlocking Block Open Cell Type ___	square yard
2515.504	Articulated Interlocking Block Closed Cell Type ___	square yard
2515.504	Concrete Armor Units ____ (size)	square yard

2519 CELLULAR CONCRETE GROUT – CONTROLLED LOW STRENGTH MATERIAL

2519.1 DESCRIPTION

This Work consists of pressure grouting the area and voids between the existing pipe Culvert and the inserted liner pipe.

2519.2 MATERIALS

A Cement **3101**

B Fly Ash **3115**

C Fine Aggregate **3126**

D Water **3906**

E Admixtures **3113**

2519.3 CONSTRUCTION REQUIREMENTS

A Mix Design

Submit a mix design on the most current Department Concrete Mix Design Submittal sheet to the Engineer for review and approval, in conjunction with the Concrete Engineer, at least 15 Calendar Days before placing the grout. Design the Controlled Low Strength Material (CLSM) in accordance with Table 2519.3-1 or Table 2519.3-2 and meeting the requirements of *ASTM C403*, *Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance*.

A.1 CLSM Low Density

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

Table 2519.3-1
CLSM Low Density Design

Materials	Proportions per unit batch and mix parameters
Portland cement	≥100 pounds
Total cementitious (Portland cement and Class C fly ash)	≥500 pounds
Water/cementitious ratio	0.50
Pre-formed foam*	20 cubic feet
Grout (cast density)	30 pound ±3 pound per cubic foot
Slump	10 inches ± 1 inch
28-Calendar Day compressive strength	75 psi – 400 psi
* Provide foaming agent meeting the requirements of *ASTM C869*, *Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete*, when tested in accordance with *ASTM C796¸ Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam*. The Contractor may use other admixtures, if approved by the mix designer and the Engineer, in conjunction with the Concrete Engineer. Provide cementitious Material from the *Approved/Qualified Products List*. The Engineer, in conjunction with the Concrete Engineer, will review the concrete mix design submittal and approve if the concrete mix design meets Contract requirements. The Engineer will base final approval for payment on satisfactory field placement and performance.	

A.2 CLSM High Density

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

Table 2519.3-2
CLSM High Density Design

Materials	Proportions per unit batch and mix parameters
Portland cement	≥150 pounds
Total cementitious (Portland cement and Class C fly ash)	≥500 pounds
Fine Aggregate	1,100 pounds
Water/cementitious ratio	0.50
Pre-formed foam*	13.5 cubic feet
Grout (cast density)	70 pounds±3 pound per cubic feet
Slump	10 inches ±1 inch
28-Calendar Day compressive strength	75 psi – 400 psi
* Provide foaming agent meeting the requirements of *ASTM C869*, *Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete* when tested in accordance with *ASTM C796¸ Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam*. The Contractor may use other admixtures, if approved by the mix designer and the Engineer, in conjunction with the Concrete Engineer. Provide cementitious Material from the *Approved/Qualified Products List*. The Engineer, in conjunction with the Concrete Engineer, will review the concrete mix design submittal and approve if the concrete mix design meets Contract requirements. The Engineer will base final approval for payment on satisfactory field placement and performance.	

B Grouting Procedure

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

C Placement

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

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

After grouting the liner to the in-place Culvert, encapsulate the remaining length of liner with Mix No. 3G52 concrete at least 6 inches thick.

Finish the inlet end with a 45-degree mitered fillet-transition between the in-place Culvert and the inside of the liner.

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

2519.4 METHOD OF MEASUREMENT

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

2519.5 BASIS OF PAYMENT

The Contract cubic yard price for CLSM includes the cost of dewatering, cement for securing the pipe liner to the existing Culvert, and inlet bevel construction.

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

Item No.	Item	Unit
2519.507	CLSM Low Density	cubic yard
2519.507	CLSM High Density	cubic yard

2520 LEAN MIX BACKFILL

2520.1 DESCRIPTION

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

2520.2 MATERIALS

A Concrete 2461

The Department will provide mix proportions for lean mix backfill in accordance with 2461, “Structural Concrete.” Submit mix designs in accordance with 2461.2E.2, “Concrete Mix Design Requirements.”

2520.3 CONSTRUCTION REQUIREMENTS

A Job Mix Proportioning

After adding the specified quantities of cement, fly ash, and water, provide the remaining volume consisting of fine Aggregate and coarse Aggregate. The Contractor may use admixtures in accordance with 2461.2D, “Concrete Admixtures.” Adjust the mix at any time to maintain the consistency and strengths specified in Table 2461.2-5.

The Engineer will base final approval for payment on satisfactory field placement and performance.

B Batching and Mixing Requirements

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

C Lean Mix Backfill Placement

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

D Curing and Protection

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

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

2520.4 METHOD OF MEASUREMENT

If the Contract specifies Lean mix backfill as a Contract Item, the Engineer will measure Lean mix backfill as the computed, theoretical volume based on the weight of the individual batch ingredients. The Engineer will deduct the volume of accountable waste from the measurement of Lean mix backfill.

2520.5 BASIS OF PAYMENT

The Department will include the cost of Lean mix backfill and common backfill with other relevant Contract Items unless otherwise shown on the Plans.

The Contract cubic yard price for Lean mix backfill includes the cost of providing the Lean mix backfill and the cost of forming, plugging, placing, venting, and protecting.

The Department will pay for Lean mix backfill on the basis of the following schedule:

Item No.	Item	Unit
2520.507	Lean Mix Backfill	cubic yard

2521 WALKS

2521.1 DESCRIPTION

This Work consists of constructing concrete or bituminous walks. Concrete walks include concrete median walk and concrete truck aprons.

2521.2 MATERIALS

A Concrete **2461**

A.1 Concrete Walk .... **Mix No. 3F52**

A.2 Concrete Walk, Exposed Aggregate Finish .... **Mix No. 3F57EX**

A.3 Concrete Walk, Colored .... **Mix No. 3F52CO**

B Preformed Joint Filler **3702**

2521.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Excavate, shape, and compact the foundation to a firm, uniform bearing surface to the dimensions and grade as shown on the Plans and in accordance with 2106, “Excavation and Embankment – Compacted Volume Method,” 2112, “Subgrade Preparation,” and 2211, “Aggregate Base.”

B Sawing Concrete Walk

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

C Forms

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

Before placing the concrete, coat the contact surfaces of the forms with an approved form treating Material in accordance with 3902, “Form Coating Material.”

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

D Placing and Finishing Concrete

The concrete Contractor, or Subcontractor, shall have at least two people with a current ACI concrete flatwork associate, concrete flatwork finisher, or advanced concrete flatwork finisher certification, and at least one of them must be onsite for every concrete pour.

Wet the foundation and forms before placing the concrete.

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

D.1 Specialty Concrete Walk

D.1.a Exposed Aggregate Finish

Provide concrete mix No. 3F57EX with multi-colored rounded stone, modified for exposed Aggregate construction.

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

Apply retardant coating immediately after completion of the concrete surface screeding, edging, and jointing. Apply retardant as recommended by the manufacturer to produce a 1/4 inch ± 1/8 inch etch of mortar removal after final concrete set.

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

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

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

Seal the exposed Aggregate finish with 2 coats of a clear acrylic based compound with at least 18 percent solids meeting the requirements of *ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete*.

D.1.b Colored Concrete

Provide concrete mix No. 3F52CO with approved color additive for colored concrete walk construction.

For color verification, provide sample chip(s) of specified color(s) indicating color additive number(s) and required dosage rate(s). Samples indicate general color and may slightly vary from concrete finished in the field.

One week before first placement of the colored concrete on the Project, hold a preconstruction meeting with the Department, prime Contractor, concrete Contractor, ready-mix concrete representative, testing Department, and colored admixture manufacturer representative to discuss the proposed colored concrete placement and application Materials.

D.1.b(1) Colored Concrete Contractor/Installer Qualifications

Pre-qualified colored concrete Contractors/installers shall meet the following requirements:

(1) Minimum of 5 years of experience with Work of similar scope and quality.
(2) A minimum of 5 Projects including references completed in the last 5 years by Contractor/installer.

(3) Listed on the Department *Pre-qualified Colored Concrete Contractor/Installers List* available from the Department website.

D.1.b(2) Test Panels

Before placing any colored concrete, demonstrate workmanship by constructing test panels of the colored concrete in accordance with the following:

(1) For each color, a separate test panel is required.
(2) At a location approved by the Engineer.
(3) Using the same processes, techniques, personnel, Materials, concrete supplier, and concrete plant intended for use on permanent Work, including stamping and curing/sealing procedures.
(4) The minimum size of the test panels shall be 6 feet by 6 feet by 4 inches unless otherwise directed by the Engineer.
(5) Retain and protect Engineer accepted test panels as the visual standard for the Work of this section and quality standard for permanent Work.

D.1.b(3) Placing, Finishing, and Curing Colored Concrete

Construct colored concrete in accordance with products processes and techniques used on approved test panel(s). Do not add water at any time to the slab surface while finishing. Do not over finish the concrete edges.

After completing final finishing operations, cure and seal exposed concrete surfaces meeting the following requirements and methods:

(1) Use a curing/sealing compound on *Approved/Qualified Products List* conforming to 3752, “Membrane Curing/Sealing Compound for Colored Concrete.”
(2) Apply the curing/sealing compound within 30 minutes of concrete placement/form removal or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2521.3E.1.a, “Membrane Curing Method.”
(3) Ensure that the curing/sealing compound is applied homogeneously to provide a uniform coverage on exposed colored concrete surfaces including the edges.
(4) Apply an additional application of curing/sealing compound a minimum of 30 Calendar Days after placement of the colored concrete.

Cover adjacent finished surfaces to protect from splatters and excess Materials during colored concrete installation and curing/sealing.

D.2 Joint Construction

Divide the walk into square panels of uniform size no greater than 36 square feet and outlined with contraction or expansion joints as shown on the Plans.

Provide vertical and straight joints parallel with or at right angles to the walk centerline. Align the joints with joints in adjoining work unless isolated by a 1/2 inch preformed joint filler.

The Contractor may form or saw the joints in walking surfaces as approved by the Engineer. If forming the joints, round joints within the walking surface with a 1/4 inch radius grooving tool and round edges of the walk with an edging tool having a radius no greater than 1/2 inch.

Extend contraction joints to a depth of at least 30 percent of the walk thickness. If saw cutting, provide 1/8 inch wide contraction joints.

Provide joint filler in accordance with 3702, “Preformed Joint Fillers,” that is 1/2 inch wide and equal in depth to the full thickness of the walk.

Modify joint construction if a fixed object or Structure extends through the walk, as directed by the Engineer. Place preformed joint filler material 1/2 inch thick adjacent to fixed objects to separate the object from the abutting concrete edges.

D.3 Workmanship and Quality

The Engineer will use a 10 foot straightedge to measure surface tolerance. The Department considers vertical deviations in the surface greater than 3/16 inch and line deviations greater than 1/2 inch from the required location as unacceptable Work. Remove and replace unacceptable Work as directed by the Engineer.

E Concrete Curing and Protection

After completing final finishing operations, cure exposed concrete surfaces. Use one of the following curing methods:

(1) In accordance with 2521.3E.1.a, “Membrane Curing Method,” place the membrane curing compound conforming to 3754, “Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound,” or 3755, “Linseed Oil Membrane Curing Compound,” within 30 minutes of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise. Place the membrane curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets, unless the Contract requires otherwise.
(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2521.3E.1.b, “Curing Blanket Method.”
(3) For exposed Aggregate placement, cure in accordance with 2521.3D.1.a, “Exposed Aggregate Finish.”
(4) For colored concrete placement, cure in accordance with 2521.3D.1.b, “Colored Concrete.”

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

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

E.1 Curing Methods

E.1.a Membrane Curing Method

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

The Engineer will only approve airless spraying machines equipped with a recirculating bypass system that provides for continuous agitation of the reservoir Material, separate filters for the hose and nozzle, and multiple or adjustable nozzle system that provides for variable spray patterns.

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

(1) At a minimum rate of 1 gallon per 150 square feet of surface curing area.
(2) Apply homogeneously to provide a uniform, solid, white, opaque coverage on exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some Department-approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform, solid, opaque consistency meeting the intent of the above requirement.
(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by respraying.

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

E.1.b Curing Blanket Method

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

E.2 Protection Against Rain

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

E.3 Protection Against Cold Weather

If the National Weather Service forecast for the construction area predicts air temperatures of 36°F or less within the next 24 hours and the Contractor wishes to place concrete, submit a cold weather protection Plan.

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

E.3.a Cold Weather Protection Plan

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

F Bituminous

Place the bituminous mixture in accordance with 2360, “Plant Mixed Asphalt Pavement.”

G Backfill Construction

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Perform vibratory operations and backfilling 72 hours after placing the concrete or after the concrete reaches a compressive strength of at least 2,000 psi. The Engineer will cast, cure, and test the concrete field control specimens in accordance with 2461.3G.5.c, “Field Control Strength Cylinders.” If damage results from any of these operations, the Engineer will suspend operations until the Contractor takes corrective action and obtains the Engineer’s approval of a new method. The Engineer may require removal and replacement of the damaged concrete in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

The Contractor may use hand-operated concrete consolidation Equipment and walk behind vibratory plate compactors 24 hours after placing the concrete, and other Equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

After the curing is complete and without subjecting the concrete Work to damaging stresses, perform the backfill or embankment construction to the elevations shown on the Plans. Use suitable grading Materials from the excavation for backfill Material in accordance with 2106, “Excavation and Embankment – Compacted Volume Method,” unless otherwise required by the Contract. Place and compact the backfill Material in accordance with 2106, “Excavation and Embankment – Compacted Volume Method.”

Dispose of surplus excavated Materials in accordance with 2106, “Excavation and Embankment – Compacted Volume Method.”

2521.4 METHOD OF MEASUREMENT

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

2521.5 BASIS OF PAYMENT

Payment for concrete walk (colored) at the Contract price per unit of measure is full compensation for cost to providing concrete walk and concrete truck aprons to the specified lines, grade and minimum thickness specified in the Plans, including but not limited to: forming, joint filler Material, colored concrete test panels, furnishing and placing concrete, concrete compaction by vibration, concrete curing, and protecting the completed Work from damage.

The Engineer will measure and pay for concrete truck aprons (colored) as ___” Concrete Walk.

The Contract Unit Price for concrete or bituminous construction includes furnishing the Materials and placement of the Work to the lines and grade of the Plan as specified.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Walks. The amounts of these adjustments are deemed reasonable.

Failure to properly cure and protect the concrete in accordance with 2521.3E, “Concrete Curing and Protection,” will result in the Engineer applying a monetary deduction in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” If the Contract does not contain a separate Contract Item for Structural concrete, the Department will apply a monetary deduction of $50.00 per cubic yard or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

B Schedule

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

Item No.	Item	Unit
2521.518	___" Concrete Walk	square foot
2521.518	___" Colored Concrete Walk	square foot
2521.518	___" Bituminous Walk	square foot

2531 CONCRETE CURBING

2531.1 DESCRIPTION

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

2531.2 MATERIALS

A Concrete 2461

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

A.1 Manual Placement ..... Mix No. 3F32 or 3F52

A.2 Slip-form Placement ..... Mix No. 3F32

B Reinforcement Bars 3301

C Welded Wire Reinforcing 3303

D Preformed Joint Filler 3702

E Curing Materials

E.1 Burlap Curing Blankets 3751

E.2 Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound 3754

E.3 Linseed Oil Membrane Curing Compound 3755

E.4 Plastic Curing Blankets 3756

F Granular Materials 3149

2531.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Excavate, shape, and compact the foundation to a firm, uniform bearing surface that conforms to the dimensions and grade shown on the Plans and in accordance with 2106, "Excavation and Embankment – Compacted Volume Method," 2112, "Subgrade Preparation," and 2211, "Aggregate Base."

B Forms

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

For radii less than 100 feet, use flexible or curved forms approved by the Engineer.

Before placing concrete, coat the contact surfaces of forms with an approved form treating Material in accordance with 3902, “Form Coating Material.”

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

C Placing and Finishing Concrete

The concrete Contractor, or Subcontractor, shall have at least two people with a current ACI concrete flatwork associate, concrete flatwork finisher, or advanced concrete flatwork finisher certification, and at least one of them must be onsite for every concrete pour.

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

Place the concrete in a manner that will prevent segregation. Consolidate the concrete to fill voids using internal vibration. The Engineer will allow hand tamping of stacked concrete during forming of the curb. Strike-off the concrete to the grade shown on the Plans, and float the surface smooth.

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

D Slipform Machine Placement

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

E Joint Construction

Place transverse expansion joints, filled with 1/2 inch preformed joint filler Material, at the ends of curved sections and at the ends of the curved portions of entrance and Street returns. Place longitudinal expansion joints as shown on the Plans. Place expansion joints with preformed joint filler Material at locations where the concrete surrounds or adjoins an existing fixed object, such as a fire hydrant, building foundation, or other rigid Structure.

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

(1) Adjacent to bituminous mainline, every 10 feet maximum
(2) Adjacent to concrete mainline, match the adjacent concrete pavement joints
(3) In solid median construction where the width is at least 10 feet wide, install joints not to exceed a maximum of 150 square feet

Form or saw the contraction joints to a depth to prevent random/uncontrolled cracking.

Construct joints perpendicular to the Subgrade. Align joints with joints in adjoining Work unless a 1/2 inch preformed joint filler isolates the Work. Place transverse joints at right angles to the longitudinal axis of the Work, unless otherwise required by the Contract.

Use an edging tool with a radius no greater than 1/2 inch to round edges of longitudinal construction joints between a concrete median or gutter section and a concrete pavement.

Do not saw or seal longitudinal construction joints between a concrete median and concrete pavement, or between a gutter section and concrete pavement, unless specified otherwise in the Plans.

F Metal Reinforcement

Provide and place metal reinforcement as shown on the Plans and in accordance with 2472, “Metal Reinforcement.”

G Concrete Curing and Protection

After completing final finishing operations, cure exposed concrete surfaces. Use one of the following curing methods:

(1) In accordance with 2531.3G.1.a, “Membrane Curing Method,” place the membrane curing compound conforming to 3754, “Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound,” or 3755, “Linseed Oil Membrane Curing Compound,” within 30 minutes of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise. Place the membrane curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets, unless the Contract requires otherwise.

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

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

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

G.1 Curing Methods

G.1.a Membrane Curing Method

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

The Engineer will only approve airless spraying machines equipped with a recirculating bypass system that provides for continuous agitation of the reservoir Material, separate filters for the hose and nozzle, and multiple or adjustable nozzle system that provides for variable spray patterns.

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

(1) At a minimum rate of 1 gallon per 150 square feet of surface curing area.

(2) Apply homogeneously to provide a uniform, solid, white, opaque coverage on exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some Department approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform, solid, opaque consistency meeting the intent of the above requirement.

(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by respraying.

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

G.1.b Curing Blanket Method

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

G.2 Protection Against Rain

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

G.3 Protection Against Cold Weather

If the National Weather Service forecast for the construction area predicts air temperatures of 36°F or less within the next 24 hours and the Contractor wishes to place concrete, submit a cold weather protection Plan.

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

G.3.a Cold Weather Protection Plan

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

H Backfill Construction

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Perform vibratory operations and backfilling at least 72 hours after placing the concrete or after the concrete reaches a compressive strength of at least 2,000 psi. The Engineer will cast, cure, and test the concrete field control specimens in accordance with 2461.3G.5.c, "Field Control Strength Cylinders." If damage results from any of these operations, the Engineer will suspend operations until the Contractor takes corrective action and obtains the Engineer's approval of a new method. The Engineer may require removal and replacement of the damaged concrete in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may use hand-operated concrete consolidation Equipment and walk behind vibratory plate compactors 24 hours after placing the concrete, and other Equipment as approved by the Engineer, in conjunction with the Concrete Engineer.

After the curing is complete and without subjecting the concrete Work to damaging stresses, perform the backfill or embankment construction to the elevations as shown on the Plans. Use suitable grading Materials from the excavations in accordance with 2106, "Excavation and Embankment – Compacted Volume Method," unless the Contract requires otherwise. Place and compact the backfill Material in accordance 2106, "Excavation and Embankment – Compacted Volume Method."

Dispose of surplus excavated Materials in accordance with 2106, "Excavation and Embankment – Compacted Volume Method."

I Workmanship and Finish

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

The Engineer will use a 10 foot straightedge to measure the surface.

2531.4 METHOD OF MEASUREMENT

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

A Length

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

For solid medians and other construction with uniform widths and symmetrical cross-sections, the Engineer will measure the length along the center of the longitudinal axis.

B Area

For solid medians and other construction with non-uniform widths and non-symmetrical cross-sections, the Engineer will measure by the square yard area. The area is based on the width at grade by the exposed length. The Engineer will disregard variations in concrete thickness caused by integral construction. The Engineer will separately measure driveway pavement of each specified thickness.

2531.5 BASIS OF PAYMENT

Payment for concrete curb and gutter, concrete curb, concrete medians, and concrete driveway pavement at the Contract price per unit of measure is full compensation for cost of providing concrete curb and gutter, concrete curb, concrete medians, and concrete driveway pavement to the specified lines, grade and minimum thickness specified in the Plans, including but not limited to: forming, joint filler Material, furnishing and placing concrete, concrete compaction by vibration, concrete curing, and protecting the completed Work from damage.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Concrete Curbing. The amounts of these adjustments are deemed reasonable.

A.1 Concrete Curing and Protection

Failure to properly cure and protect the concrete in accordance with 2531.3G, “Concrete Curing and Protection,” will result in the Engineer applying a monetary deduction in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.” If the Contract does not contain a separate Contract Item for structural concrete, the Department will apply a monetary deduction of $50.00 per cubic yard or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

A.2 Workmanship and Finish

The Engineer will consider concrete Work with deviations 3/8 inch or greater in any 10 feet length of finish curb and gutter, either horizontal or vertical, as unacceptable Work. Remove and replace unacceptable Work as directed by the Engineer.

If the Engineer does not direct the removal and replacement of unacceptable Work, the Engineer will reduce the Contract Unit Price for the unacceptable concrete Work in accordance with the following:

(1) For deviations from 3/8 inch to 9/16 inch, payment at 75 percent of the Contract Unit Price
(2) For deviations greater than 9/16 inch, payment at 50 percent of the Contract Unit Price

Repair or replace concrete with random or uncontrolled cracks as directed by the Engineer. Submit the intended repair technique to the Engineer for approval. Perform repairs at no additional cost to the Department. If the repair fails, replace the concrete at no additional cost to the Department. The Engineer will accept repairs in accordance with 1516.2, "Project Acceptance."

B Schedule

The Department will pay for concrete curbing, median, and driveway construction on the basis of the following schedule:

Item No.	Item	Unit
2531.503	Concrete Curb and Gutter Design ____	linear foot
2531.503	Concrete Curb Design ____	linear foot
2531.503	Concrete Median	linear foot
2531.504	Concrete Median	square yard
2531.504	___" Concrete Driveway Pavement	square yard

2533 CONCRETE MEDIAN BARRIERS

2533.1 DESCRIPTION

This Work consists of constructing or reconstructing cast-in-place median barrier or precast median barriers for Traffic Lane separation.

2533.2 MATERIALS

A Concrete **2461**

A.1 Fixed Form Cast-In-Place .... **Mix No. 3M52**

A.2 Slipform Placement .... **Mix No. 3M12**

A.3 Precast .... **Mix No. 3M82**

B Reinforcement Bars **3301**

C Dowel Bars **3302**

D Precast Concrete Median Barrier **3630**

E Curing Materials

E.1 Burlap Curing Blanket **3751**

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

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

E.4 Plastic Curing Blankets **3756**

F Granular Materials **3149**

2533.3 CONSTRUCTION REQUIREMENTS

A General

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

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

Excavate, shape, and compact the foundation to a firm, uniform bearing surface and grade as shown on the Plans and in accordance with 2106, "Excavation and Embankment – Compacted Volume Method," 2112, "Subgrade Preparation," and 2211, "Aggregate Base."

B Cast-In-Place Fixed Form Construction

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

Wet the foundation and forms immediately before placing the concrete.

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

Round concrete edges to the radii as shown on the Plans after removing the Roadway face forms.

C Cast-In-Place Slipform Construction

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

D Surface Finishes

D.1 Cast-In-Place

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

D.2 Precast

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

E Concrete Curing and Protection

When the Contract requires additional surface finishing (i.e. painting), cure in accordance with 2533.3E.1.b. "Curing Blanket Method."

After completing final finishing operations, cure exposed concrete surfaces. Use one of the following curing methods:

(1) In accordance with 2533.3E.1.a, “Membrane Curing Method,” Place the membrane curing compound conforming to 3754, “Poly-Alpha Methyl Styrene (AMS) Membrane Curing Compound,” or 3755, “Linseed Oil Membrane Curing Compound,” within 30 minutes of concrete placement or once the bleed water has dissipated, unless otherwise directed by the Engineer. Place the membrane curing compound on the edges within 30 minutes after permanent removal of the forms or curing blankets, unless the Contract requires otherwise.

(2) Place plastic curing blankets or completely saturated burlap curing blankets as soon as practical without marring the surface in accordance with 2533.3E.1.b, “Curing Blanket Method.”

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

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

E.1 Curing Methods

E.1.a Membrane Curing Method

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

The Engineer will only approve airless spraying machines equipped with a recirculating bypass system that provides for continuous agitation of the reservoir Material, separate filters for the hose and nozzle, and multiple or adjustable nozzle system that provides for variable spray patterns.

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

(1) At a minimum rate of 1 gallon per 150 square feet of surface curing area.

(2) Apply homogeneously to provide a uniform, solid, white opaque coverage on exposed concrete surfaces (equal to a white sheet of typing paper) at the time of application. Some Department approved curing compounds may have a base color (i.e. yellow) that cannot comply with the above requirement. In this case, provide a uniform, solid, opaque consistency meeting the intent of the above requirement.

(3) If the curing compound is damaged during the curing period, immediately repair the damaged area by respraying.

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

E.1.b Curing Blanket Method

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

E.2 Protection Against Rain

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

E.3 Protection Against Cold Weather

If the National Weather Service forecast for the construction area predicts air temperatures of 36°F or less within the next 24 hours and the Contractor wishes to place concrete, submit a cold weather protection Plan.

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

E.3.a Cold Weather Protection Plan

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

F Finish and Workmanship

Produce concrete barrier to the dimensions and height shown in the Plans. Finish concrete barrier to a neat uniform surface finish with a light (vertical) broom texture before applying the curing medium.

The Engineer may use a 10 foot straightedge to measure the barrier surface for irregularities.

2533.4 METHOD OF MEASUREMENT

The Engineer will linearly measure each Type A and Type AA concrete median barrier on the top of the barrier, measured along the midpoint of the top width. The Engineer will linearly measure Type A barrier with glare screen in accordance with Type A and Type AA barrier or measured along both sides the barrier with a computed average of both measurements. The Engineer will take both measurements at the interface of the barrier and adjacent pavement. The Engineer will linearly measure transitions, and special and modified barriers by the length on the top of the barrier, measured along the midpoint of the top width.

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

When portable median barrier is removed from the Project Roadway and the Engineer directs stockpiling the portable median barrier on or near the Project Site for use again in a later phase of the Work, the Engineer will separately measure the stockpiled length of barrier and also the length of barrier reinstalled on the Project Roadway. The Engineer will only measure the stockpiled barrier when the Contract Unit Price for double payment of Relocate Portable Precast Concrete Barrier, Design 8337 and/or Relocate Portable precast concrete barrier, Design 8337 - Anchored would equate to lower price than furnishing Portable Precast concrete barrier, Design 8337.

2533.5 BASIS OF PAYMENT

The Contract Unit Price for concrete median barrier construction includes furnishing the Materials, placement of the Work to the lines and grade on the Plans, and surface finish as specified.

The Contract Unit Price for portable precast concrete barrier includes costs of installation and removal once.

The Contract Unit Price for relocating portable precast concrete barrier includes removing, stockpiling, and reusing as directed by the Engineer.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Concrete Median Barriers. The amounts of these adjustments are deemed reasonable.

A.1 Concrete Curing and Protection

Failure to properly cure and protect the concrete in accordance with 2533.3E, "Concrete Curing and Protection," will result in the Engineer applying a monetary deduction in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the Contract does not contain a separate Contract Item for structural concrete, the Department will apply a monetary deduction of $50.00 per cubic yard or 50 percent of the Contractor-provided invoice amount for the concrete in question, whichever is less.

A.2 Finish and Workmanship

The Engineer will consider surface irregularities greater than the following as unacceptable Work:

(1) Top barrier surface with high or low spots (elevation irregularities) greater than 1/4 inch.
(2) Slip-formed placed barrier face(s) with high or low spots (convex/concave irregularities) greater than 1/2 inch.
(3) Fixed form placed barrier face(s) with high or low spots (convex/concave irregularities) greater than 1 inch.
(4) Vertical transitions of barrier face(s) with high or low spots (convex/concave irregularities) greater than 1 3/4 inches.

The Engineer will evaluate unacceptable Work in accordance with Table 2533.5-1.

Table 2533.5-1
Monetary Deductions for Workmanship

Amount of Surface Irregularities (Measured by Length)	Corrective Action	Monetary Deduction
≤ 10 percent of median barrier length *	Monetary Deduction	The Engineer will reduce payment for the length of out-of-tolerance barrier by up to 50 percent of the Contract Unit Price.
> 10 percent of median barrier length *	Remove and Replace or Monetary Deduction	If the Engineer does not direct removal and replacement, the Engineer will reduce payment for the length of out-of-tolerance barrier by 50 percent of the Contract Unit Price.
* Based on the measured length for each separate barrier Pay Item on the Project.		

B Schedule

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

Item No.	Item	Unit
2533.503	Concrete Median Barrier Des ___* Type ___‖	linear foot
2533.503	Conc Med Bar Des Single Slope Type ___‖	linear foot
2533.503	Conc Med Bar & Gl Scr Des ___* Type ___‖	linear foot
2533.503	Portable Precast Concrete Barrier Design ___*	linear foot
2533.503	Relocate Portable Precast Concrete Barrier, Design ___*	linear foot

* Current Standard Plate or Plan
‖ Type A, Type AA, Type AL, Transition, A Step, or AA Step

2535 BITUMINOUS CURB

2535.1 DESCRIPTION

This Work consists of constructing a curb using bituminous Material.

2535.2 MATERIALS

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

2535.3 CONSTRUCTION REQUIREMENTS

A Tack

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

B Equipment

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

C Finishing

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

2535.4 METHOD OF MEASUREMENT

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

2535.5 BASIS OF PAYMENT

The Contract linear foot price for Bituminous curb includes the cost of construction and providing the bituminous mixture.

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

Item No.	Item	Unit
2535.503	Bituminous Curb	linear foot

2545 LIGHTING SYSTEMS

2545.1 DESCRIPTION

This Work consists of constructing Lighting Systems and electrical systems as specified in the Contract.

A Qualifications of Workers

Provide workers in accordance with 1802, “Qualification of Workers,” and the following:

On the Project Site ensure at least one person employed by the electrical Contractor and their Subcontractor is Department Signal and Lighting Certified during the Work. Upon request of the Engineer, submit an unexpired Department Signal and Lighting Certification card or evidence of valid Department Signal and Lighting Certification for the person on the Project Site performing or directly supervising the Work.

For information on Department Signal and Lighting Certification classes and valid certifications contact Office of Traffic Engineering, (OTE) Signals, and Lighting Unit.

B Definitions

Refer to 1102, "Abbreviations and Measurement Units," 1103, "Definitions," 2565.1C, "Acronyms," *NFPA 70 National Electrical Code* – Article 100 and this section for the abbreviations, acronyms, measurement units, and definitions of words and phrases.

2545.2 MATERIALS

Provide Materials as specified in the Contract and in accordance with 2565.2, "Traffic Control, Materials" to complete the Work.

A Steel Screw-In Foundations 3813

B Hardware

B.1 Galvanize ferrous metal hardware, except stainless steel 3392

B.2 Fasteners 3391

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

C Light Poles 3811

D Service Equipment 3837

E Type B Service Cabinet 3850

F Type L1 Service Cabinet 3850

G Type L2 Service Cabinet 3850

H Type Rural Lighting and Flasher (RLF) Service Cabinet 3850

I Photoelectric Control 3812

J Safety Switch 3837

K Lighting Units

K.1 Light Poles 3811

K.2 Luminaires 3810

K.3 Light Pole wiring 2545.3F.2

K.4 Splicing in Light Pole bases 2545.3G.1

K.5 Miscellaneous Materials

Miscellaneous Materials required for installation as specified in the Contract.

2545.3 CONSTRUCTION REQUIREMENTS

A Submittals

A.1 MnDOT Approved Products Materials List

Before performing the Work, submit to the Engineer, in accordance with 1502, “Plans and Working Drawings,” a Signals and Lighting product Materials list of the Materials selected from *Approved/Qualified Products List* to be used on the Project for signals and lighting. Ensure the products selected meet the requirements of this section.

In the Signals and lighting product Materials list submitted to the Engineer, provide the following information:

(1) Title the document “MnDOT’s Approved/Qualified Products List for Signals and Lighting,” centered at the top of the document
(2) Directly under the title include the Trunk Highway, County, and State Project number
(3) For each Material type listed from *Approved/Qualified Products List*, provide a separate line that includes the following:

(a) APL product category
(b) Name of the manufacturer
(c) Name of the product
(d) Catalog number
(e) Quantity ordered for the Project

This submittal and the Engineer’s review of the submitted list do not relieve the responsibility for providing Materials that comply with *Approved/Qualified Products List*.

A.2 Shop Drawing Submittals

Prepare shop drawing submittals in accordance with 1502, “Plans and Working Drawings,” for Materials not on *Approved/Qualified Products List*.

Review shop drawings for accuracy and completeness before submittal.

A.3 Cut Sheets, Catalog Sheets, or Specification Sheets

Provide cut sheets, catalog sheets, or specification sheets for *Approved/Qualified Products List* Materials to the Engineer upon request.

B General

Perform the Work in accordance with 2565.3, “Traffic Control Signals, Construction Requirements” and the following:

The Plan shows approximate locations of foundations, Lighting Units, SOP, service Equipment, service cabinets, handholes, and conduit crossings. The Engineer will establish the exact locations.

Do not perform Work until underground facilities have been located in accordance with 1507, "Utility Property and Service."

If damage due to Contractor's negligence occurs to direct buried lighting cable, within 24 hours replace the entire cable run at no additional cost to the Department. A run is defined as a segment of direct buried lighting cable from Lighting Unit to Lighting Unit or Lighting Unit to Lighting Service Cabinet.

If damage due to Contractor's negligence occurs to individual conductors in conduit and to the conduit, or only to the conduit, within 24 hours replace the individual conductors in the conduit and the conduit at no additional cost to the Department.

Do not splice direct buried lighting cable and bury underground.

Do not splice damaged conductors and place back in conduit.

Keep Roads open to traffic during construction in accordance with 1404, "Maintenance of Traffic." Protect excavation and uncompleted Work that may cause a hazard to vehicle and pedestrian traffic.

B.1 Remove Direct Buried Lighting Cable

Remove the in-place out-of-service (abandoned) cables shown on the Plans and as directed by the Engineer once the new system constructed under the Contract has been completed. In-place out-of-service cables not shown on the Plans, the Department will pay for the removal as Extra Work in accordance with 1402, "Contract Revisions."

Do not remove direct buried lighting cable located within 2 feet of the Roadbed and under the Roadway.

Where in-place, out-of-service (abandoned) cables conduits more than 2 feet away from the Roadbed and under the Roadway are allowed to remain in-place, provide the following at no cost to the Department:

(1) Perform a megohm meter test of each cable run in accordance with 2545.3J.1, "Megohm Meter Test"
(2) Repair damaged cable with a Direct buried Underground Cable Splice in accordance with 2545.3G.2, "Direct Buried Underground Cable Splices"
(3) Place a Department furnished ball marker on the direct buried underground cable splice before backfilling
(4) Collect and record GPS coordinates of the installed direct buried underground cable splice and submit to the Engineer
(5) Install new handholes in accordance with 2545.3D, "Handhole Installation" and 2565.3E, "Handholes" at both ends of each cable run
(6) Expose and protect the conductors at both ends of each cable run to allow for future locating
(7) Identify the cable run at both ends with a tag durable to withstand wet locations and labeled "ABANDONED LIGHTING CABLE"
(8) Collect and record GPS coordinates of each cable run at 10-foot intervals and provide to the Engineer
(9) Submit an As-built of the approximate location and linear footage of each cable run to the Engineer
(10) Provide a one-time locate of each cable run using red paint and red locating flags with a capital "A" inside a circle to represent abandoned facilities before final acceptance of the Project

Noncompliance of these provisions will result in suspending the Work in accordance with 1501.2 "Suspending Work," and be subject to 2545.5A, "Monetary Adjustment."

The requirements listed are necessary for the Department to maintain its abandoned facilities in accordance with MN Statutes 216D.04 Subd 3, "Locating underground facility; operator" and MN Administrative Rules 7560.0125, "Abandoned and Out-Of-Service Facilities."

The Engineer will distribute copies of the As-builts and GPS coordinates to the Project file, District Traffic Office, and Department's Locating Office.

C Maintenance and Operation of New and Existing Lighting Systems

Maintain and keep in operation the new and existing Lighting Systems in accordance with 2565.3B, "Maintenance and Operation of New and Existing Electrical Systems" and the following:

(1) Lighting Units
(2) Lighting Service Cabinets
(3) Photoelectric controls
(4) Foundations and Equipment pads
(5) Lighting cable, and conductors
(6) Conduit
(7) Damage and knockdowns resulting from Contractor operations

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

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

D Handhole Installation

Install handholes and pulling vaults within a direct buried lighting cable run if shown on the Plans and as directed by the Engineer. Install a PVC conduit stubout with the following characteristics for each cable entering and exiting the handhole or pulling vault:

(1) 2 inches
(2) At least 36 inches long
(3) Non-metallic end bells on each open end to prevent damage to the direct buried lighting cable
(4) Through the side wall of the enclosure

Install the approved power cable splice encapsulation kit for direct buried lighting cable and individual conductors for splices in handholes and pulling vaults as specified in the Contract.

When pulling vaults are required, provide an Aggregate drain bed 12 inches to 18 inches larger than the base of the pulling vault. Center the pulling vault on the drain bed.

E Light Foundation and Equipment Pad Installation

Construct light foundations and Equipment pads as shown on the Plans and the following:

Install preformed joint filler in accordance with 3702, "Preformed Joint Fillers," between the foundation and Sidewalk or concrete area.

Orient light foundation anchor rods so that mast arms or davits of Light Poles are perpendicular to the centerline of the Roadway unless specified elsewhere in the Contract.

Install Roadside light foundations located in the clear zone in accordance with AASHTO's *2015 LRFD Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and as follows:

Ensure breakaway poles on foundations placed on Roadside slopes do not allow impacting vehicles to snag on either the foundation or anchor rods. Shape the terrain around the foundations to ensure anchor rods do not project more than a maximum of 4 inches above a horizontal line between the straddling wheels of a vehicle on 60-inch centers. The horizontal line from wheel to wheel connects any point on the ground surface on one side of the light standard foundation, including anchor rods, to a point on the ground surface on the other side of the light standard foundation, including anchor rods. The horizontal line is aligned radially or perpendicular to the centerline of the Roadway.

E.1 Precast Concrete Foundations

Install precast concrete foundations as specified in the Contract and the following:

(1) Use an appropriate size earth auger bit to excavate a cylindrical drilled shaft into the ground 3 inches to 6 inches larger in diameter than the diameter of the foundation

 (a) Use auger drilling Equipment with adequate capacity, including power, torque, and down thrust to auger a cylindrical drilled shaft to the depth specified in the Contract

(2) Level and firmly compact the bottom of the shaft so it is flat and horizontal while maintaining the required depth of the shaft

(3) Remove the forming tube from the foundation before placing the precast foundation in the shaft

(4) Center, set, and level the foundation in the shaft and maintain a 3 inch minimum to a 6 inch maximum continuous symmetrical annular void between the precast foundation and surrounding soil

(5) Before backfilling place in the annular void the ground rod electrode and ground rod electrode conductor if specified in the Contract

(6) Completely backfill the annular void between the foundation and the surrounding soil of the shaft with firmly compacted fine filter Aggregate in accordance with 3149.2I.2, "Fine Filter Aggregate"

 (a) Using a mechanical pole tamper place backfill Material in accordance with 2451.3D "Backfilling and Compacting Excavations"

 (b) Substitution of lean mix backfill in accordance with 2520, "Lean Mix Backfill," instead of fine filter Aggregate is permitted

  (i) Protect the conduit openings from lean mix backfill to ensure the conduits are accessible and free of debris if installing direct buried lighting cable

  (ii) 24 hours after placing lean mix backfill, install the direct buried lighting cable

(7) Test and verify the compaction of the filtered Aggregate backfill Material around the foundations in accordance with 2106.3G.3, "Penetration Index (PI)," at a rate of one test per every 10 foundations with a minimum of 2 tests per Project

F Wiring

Install wiring, cables, conductors, and conduits as shown on the Plans and the following.

If Equipment grounding conductors are not noted or shown on the Plans for branch circuits using conductors in conduit, provide, and install Equipment grounding conductors (EGC).

F.1 Underground Wiring

Install direct buried lighting cable and underground conduit with single conductors at the same distance behind the bituminous Shoulder or back of curb as the light foundations. When an obstruction has been encountered in the path of the direct buried lighting cable or underground conduit, re-route the direct buried lighting cable and underground conduit around the obstruction away from the Roadway.

Mark the location of the newly installed direct buried lighting cable and underground conduits with red flags and red paint immediately after installation. Throughout the course of the Project protect and preserve the locate flags and paint on the newly installed underground lighting facilities. In the event the locate marks have been obliterated or are obscured or missing refresh and remark the area.

F.1.a Direct Buried Lighting Cable

Trench or plow to install direct buried lighting cable to a depth of at least 2 feet and in accordance with 2565.3I.1 “Underground Wiring.”

Feed the cable through the plow blade chute and ensure the plow blade does not pull the cable. Obtain the Engineer’s approval for the plowing method before installing the cable.

If encountering solid rock or other obstructions, install the cable in a 3 inch conduit buried at least 6 inches deep with a 2 inches thick concrete slab above conduit.

Install direct buried lighting cable in rigid PVC or HDPE conduit if located under bituminous, concrete, or other Material not considered a top soil. Provide 3 inch conduit if the Contract does not specify size of conduit.

Install an additional 2 feet of slack direct buried lighting cable near the light foundation in an “S” shape before the cable enters the foundation conduit.

Extend direct buried lighting cable 2 feet above the top of the light foundations. Leave 4 inches to 6 inches of the outer cable jacket extending above the conduit.

Install direct buried lighting cable from the reel or spool immediately into the ground. Do not lay direct buried lighting cable for the new Lighting System on the ground to use as temporary wiring.

F.1.b Single Conductors Installed in Underground and Barrier Conduits

Pull single conductors directly from reels or spools. Do not pull off and lay conductors on the ground before installation.

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

Extend the conductors above the top of the light foundations 18 inches to 2 feet.

F.2 Above Ground Wiring

Electrically bond the Equipment grounding conductor (EGC) to metal poles and Equipment.

F.2.a Light Pole Wiring

For each luminaire, provide a continuous length without splice of 12-2 (with ground) UF cable within the Light Pole from the required terminations in the Light Pole base to the luminaire.

Provide approved luminaire wire holders listed on *Approved/Qualified Product List* under “Lighting” that supports the luminaire cable within the end of the Light Pole tenons near the connection point of the luminaires.

Provide fuse holders listed on *Approved/Qualified Products List* under “Lighting” with fuses and position the fuse holders inside the Light Pole bases where it can be easily seen and removed when the access doors are removed.

Use 2 Amp fast acting fiber body 5AG midget type fuses.

Connect the UF cable at one end by properly terminating the individual conductors to their designated tunnel lug terminals in the luminaire. At the other end of the UF cable, properly terminate the individual conductors to the correct circuit conductors located in the Light Pole base.

Strip the insulation from the end of the ungrounded black conductor of the UF cable as far back as needed to ensure a safe connection to the “Load” side terminal of the fuse holder. Before terminating apply anti-oxidant joint compound to the end of the conductor. Terminate the conductor to the “Load” side of the fuse holder in accordance with the fuse holder manufacturer’s installation instructions. After terminating, apply 2 layers of vinyl electrical tape over the terminal end and extend the wrap at least 1 inch over the incoming conductor insulation.

Terminate the grounded “neutral” conductor of the UF cable to the grounded neutral circuit conductor by splicing in accordance with 2545.3G.1, “Above Ground Splices.”

Terminate the bare grounding conductor of the UF cable to the EGC in accordance with 2545.3O “Bonding and Grounding.”

Provide a continuous, without splice, short piece of 10 AWG stranded insulated conductor and:

(1) Strip insulation from the both ends of the 10 AWG conductor as far back as needed for splicing and terminating connections
(2) Before splicing and terminating apply an anti-oxidant joint compound to the ends of the conductors
(3) Terminate one end of the 10 AWG conductor to the assigned ungrounded “Hot” branch circuit conductors shown on the Plan to make above ground splices in accordance with 2545.3G.1 “Above Ground Splices”
(4) Terminate the other end of the 10 AWG conductor to the “Line” side terminal of the fuse holder in accordance with the manufacturer’s installation instructions
(5) After the 10 AWG conductor has been terminated to the fuse holder, apply 2 layers of vinyl electrical tape over the terminal and extend the wrap at least 1 inch over the incoming conductor insulation

F.2.b Temporary Overhead Lighting Cable

The Contractor may use quadruplex aluminum conductor, steel reinforced (ACSR) cable meeting the requirements of 3815, "Cables and Conductors," to provide temporary power distribution through aerial lines.

Do not support overhead lighting cable by the luminaires.

G Splices

Do not splice unless specified in the Contract or approved by the Engineer.

If specified in the Contract or approved by the Engineer, only splice in handholes, pulling vaults, junction boxes, and pole bases.

G.1 Above Ground Splices

Provide splices for conductors and cables as specified in the Contract and the following:

(1) Strip insulation from the ends of the conductors as far back as needed for the splice
(2) Before splicing, apply conductor anti-oxidant joint compound to the stripped ends of the conductors
(3) Install split bolt connectors on the neutral (grounded) conductor splices
(4) Install split bolt connectors or approved insulated wire splice connector blocks for ungrounded and grounding conductor splices
(5) Apply 1 complete wrap of self-fusing electrical insulation putty tape around each split bolt connector splice, except grounding splices, to a thickness of at least 1.5 times that of the original insulation
(6) Apply 2 layers of vinyl electrical tape over the self-fusing electrical insulation putty tape and extend tape at least 1 inch over the conductor insulation
(7) For splices using the insulated wire splice connector blocks, apply 2 layers of vinyl electrical tape overlapping the connector ports and 1 inch over the incoming conductor insulation

Approved insulated wire splice connector blocks listed on *Approved/Qualified Products List* under "Lighting." Install wire splice connector blocks in accordance with the manufacturer's installation requirements.

If required for temporary Lighting Systems, provide NRTL listed connectors designed to terminate aluminum and copper conductors in the same splice. Provide NRTL listed terminals for use with aluminum wire for terminals used on aluminum conductors. Tighten the connections to the manufacturer's recommended torque.

G.2 Direct Buried Underground Cable Splices

Provide and install a direct buried underground cable splice as shown on the Plan and the following:

(1) Splice each individual cable together using a NRTL listed compression–type butt splice barrel connector that is rated for the size of conductor being spliced
(2) Crimp the barrel connector to the conductors using the manufacturer specific compression tool
(3) Cover the entire wire splice with appropriately sized shrink tubing. The shrink tubing must also cover a minimum of 1/4 inch of the conductor insulation on both sides of the splice. After the tubing is slid into position, heat-shrink to form a tight seal around the splice and the insulation of the conductor on both sides of the splice

(4) Wrap each conductor splice, after compression and installation of the shrink tubing, with at least 2 layers of electrical tape to insulate individual conductors before encapsulation
(5) Splice together the shielding by drilling a hole in each piece of shield and then bolting the pieces together using brass nuts, bolts, and flat washers to form an electrical bond between the 2 pieces. The bolt head faces the cables and the shaft of the bolt faces outward
(6) Assemble splices in accordance with the manufacturer's installation instructions
(7) Place the entire cable splice inside the approved power cable splice encapsulation kit, ensuring that when the encapsulating Material is poured in the mold it seals up the conductor splices, cable shield, and the outer jacket of the direct buried lighting cable and forms 1 complete assembly. Ensure that no individual conductor insulation or cable shield is exposed when the splice is complete

Provide power cable splice encapsulation kits listed on *Approved/Qualified Products List* under "Lighting."

Assemble the power cable splice encapsulation kit in accordance with manufacturer's installation instructions.

Wrap electrical insulating tape around the end of each epoxy resin mold where it meets the outer jacket of the cable assembly to prevent epoxy from leaking out of the mold before curing.

Allow the resin to harden and cool.

Test conductors of the splice in accordance with 2545.3J.1, "Megohm Meter Test."

G.3 Two Way Underground Handhole Cable Splices

Provide and install a 2-way underground handhole cable splice as shown on the Plan and as follows:

(1) Provide adequate slack in the cable assembly to allow each individual cable to extend at least 3 feet above the top of the handhole before stripping the cable
(2) Strip off the outer jacket of the cable assembly to within 6 inches of where the cable enters the handhole
(3) Unwind the copper shield to within 6 inches of where the cable enters the hand hole
(4) Splice together the shielding by drilling a hole in each piece of shield and then bolting the pieces together with brass nuts, bolts, and flat washers to form an electrical bond between the 2 pieces of copper shielding
(5) Apply pole base terminal block coating to the entire shield splice point
(6) Provide pole Base terminal block coatings listed on *Approved/Qualified Products List* under "Signals"
(7) Provide adequate slack in the cable assembly to allow each individual cable to extend at least 3 feet above the top of the handhole before stripping the cable
(8) Splice each individual conductor of the 4 conductor cable assemblies separately
(9) Maintain proper circuit color identification within each splice
(10) Splice each conductor pair together using a NRTL listed compression–type butt splice barrel connectors that is rated for the size of cable being spliced
(11) Crimp the barrel connector to the conductors using the manufacturer specific compression tool

(12) Separately encapsulate each individual conductor splice using a Department-approved loop detector splice encapsulation kit

Provide loop detector Splice Encapsulation kits listed on *Approved/Qualified Products List* under "Signals"

Assemble the loop detector splice encapsulation kit in accordance with the manufacturer's installation instructions and as follows:

Wrap electrical insulating tape around the end of each epoxy resin mold where it meets the outer jacket of the cable assembly to prevent epoxy from leaking out of the mold before curing.

Allow the resin to harden and cool.

Test conductors of the splice in accordance with 2545.3J.1, "Megohm Meter Test"

G.4 Three Way Underground Handhole Cable Splice

Provide and install a 3-way underground handhole cable splice as shown on the Plan and as follows:

(1) Provide adequate slack in the cable assembly to allow each individual cable to extend at least 3 feet above the top of the hand hole before stripping the cable
(2) Strip off the outer jacket of the cable assembly to within 6 inches of where the cable enters the handhole
(3) Unwind the copper shield to within 6 inches of where the cable enters the handhole
(4) Splice together the shielding by drilling a hole in each piece of shield and then bolting the pieces together with brass nuts, bolts, and flat washers to form an electrical bond between the 3 pieces of copper shielding
(5) Apply pole base terminal block coating to the entire shield splice point. Provide pole base terminal block coatings listed on the *Approved/Qualified Products List* under "Signals"
(6) Unwind the copper shield to within 6 inches of where the cable enters the handhole
(7) Splice each individual conductor of the 4 conductor cable assemblies separately
(8) Maintain proper circuit color identification within each splice
(9) Splice the 3 conductors together using a NRTL listed split bolt splice connector that is rated for the size and number of the conductors being spliced
(10) Ensure the split bolt is adequately tightened
(11) Separately encapsulate each individual conductor splice using a Department approved 3-way power cable splice encapsulation kit

Provide 3-way power cable splice encapsulation kit listed on *Approved/Qualified Products List* under "Lighting."

Assemble the 3-way power cable splice encapsulation kit in accordance with the manufacturer's installation instructions. Wrap electrical insulating tape around the end of each epoxy resin mold where it meets the outer jacket of the cable assembly to prevent epoxy from leaking out of the mold before curing.

Allow the resin to harden and cool.

Test conductors of the splice in accordance with MnDOT 2545.3J.1, Megohm Meter Test."

H Pole Installation

Unless otherwise specified in the Contract, install poles and high mast light towers (poles) in accordance with the manufacturer's pole erection drawings and installation instructions, and *AASHTO's 2015 LRFD Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Set poles plumb on foundations.

Lift and safely move poles without damage. Avoid abrasion during lifting operations. Do not drag poles on the ground.

Repair surface finish damage in accordance with the manufacturer's recommendations.

Use natural or synthetic fiber slings and chokers or prevent the pole surface finish from coming in direct contact with metal chains and hardware when lifting poles to protect factory surface finish from mars, blemishes, or scratches.

Before standing poles on foundations:

(1) Verify the anchor rod pattern matches the base plate bolt hole pattern for a properly fitted connection
(2) Verify the required anchor rod grade by locating the steel die stamped grade identification on the end of the anchor bolt projecting above the concrete
(3) Verify anchor rods meet projections for a properly secured pole, and meet AASHTO's stub height requirements when breakaway is mandated
(4) Verify anchor rods are clean, not damaged, and plumb
(5) Verify nuts can be turned down on the anchor rods to the foundation and backed off by hand or by one worker using an ordinary wrench without a cheater bar
(6) Verify the base plate opening accommodates conduits and ground rod electrodes
(7) Ensure the pole and base are free of dirt or other foreign Material
(8) Inspect poles for damage

Replace damaged poles or pole accessories with new. Before replacing, obtain the Engineer's approval. Do not install poles or accessories from previous electrical systems.

Immediately after standing the pole on the foundation complete the entire pole installation process. The pole installation process is from the time the pole is set on the foundation to the completion of final tightening of anchor rod connections in accordance with the Contract. Do not stop midway through the installation process. Do not stand poles on foundations without completion of final anchor rod connection tightening.

H.1 Anchor Rod Connections

Ensure the required anchor rods (bolts), nuts, washers, and pole base plate fit solidly together. Assemble threaded portions of anchor rods and nuts, and faying surfaces of nuts and washers to ensure threads and surfaces are free of the following:

(1) Scale, except tight mill scale
(2) Dirt
(3) Loose scale
(4) Burrs
(5) Other foreign Material
(6) Other defects preventing solid seating of connections

Use anchor rods, nuts, and washers in accordance with the Contract and manufacturer's installation instructions. Use the amount of washers and nuts for each connection as specified in the Contract and pole manufacturer's installation instructions. Do not remove required nuts or washers from the connection. Do not add extra washers, spacers, or other hardware to the connection other than what is required.

Place nuts, washers, and pole base plate on anchor rods in the installation order as specified in the Contract and manufacturer's installation instructions.

Do not use lock washers unless the pole manufacturer requires otherwise.

Ensure the top of the anchor rod extends at least 1 thread beyond the top surface of the top nut. An anchor rod end inside the top nut where no threads extend beyond the top surface of the nut and the top nut is not fully engaged on the anchor rod after tightening is not acceptable.

Clean and lubricate the exposed threads of anchor rods, nuts, and the bearing surfaces of nuts and washers just before setting the pole base on the foundation. Use anti-seize and lubricating compound in accordance with 3842, "Electrical Systems Compounds and Lubricants" to lubricate. If more than 24 hours has elapsed since earlier lubrication, or if the anchor rods and nuts have become wet since they were first lubricated then clean and re-lubricate exposed threads of anchor rods, nuts, and the bearing surfaces of nuts and washers.

Use wrenches designed for turning nuts to tighten anchor rod connections. Do not use pipe wrenches to turn nuts.

Use wrenches sized specifically for the nut being turned. Do not use adjustable wrenches.

H.1.a Single-Nut Anchor Rod Connections

Light Poles requiring single-nut anchor rod connections are set directly on the foundation. Leveling nuts are not used in the connections. One heavy hex nut for each anchor rod is used to fasten the pole base to the foundation anchor rods.

Use washers in the connections in accordance with the pole manufacturer's installation requirements and the Contract.

Use leveling shims in accordance with *Standard Plate 8129* when shims are required by the pole manufacturer for leveling poles installed on single-nut anchor rod connections.

Use a calibrated torque wrench to tighten to the specified torque value in accordance with the pole manufacturer's requirements for tightening nuts on anchor rod connections. Check for loose nuts 48 hours to 96 hours after tightening anchor rod connections. If nuts move, retighten the connection using the required tightening method.

If more than 2 of the anchor rod connections nuts move per pole, remove the pole and disassemble the connections. Re-install the pole and connections.

H.1.b Double-Nut Anchor Rod Connections

Poles requiring double-nut connections use 2 heavy hex nuts for each anchor rod to fasten the base plate to the foundation anchor rods. A bottom nut, also called a leveling nut is positioned under the base plate to level and support the pole and a top nut is located above the base plate.

Two hardened flat washers are required for each connection. Place 1 washer directly above the leveling nut and the other washer directly under the top nut. Use additional washers or spacers if required by the pole manufacturer.

Use the standoff distances provided by the pole manufacturer. If the pole manufacturer does not provide standoff distances then use the *AASHTO LRFD Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals* standoff distance of less than 1 anchor rod diameter.

Fully tighten the anchor rod connections in accordance with the Contract documents.

I Sign Lighting Installation

Provide sign lighting as specified in the Contract.

Use direct buried lighting cable to provide power distribution to the sign Structure unless otherwise specified in the Contract.

Use PVC Coated Hot-Dipped Galvanized Rigid Steel Conduit and conduit fittings in accordance with 3805, “PVC Coated Hot Dipped Galvanized Rigid Steel Conduit (PVC Coated RSC),” and install in accordance with 2565.3D.6, “Conduit on Bridges (Concrete Encased, Hanging, and Surface Mounted).”

I.1 Safety Switch

Provide a safety switch in accordance with 3837.2A.5, “Heavy Duty Safety Switch,” and install in a vertical upright position.

I.2 Safety Switch Wiring

Install 12 AWG conductors with a 12 AWG Equipment grounding conductor in 3/4 inch conduit.

Extend direct buried lighting cable or conductors from conduit at least 5 feet above the top of the sign pole foundation. Remove the outer jacket of the cable to access the individual conductors and the copper shield. Leave in-place a minimum of 4 inches and a maximum 6 inches of the outer jacket extending above the conduit. Splice the existing or new direct buried lighting cable in the sign pole base to the conductors from the safety switch in accordance with 2545.3G, “Splices.”

Provide bonding and grounding in accordance with 2545.3O, “Bonding and Grounding.”

I.3 Lighting System Identification Plate (Overhead Sign)

Provide and install a Lighting System identification plate as shown on the Plans and in accordance with 2564 “Traffic Signs and Devices.”

I.4 Safety Cable

Provide and install brackets, aircraft cable, and hardware required to assemble and attach a safety cable as shown on the Plans in accordance with 2564, “Traffic Signs and Devices.”

J System Testing and Acceptance

J.1 Megohm Meter Test

Perform a megohm meter test for unwanted grounds, at 500 VDC, showing the insulation resistance of each circuit. Energize the megohm tester for 15 seconds on the circuits to check for breakdown of the circuits. Submit a written report of the megohm meter readings for the permanent record with the following information to the Engineer:

(1) Project number
(2) Project location
(3) Feedpoint number as shown on the Plans
(4) Branch circuit that identifies each lighting branch circuit being tested by indicating the number of the first light connected to that circuit, as shown on the Plans
(5) Phase conductor insulation resistance. Determine the phase conductor insulation resistance by measuring the resistance between the phase conductors, and the resistance between each phase conductor and the Equipment ground bar in the service cabinet. Remove the fuses from the inline fuse connectors in the Light Poles before measuring. The Engineer will not allow a resistance less than 100 milliohm
(6) Neutral conductor insulation resistance. Determine the neutral conductor insulation resistance by measuring the resistance between each neutral conductor and the Equipment ground bar in the service cabinet. Remove the fuses from the inline fuse connectors in the Lighting Poles before measuring. The Engineer will not allow a resistance less than 100 milliohm
(7) Circuit insulation resistance. Determine the circuit insulation resistance by measuring the resistance between each phase conductor and the Equipment ground bar in the service cabinet. The Engineer will not allow a resistance less than 100 milliohm

Perform tests at the service cabinet, in the presence of the Engineer, with grounding connections in place. Disconnect the phase and neutral conductors at the service cabinet for the insulation resistance tests.

If the tests show faulty insulation or a faulty connection within the circuit, correct and retest circuits at no additional cost to the Department. Replace circuits or circuit parts to make the circuits meet the test requirements at no additional cost to the Department.

J.2 12-Hour Burn Test

After completing the Feed Point and before the Department pays for greater than 90 percent of the Feed Point cost, energize the service cabinet and ensure the entire system can successfully operate without interruption for 12 hours during daylight.

This Work is included in the Unit Prices of the Pay Items that are part of the Lighting System.

K Lighting Service Cabinet Installation

Install components of each Lighting Service Cabinet and include miscellaneous hardware required for a complete Lighting Service Cabinet installation. Coordinate the connection of power to each Lighting Service Cabinet with the electric utility company to perform a visual inspection before making the service connection. Ensure the Contractor's electrician is present when the electric utility company makes the visual inspection.

Position the photoelectric control to face north. The photoelectric control may face east or west only if facing it north is not an option due to service cabinet orientation.

Position the cabinet door from 90 degrees to 180 degrees to the Roadway, away from traffic.

K.1 Type B Service Cabinet

Attach service cabinet Type B to wood poles or mounting bracket assemblies as required by the Contract. Provide and install service Equipment including the following:

(1) Meter socket in accordance with 3837, “Service Equipment”
(2) Mounting brackets as shown on the Plans
(3) Conduit fittings
(4) Wiring as shown on the Plans
(5) Other items Incidental to a complete meter socket installation

K.2 Type L1, Type L2, and Type Rural Lighting and Flasher (RLF) Service Cabinets

Securely fasten Lighting Service Cabinets to the Equipment pads specified in the Contract.

Install the supplied rubber gasket sections between the bottom of each cabinet base and the top of the Equipment pad.

Leave one 1/2 inch gap in the gasket to ensure proper water drainage.

L Restoration and Cleanup 2565.2A

M Lighting System Component Numbering and Labeling

M.1 Lighting System Numbering

Number Lighting Units and Lighting Service Cabinets as shown on the Plans with labels in accordance with 3844,”Labels.”

Verify reinstalled Lighting Units are numbered as shown on the Plans.

M.1.a Lighting Service Cabinet Numbering

Number the service cabinets 4 feet above the Equipment pad with the Feed Point numbers and letters as shown on the Plan on the outside of the front door and the side of the cabinet that faces traffic.

M.1.b Light Pole Numbering

Number the Lighting Unit pole with Feed Point numbers and letters, and Lighting Unit number as shown on the Plans.

Place the Feed Point numbers and letters, and Lighting Unit number 6 feet above the foundation on the pole at 45 degrees facing oncoming traffic.

Lighting Units installed on barrier place the Feed Point numbers and letters, and the Lighting Unit number 6 feet above the Roadway surface on the pole at 45 degrees facing oncoming traffic.

For twin arm davit Lighting Units in center median, place the Feed Point numbers and letters for both directions of travel with the assigned Lighting Unit numbers as shown on the Plans.

Lightly sand the pole shaft to remove oxidation. Wipe the pole shaft with isopropyl alcohol before applying numbers and letters.

Heat the surface of the pole with a propane torch to ensure the label sticks to the pole when the outside temperature is less than 60°F. Avoid overheating the surface to prevent damage to the label.

M.1.c Underpass Luminaire Numbering

Number underpass luminaires with the last letter of the Feed Point and with the assigned Lighting Unit number as shown on the Plans.

M.2 Lighting System Labeling

M.2.a Labeling Branch Circuit Breakers in Lighting Service Cabinets

Label branch circuit breakers on the interior of the Lighting Service Cabinets with the color of the circuit conductor and the Lighting Unit number. Use machine printed labels suitable for use in damp locations. Do not use labels made of paper.

M.2.b Labeling Lighting Cable and Conductors

Label cable or conductors in conduit in service cabinets and Light Pole bases indicating the next termination point. For example, in the Lighting Service Cabinet the label would read “TO POLE #1”; in pole No. 1 the label would read “TO LIGHTING SERVICE CABINET” and “TO POLE #2.”

Provide labels that consist of white vinyl adhesive tape wrapped around the cable or conductors. Hand write the labeling on the vinyl adhesive tape or produce with a label maker. If label marking is handwritten, accomplish the labeling by using a black permanent marker, in such a manner, that the markings are legible to the satisfaction of the Engineer. If labels are produced from a label maker, ensure labels are suitable for use in wet locations, and wrap the label around the cable one complete revolution with some overlap.

M.2.c Labeling Luminaires

(1) Label the luminaire with the installation date as follows: Provide labels for the date of installation meeting the following requirements:

(a) Record the installation date on white self-adhering label
(b) Use machine printed numbers
(c) Black text which is 1/2 inches tall
(d) Month/Year numeric format
(e) Suitable for placement in wet locations
(f) Paper based labels are not acceptable
(g) Place inside of the luminaire housing and on the luminaire access door so the label showing the date can be read from ground level

(2) Label the bottom outside of pole mounted luminaires access door with the number 40 for a luminaire listed on *Approved/Qualified Products List* under “Lighting” titled “LED Luminaires For Use Mounted at 40 feet”

(3) Label the bottom outside of pole mounted luminaires access door with the number 49 for a luminaire listed on *Approved/Qualified Products List* under “Lighting” titled “LED Luminaire For Use Mounted at 49 feet”

M.2.d Service Cabinet Arc Flash Warning Hazard Labeling

Provide arc flash warning hazard labels in accordance with 3844, “Labels.”

M.2.e Available Fault Current Calculation Labeling

Provide arc flash warning hazard labels in accordance with 2565.2OO, “Arc Flash Warning Labels.”

N Luminaire Installation

Obtain the Engineer’s approval before installing luminaires.

Install and level luminaires in accordance with the manufacturer’s installation instructions and as approved by the Engineer.

Install a Department approved wire holder that supports the luminaire cables and conductors within the end of pole tenon near the luminaire slipfitter connection.

After the Light Pole has been installed on the foundation place the luminaire on the pole tenon. Use a level on the designated area on top of the luminaire, or if provided use the luminaire internal leveling bubble. When leveling, level the luminaire side-to-side and front-to-back. Tighten the luminaire fitter connection bolts to the manufacturer’s recommended torque values.

Use a calibrated torque wrench or other method that ensures manufacturer’s recommended torque values have been met when tightening luminaire fitter connection bolts. Demonstrate to the Engineer for approval if using a method other than a calibrated torque wrench to meet recommended torque values before installing luminaires.

If a photoelectric control or lighting control node (smart lighting control) is required to be installed on a luminaire, install the unit in accordance with the manufacturer’s installation requirements and the following:

(1) Install the control or node window facing north
(2) If possible mount the control or node in a position so the photoelectric window is clear of surrounding light sources and shadowing of Structures and vegetation
(3) If facing the photoelectric window north interrupts normal operation of the luminaire, then face the window east or west
(4) Test each photoelectric control or node once installed

N.1 Underpass Luminaire Installation

Install and level underpass luminaires in accordance with the manufacturer's installation instructions, as approved by the Engineer, and the following:

(1) Install the luminaire 17 feet above the driving surface
(2) Install the luminaire a maximum of 20 feet horizontally away from either the most left or right edge of the Travel Lane or Lanes
(3) Install 10 AWG stranded green insulated Equipment grounding conductor from the underground handhole cable splice to the luminaire without any intermediate splices in the conductor run

Install components required for a complete and operational underpass luminaire which includes hardware for mounting.

Provide liquid tight flexible non-metallic conduit in accordance with 3804, “Liquid Tight Flexible Non-Metallic Conduit (LFNC-B).”

O Bonding and Grounding

Provide bonding, grounding, grounding electrodes, grounding electrode conductors, Equipment grounding conductors, grounding electrode systems, and grounding connections in accordance with 2565.2A, “Conduit Accessories,” the NEC, and the following:

Provide mechanically and electrically secured metal poles, conduit, service cabinets, service Equipment, and other non-current-carrying metal surfaces to form a continuous, bonded, grounded system and to provide a low impedance path from exposed metal surface to the system ground at the service cabinet or service Equipment.

Bond the following to the system Equipment grounding conductor as specified in the Contract:

(1) Equipment grounding electrode conductor
(2) Copper tape shield of the direct buried lighting cable
(4) Metal raceways
(5) Grounding lug of the Light Pole or sign post
(6) Aluminum-conductor steel-reinforced cable (ACSR) Equipment ground messenger of overhead light cable

Use NRTL listed stainless steel, copper, tin plated copper, brass, or bronze connectors for bonding and grounding unless otherwise specified in the Contract.

Use a lug type connector or bolt to connect the grounding and bonding jumper to the copper shield. Use cast clamps or grounding bushings with an integral lug to accommodate the jumper to attach other grounding and bonding jumper attachments.

Provide at least 6 AWG solid bare bonding jumpers.

Provide green colored insulated Equipment grounding conductors (EGC) of the same wire gauge size as the circuit conductors.

Bond Light Poles to ground as specified below:

(1) Drill the shield for each cable assembly, in each pole base, with a 5/16 inch drill bit for stainless steel poles or 1/2 inch hole for aluminum poles for placement under the active clamping grounding lug
(2) Place a re-usable screw type active clamping ground lug with a tang on top of the shield
(3) Insert a 5/16 inch or 1/2 inch stainless steel bolt through the grounding lug and then through the copper shield. Non-breakaway pole bases may have a 5/16 inch stud welded in place for terminating the ground lug. Securely fasten the connection to the pole base
(4) Provide a 6 AWG solid bare grounding jumper and terminate one end to the Equipment grounding conductor splice. Terminate the other end of the jumper to the pole base 5/16 inch grounding stud by using a NRTL listed re-usable screw type active clamping ground lug with a tang that connects to the 5/16 inch or 1/2 inch pole base grounding bolt
(5) Tighten the entire assembly (shield and the grounding lug) to form an electrically bonded and grounded connection
(6) Apply anti-oxidant joint compound to conductor ends and connectors before terminating and to the entire connection after final connection and assembly

Install the supplemental ground rod electrodes at the locations specified in the Contract.

Provide ground rod electrodes at every other light foundation and at the light foundations located at both ends of a run, unless otherwise specified in the Contract.

Provide a direct grounding connection to a ground rod electrode for main switch cabinets, control cabinets, or service cabinets. For Bridges and buildings, bond each cabinet or metal Structure to the Bridge or building grounding electrode system. Make grounding conductor runs as short as possible.

Apply anti-oxide joint compound on bonding and grounding conductors and connectors before final termination.

P **Service Equipment Installation** **2565.2A**

Q **Existing Materials and Electrical Equipment** **2565.3**

Remove, salvage, reinstall, or stockpile existing Materials and electrical Equipment as specified in the Contract or as directed by the Engineer.

R **Wood Pole Installation** **2565.2A**

S **Lighting Units**

Install components of Lighting Units and include hardware required for a complete Lighting Unit installation.

T **Rodent Intrusion Barrier**

Provide rodent intrusion barrier in accordance with 3836, "Rodent Intrusion Barrier," and install in pole bases using double-nut connections. Fill gaps between the barrier and the rodent intrusion barrier with 100 percent clear silicone sealant.

If using stainless steel woven wire cloth, install as follows:

(1) Insert and wind around the transformer base opening to prevent rodent entry
(2) Cut even and smooth and secure flush with:

   (a) Self-tapping screws to the upper edge of steel transformer base openings, or
   (b) Number 10 round head screw end stainless steel bolts and nuts in each of the 4 equally spaced factory supplied punched holes along the upward lip of the base plate in stainless steel transformer base openings

(3) Ensure the top edge of the woven wire cloth is smooth, flush with the top edge of the base plate, and the bottom edge of the woven wire cloth is tight against the top of the concrete foundation
(4) Overlap the ends of the woven wire cloth at least 2 inches and secure in a manner that prevents movement
(5) Bond the entire woven wire cloth assembly as required by the *National Electrical Code* (*NEC*)

If using rodent intrusion barrier listed on the APL for base plate openings with a 10 inch or 10 3/4 inch diameter, install in accordance with manufacturer's installation instructions.

For aluminum Light Pole bases, fill gaps as a result of using leveling shims that exceed a 1/8 inch between the foundation and the aluminum light pole base with 100 percent clear silicone sealant. Do not completely seal around the perimeter between the foundation and aluminum light base.

U **Available Fault Current Calculations**

Provide available fault current calculations as required by Article 110.24 of the *NEC* and in accordance with 2565.3Z "Available Fault Current Calculations."

2545.4 METHOD OF MEASUREMENT

A **Complete Systems**

The Engineer will measure separate items listed in the Contract for various types of complete electrical systems. The Engineer will measure the separate systems in accordance with the following:

A.1 **Lighting System**

The Engineer will measure each separate Lighting System as a single unit, complete in-place and operating.

A.2 Sign Lighting System

The Engineer will measure each separate sign Lighting System as an integral unit, complete in-place.

A.3 Sign Lighting System Bridge Mounted

The Engineer will measure each separate sign Lighting System Bridge mounted as an integral unit, complete in-place.

A.4 Conduit System

The Engineer will measure each separate Conduit System as an integral unit, complete in-place.

B Electrical System Components

The Engineer will measure separate items listed in the Contract for the various component parts of an electrical system in accordance with the following:

B.1 Lighting Units

The Engineer will separately measure Lighting Units of each type of mounting and luminaire design by the number of units of each type, complete in-place.

B.2 Air Obstruction Light

The Engineer will separately measure Air obstruction lights of each type of mounting and luminaire design by the number of lights of each type, complete in-place.

B.3 Luminaires

The Engineer will separately measure Luminaires of each type and wattage by the number of Luminaires complete in-place.

B.4 Underpass Luminaires

The Engineer will separately measure Underpass luminaries of each design by the number of Underpass lighting luminaires complete in-place.

B.5 Light Foundations

The Engineer will separately measure concrete foundations of each design for Lighting Units as integral units, complete in-place.

B.6 Expansion Fittings

The Engineer will separately measure Expansion fittings of each size for Lighting Units complete in-place.

B.7 Deflection/Expansion Fittings

The Engineer will separately measure Deflection/expansion fittings of each size for Lighting Units complete in-place.

B.8 Service Cabinets

The Engineer will separately measure Service cabinets of each type by the number of cabinets, complete in-place.

B.9 Wood Poles

The Engineer will separately measure Wood poles by the number of Wood poles complete in-place.

B.10 Underground Cable Splice

The Engineer will separately measure Underground cable splices by the number of splices complete and in-place.

B.11 Service Equipment

The Engineer will separately measure Service Equipment by the number of Service Equipment complete and in-place and fully operational.

B.12 Equipment Pads

The Engineer will separately measure Equipment pads of each type by the number of Equipment pads complete in-place.

B.13 Junction Boxes

The Engineer will measure Junction boxes by the number of Junction boxes complete in-place.

B.14 Handholes

The Engineer will separately measure Handholes of each design by the number of Handholes complete in-place.

B.15 Pulling Vaults

The Engineer will separately measure Pulling vaults by the number of Pulling vaults complete in-place.

B.16 Grounding Electrode

The Engineer will separately measure Grounding electrodes by the number of Grounding electrodes complete in-place.

B.17 Conduit

The Engineer will separately measure conduit of each kind and diameter by the length between end terminals along the centerline of the conduit as installed.

B.18 Underground Wire

The Engineer will separately measure Underground wire of each kind and size by the length between end terminals along the centerline of the wire as installed.

B.19 Direct Buried Lighting Cable

The Engineer will separately measure Direct buried lighting cable of each kind and size by the length between end terminals along the centerline of the cable as installed.

B.20 Overhead Light Cable

The Engineer will separately measure Overhead light cable of each kind and size by the length between end terminals along the centerline of the wire as installed.

2545.5 BASIS OF PAYMENT

The Contract Unit Price for Lighting Systems, sign Lighting Systems, sign Lighting System Bridge is full compensation for the cost of furnishing and installing the complete system as required by the Contract.

The Contract Unit Price for conduit system includes conduit, trenching, augering, conduit sleeves, couplings, weatherheads, elbows, bushings, application of ferrous metal electrically conductive compound to threaded portions of the conduit, sealing around the conduit where it enters a pull box, sealing conduit ends in concrete foundations and in pull boxes, grounding and bonding of conduit, backfilling and restoring sod, Sidewalks, pavements, and other miscellaneous items required for a complete installation of the conduit.

The Contract Unit Price for Lighting Units includes the luminaire, pole base, pole and bracket, inline fuse, wiring between pole base and luminaire, luminaire wire holder, splice to power circuit, numbering of the Light Pole, luminaire labeling, rodent intrusion barrier, and other miscellaneous items required for a complete installation of the Lighting Unit.

The Contract Unit Price for Air obstruction lights includes the light, mounting bracket (if required), wiring between pole base and luminaire, splice to power circuit, luminaire labeling, and other miscellaneous items required for a complete installation of the Air obstruction light.

The Contract Unit Price for Luminaires includes the complete Luminaire assembly, mounting, mounting hardware, wiring, connections, numbering of the Luminaire if not installed on a Light Pole, and other miscellaneous items required for a complete installation of the Luminaire.

The Contract Unit Price for Underpass luminaries includes the complete Underpass luminaire assembly, mounting, mounting hardware, wiring, connections, luminaire labeling, and miscellaneous items required for the complete installation of Underpass luminaires.

The Contract Unit Price for concrete foundations includes the cost of excavation, concrete, reinforcement, anchor rods, ground rod, ground lead, grounding connections, conduit elbows and bushings, and other miscellaneous items required for a complete installation of the light foundation.

The Contract Unit Price for Expansion fittings includes the Expansion fitting, grounding, connections, hangers, wrapping with sponge rubber, and other miscellaneous items required for a complete installation of an Expansion fitting.

The Contract Unit Price for Deflection/expansion fittings includes the Deflection/expansion fitting, grounding, connections, hangers, wrapping with sponge rubber, and other miscellaneous items required for a complete installation of an Expansion fitting.

The Contract Unit Price for Service cabinets includes the panel board enclosure, circuit breakers, switches, relays, photoelectric control, internal wiring, service entrance circuit, service entrance conduit and weatherhead for wood pole mounted cabinets, mounting hardware, grounding, painting, sealing around cabinet base, numbering of the service cabinet, and miscellaneous items required for a complete installation of the Lighting Service Cabinet.

The Contract Unit Price for Wood poles includes the class of Wood pole, surface restoration, and other miscellaneous items required for the complete installation of Wood poles.

The Contract Unit Price for Underground cable splices includes the splice kits and miscellaneous items required for a complete Underground cable splice.

The Contract Unit Price for Service Equipment includes the meter socket and mounting brackets, conduit and power conductors on Wood pole, wiring connections, ground rod electrode, bonding and grounding Materials and connections, and Incidental items required to complete meter socket installation.

The Contract Unit Price for Equipment pads includes the excavation, concrete, reinforcement, anchoring hardware within the pad, conduits within the pad, ground rods, grounding connections, mounting brackets, mounting hardware, surface restoration, and miscellaneous items required for the complete Equipment pad installation.

The Contract Unit Price for Junction boxes includes the Junction boxes, bushings, covers, gaskets, and miscellaneous items required for the complete installation of Junction boxes.

The Contract Unit Price for Handholes includes the Handhole, frame and cover, excavation, Aggregate drain bed, backfilling, sealing conduit entrances, surface restoration, and miscellaneous items required for the complete installation of Handholes.

The Contract Unit Price for Pulling vaults includes the Pulling vault and cover, excavation, Aggregate drain bed, backfilling, sealing conduit entrances, surface restoration, and miscellaneous items required for the complete installation of Pulling vaults.

The Contract Unit Price for Grounding electrode includes Grounding electrode and splicing of grounding conductors to the Grounding electrode and miscellaneous items required for a complete bonded and grounded electrical system.

The Contract Unit Price for conduit includes the conduit, conduit sleeves, couplings, elbows, bushings, sealing around the conduit where it enters a pull box, grounding and bonding, and other miscellaneous items required for a complete installation of the conduit.

The Contract Unit Price for Underground wire includes the wire, pulling, splicing, terminals, making required connections, testing, and other miscellaneous items required for complete installation of Underground wire.

The Contract Unit Price for Direct buried lighting cable includes the cable, trenching, shield bonding, connections, fittings, fastenings, hangers, backfilling and surface restoration, testing, and other miscellaneous items required for a complete installation of the Direct buried lighting cable.

The Contract Unit Price for Overhead light cable includes the cable, grounding of the messenger wire, connections, fastenings, hangers, testing, and other miscellaneous items required for a complete installation of Overhead light cable.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Lighting Systems. The amounts of these adjustments are deemed reasonable.

Submit a Unit Price of at least $1.00 per linear foot for Remove Direct Buried Lighting Cable. If the submitted Unit Price is less than $1.00 per linear foot for Remove direct buried lighting cable, the Department may assess a monetary deduction of $1.99 per linear foot for each foot of abandoned, out of service, no longer in use cable that was not able to be removed and the Engineer allowed to remain in-place.

B Schedule

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

Item No	Item	Unit
2545.501	Lighting System	lump sum
2545.501	Conduit System ____	lump sum
2545.502	Lighting Unit Type ___	each
2545.502	Air Obstruction Light	each
2545.502	Luminaire (____)	each
2545.502	Underpass Luminaires Type ___	each
2545.502	Light Foundation Design ___	each
2545.502	___" Expansion Fitting	each
2545.502	___" Deflection/Expansion Fitting	each
2545.502	Service Cabinet - Type ___	each
2545.502	___' Wood Pole, Class ___	each
2545.502	Underground Cable Splice	each
2545.502	Service Equipment	each
2545.502	Equipment Pad ____	each
2545.502	Junction Box	each
2545.502	Handhole	each
2545.502	Pulling Vaults	each
2545.502	Grounding Electrode	each
2545.503	___" Rigid Steel Conduit	linear foot
2545.503	___" Non-Metallic Conduit	linear foot
2545.503	___" Intermediate Metal Conduit	linear foot
2545.503	___" Non-Metallic Conduit	linear foot
2545.503	___" Flexible Non-Metallic Conduit	linear foot
2545.503	Underground Wire ___/C __ AWG	linear foot
2545.503	Direct Buried Lighting Cable ___ Cond ___ AWG	linear foot
2545.503	Overhead Lighting Cable ___/C ___ AWG	linear foot
2545.516	Sign Lighting System	system
2545.516	Sign Lighting System Bridge Mounted	system

2550 TRAFFIC MANAGEMENT SYSTEM

2550.1 DESCRIPTION

This Work consists of providing and installing Intelligent Transportation System (ITS) and Traffic Management System (TMS) components, including electrical service, for communications, traffic control, surveillance, and motorist information.

A Acronyms

For the purpose of the Work specified in section 2550, "Traffic Management System," and 2565, "Traffic Control Signals," acronyms in Table 2550.1-1 represent the full text shown in the table.

Table 2550.1-1
Acronyms Used

Acronym or Short Form	Full Name or Meaning
BD-4	TWP (Twisted Pair) Distribution Pedestal (Splice Cabinet)
BD-7	TWP (Twisted Pair) Distribution Pedestal (Splice Cabinet)
DMS	Dynamic Message Sign
FC-PC	Field Connector-Physical Contact
FDF	Fiber Distribution Frame
FNMC	Flexible Non-metallic Conduit
FO	Fiber Optic
FOTP	Fiber Optic Test Procedure
JB	Junction Box
LC	Lucent Connector
LCS	Lane Control Signal
LTU	Line Terminal Unit
MIL	Military
MM	Multimode
NESC	National Electric Safety Code
NID	Non Intrusive Detection
OTDR	Optical Time Domain Reflectometer
PTZ	Pan Tilt and Zoom
PV	Pull Vault
RCS	Ramp Control Signal
RTMC	Regional Traffic Management Center
RUS	Rural Utilities Service
SGU	Sheath Grounding Unit
SNR	Signal to Noise Ratio
SS	Stainless Steel
STP	Shielded Twisted Pair
SM	Single mode
ST	Straight Tip
TIA	Telecommunication Industry Association
TWP	Twisted Wire Pair
XLP	Crosslinked Polyethylene
ZDW	Zero Dispersion Wavelength

2550.2 MATERIALS

A General

Provide Materials and Equipment and perform Work meeting the requirements of the National Electrical Manufacturers Association, the Electronic Industries Association, NRTL, NEC, NESC, local codes and ordinances, these Specifications, and as required by the Contract.

Warranty all furnish and install Materials, furnish and install workmanship, and workmanship on Materials that are paid for as an install item for a minimum of 6 months after 1516.2, “Project Acceptance.” Specific items within these Specifications may require longer warranty periods. Provide Department with all required pass through manufacturer warranty claim information.

B Conduit

2550.3 CONSTRUCTION REQUIREMENTS

Before starting Work, submit a written statement that identifies all Subcontractors performing the Work contained in 2550, “Traffic Management System.”

A Cable Installation

A.1 Cable Installed In Conduit

If pulling cable into conduit by hand or machine, use a limiting device to prevent exceeding the pulling tension specified by the manufacturer.

If pulling cable, apply a Material compatible, industry accepted lubricant to the cables to reduce pulling tension. Install each cable with slack in accordance with the manufacturer’s recommendations to prevent disconnection or damage from contraction. Do not use damaged cable. Remove abandoned cables from each conduit. Ensure the operating TMS remains active while removing the cables.

A.2 Copper Cable Installation

Repair Contractor damaged TMS cable as approved by the Engineer.

Do not use buried splices.

Splice telephone cables in BD-4 and BD-7 cabinets with a weather resistant, crimp connector designed to splice three No. 19 conductors.

A.3 Fiber Optic Cable Installation

Use manufacturer-recommended Equipment to ensure the cable is not damaged by exceeding the maximum tensile strength and violating the minimum bend radius. Make continuous and steady cable pulls between pull points.

Complete direction changes of fiber optic cable before entering a HH/PV or other conduit access point. Do not pull fiber optic cables through HH/PV. This applies to both the horizontal and vertical directions.

Install fiber optic cable in orange colored split conduit through the HH/PV. Extend the conduit 2 inches beyond the wall of each HH/PV and seal the conduit to the HH/PV with duct seal.

Splice optical fibers only in outdoor fiber splice enclosures and fiber splice panels. Do not splice between cabinets and splice vaults.

Continuously monitor the tensile load on the cable.

The transition from 1 elevation to another shall not exceed 1 foot vertical per 5 foot horizontal if installing fiber optic cable in existing conduits in HH/PV. Reinstall existing conduits if necessary to provide the transition for the cable installation, at no additional cost to the Department.

B Cabinet Installation

B.1 Two Working Days' Notice
Notify the Engineer two Working Days before removing an active cabinet from service.

B.2 Secure and Seal
Secure the cabinets to the concrete foundation with anchor rods, nuts, and washers.

Seal the cabinet base to the foundation with a 1/4 inch by 2 inches, 1 piece neoprene gasket.

B.3 Conduit
Install conduits at the center of the cabinet base and extend 3.15 inches above the foundation.

C Dynamic Message Signs (DMS)
Provide Dynamic Message Sign (DMS) Structures and mounting hardware in accordance with 2564, "Traffic Signs and Devices."

Ensure that the installation of DMS electrical Equipment located on the sign Structure does not protrude over the walkway, or interfere with moving the walkway safety rail or with opening the sign door.

Install the 120/240 VAC to the sign within 7 Calendar Days after installation of the DMS to enable operating the ventilation units.

D LCS
Provide LCS mounting hardware in accordance with 2564, "Traffic Signs and Devices."

E Restore Shrubs and Bushes
Restore shrubs and bushes damaged by Contractor Activities in accordance with 1712, "Protection and Restoration of Property."

F Handhole/Pole Vault (HH/PV)
Make openings in the side of HH/PV water tight with a compound that is compatible for adherence to both the PVC HH/PV and the conduit Material.

Fill HH/PV abandoned in sodded areas, with tamped granular Material in accordance with 3149.2E, “Aggregate Backfill.”

Secure the Department-provided HH/PV locator ball to an eye bolt with a 1/4 inch wide wire wrap. Locate the Department-provided HH/PV locator ball within 1 foot of the HH/PV cover.

G RCS

Cover each installed RCS until starting the system operational test.

H Conduit

Install conduit in accordance with 2565.3D, “Conduit, Fittings, and Junction Box Installation” and the following:

H.1 Conduit on Bridges

Provide and install deflecting expansion joints meeting *NEC* requirements.

H.2 Factory Bends

Factory bends in conduit 3 inches in diameter or greater require a minimum bend radius of 36 inches.

H.3 Bored Conduit and Non-Metallic Conduit

Place all conduit under Roadways continuous without joints.

I Foundation Locations

The Engineer will stake the actual locations of the foundations, outside the clear zone, and as far from the paved portion of the Roadways as practical.

J Bonding and Grounding.. 2565.3H

Include ground(s) rod with each foundation.

J.1 Ground Cable

Wrap ground cable with green electrical tape in cabinets and HH/PV through which the cable passes.

J.2 Shield Continuity

Maintain the electrical continuity of the cable shields while terminating and splicing cables. Install shield bonding meeting the requirements of RUS splicing Standard PC-2, Section 3.3. Provide bonding connectors meeting the requirements of RUS Specification PE-33 for Cable Shield Connectors. Bond and ground the cable sheaths to a 15 feet by 5/8 inch diameter ground rod.

K Loop Detector Installation

Install loop detectors as required by the Contract and as follows:

K.1 Loop Detector Conductors

End loop detector conductors in the near HH/PV. Splice the conductors to the lead-in cable with a soldered butt splice. Wrap the splice with one wrap of electrical tape before placing into the splice encapsulator device.

L Fiber Optic System

L.1 Outdoor Fiber Splice Enclosure

Bond each outdoor fiber splice enclosure to the cable armor with a cable clamp and to the closest ground rod with a 1/C No. 6 ground wire and clamp. Provide outdoor fiber splice enclosures with non-oxidizing coating on the connections.

L.2 Fiber Splice, Patch, Splice/Patch Panel

Mount the fiber splice, patch, splice/patch panel as required by the Contract. Secure the fiber optic cables and pigtails to the splice, patch, splice/patch panel. Ground the shields by bonding them to the splice, patch, splice/patch panel ground lug.

L.3 Fiber Optic Splice Vault

Place the fiber optic splice vault on 12 inches of filter Aggregate in accordance with 3149.2H, "Coarse Filter Aggregate." Seal and flash test the vault as recommended by the manufacturer.

Coil 75 foot of cable for each entrance and exit in each vault containing splices.

M CCTV Hardware

Orient the lightning rod away from the Road at approximately 90 degrees to centerline.

2550.4 METHOD OF MEASUREMENT

The Engineer will only measure items for payment that are completed and accepted.

A Traffic Management System Components

The Engineer will measure the various system components by the units of measure required by the Contract.

2550.5 BASIS OF PAYMENT

The Department will:

(1) Retain 10 percent of the amounts payable on each partial estimate, in accordance with 1906, "Partial Payments"
(2) Pay for Material on hand
(3) Pay the remaining percentage retained upon completion of the Work as approved by the Engineer

The Contract Unit Price for ___ Foundation includes the cost of providing the Material and providing and installing the Foundation required by the Contract.

For cabinet foundations included as part of a larger pad, the cabinet foundation includes the concrete and conduit under and adjacent to the cabinet.

For service foundations included as part of a larger pad, the service foundation includes the concrete, conduit, and conductors under and adjacent to the service Equipment.

The Contract Unit Prices for TMS Contract Pay Items include the cost of providing and installing each item.

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

Item No.	Item	Unit
2550.502	___ Foundation	each
2550.502	Handhole Type ___	each
2550.502	Junction Box	each
2550.502	Fiber Optic Splice Vault	each
2550.502	Outdoor Fiber Splice Enclosure	each
2550.502	Buried Cable Sign	each
2550.502	Armored Fiber Optic Pigtail	each
2550.502	Loop Detector Splice	each
2550.502	Ramp Control Signal Design ___	each
2550.502	Flasher Signal	each
2550.502	Lane Control Signal	each
2550.502	___ Cabinet	each
2550.502	Service ___	each
2550.503	___" Bored Conduit	linear foot
2550.503	___" Rigid Steel Conduit	linear foot
2550.503	___" Non Metallic Conduit	linear foot
2550.503	___ Cable ___ Pr. No. ___	linear foot
2550.503	___ Cable ___ Conductor No. ___	linear foot
2550.503	___ Cable ___	linear foot
2550.503	Fiber Optic Trunk Cable ___ MM ___ SM	linear foot

2554 TRAFFIC BARRIERS

2554.1 DESCRIPTION

This Work consists of installing guardrail, barrier, end treatments, transitions, and other devices that protect or prohibit traffic at the locations shown on the Plans or as directed by the Engineer. This Work also consists of installing posts and guide posts, and resetting existing barriers.

2554.2 MATERIALS

A Metal Posts **3401**
Flanged Channel Sign Post

B Wood Posts **3412**

C Wire Rope **3381**

D Steel Beams

Provide W-beam, thrie-beam rail elements, posts, blockouts, soil plates, reducer sections, and end treatments meeting the requirements of *A Guide to Standardized Highway Barrier Hardware*, published by AASHTO, ARTBA, and AGC.

D.1 Steel Plate Beams **3382**

D.2 Rub Rail **3306**

E Hardware and Fittings .... **3381 & 3382**

F Paints

Provide paints as required by the Contract.

G Concrete 2461

Provide concrete for anchor blocks and bearing blocks with a compressive strength of at least 2,750 psi within 14 Calendar Days. The Department does not require air entrainment.

H Anchorage Rods... 3385

Anchorage assemblies consist of the anchor and the fittings required to connect the anchor to the end post.

2554.3 CONSTRUCTION REQUIREMENTS

A Excavation and Foundations

The Contractor may dig post holes by hand or by using mechanical methods. Excavate to the depth necessary to place the rail elements at the specified height above the ground surface and meeting the requirements for post top and side alignment as shown on the Plans. In excavating for anchorages, ensure that anchorages bear on firm, undisturbed earth at the depth shown on the Plans.

Use the natural soil at the bottom of the excavation as the foundation of line, guide, and permanent barricade posts. Tamp the natural soil at the bottom of the excavation to provide firm bearing. Found end posts and posts at intermediate guardrail anchorages on concrete bearing blocks. Provide concrete bearing blocks in the dimensions shown on the Plans. Firmly install concrete bearing blocks on a foundation prepared as required by the Contract.

B Installing Posts

Install posts of the size and type shown on the Plans, at the intervals shown on the Plans, and to the staked lines. Install posts with post tops within 3/8 inch of the elevation and grade shown on the Plans.

Provide flanged channel steel Type B guide posts as Culvert markers weighing 2 pounds per foot in the lengths specified in 3401, “Flanged Channel Sign Posts.” Install Type B guide posts as shown on the Plans.

Mechanically drive posts, unless precluded by the Plans or Engineer, without damaging the posts.

Install and consolidate backfill Materials specified on the Plans, to maintain the post plumb and in the correct position.

C Installing Barriers

Install traffic barriers as shown in the Plans. Install proprietary barrier items as specified by the manufacturer.

Drill holes in wood posts with the same diameter as the bolts or fittings used. In metal posts, drill holes for bolts or other fittings with a diameter no greater than 1/16 inch of the diameter of the bolt or fitting. Apply 2 coats of copper naphthenate or another preservative Material meeting the requirements of *AWPA M4* to field cuts in treated wood. Allow the first coat to dry for at least 2 hours before applying the second coat. The Contractor may leave field bored holes untreated.

Provide bolts no longer than necessary to allow full nut contact after tightening at the overall Nominal depth of the assembled parts, plus reasonable allowance as required by the manufacturer for oversize components. Do not allow bolt ends to project beyond the rail contact face. The Contractor may cut off the excess length of bolt to within 9/16 inch of the nut head.

C.1 Wire Rope (Cable Guardrail) Installations

Except where cable clips are allowed by the manufacturer, wire wrap free ends of wire rope to prevent unraveling.

At intermediate anchorages, space the cables to prevent contact between the separate cables.

Install proprietary high-tension cable barriers as specified by the manufacturer.

C.2 Steel Plate Beam Barriers

Provide steel plate beam barriers including W-beam guardrail and Thrie-beam guardrail.

If offset blocks are required by the Plans or the manufacturer, provide blocks made from treated timber or other Material as listed on the *Approved/Qualified Products List*. Treat field cuts on treated wood in accordance with 2554.3C, "Installing Barriers."

Install rail and end sections to overlap the adjacent section in the direction of traffic. Install guardrail panels at the height shown in the Plans with a tolerance of 2 inches above and 1 inch below the Nominal height specified.

Install end treatments as shown on the Plans and as staked in the field. Install proprietary end treatments as specified by the manufacturer.

Install the guardrail end treatments and the guardrail concurrently.

D Painting and Field Repairs

Apply 2 coats of paint as shown on the Plans and in accordance with 2479, "Inorganic Zinc-Rich Paint System," to steel above ground and not coated in accordance with 3406, "Structural Metal Fence Posts." Perform other field repairs as recommended by the manufacturer.

E Disposal of Surplus Excavated Material

Dispose of surplus excavated Material at no additional cost to the Department and as approved by the Engineer.

2554.4 METHOD OF MEASUREMENT

A Traffic Barriers

The Engineer will measure traffic barriers of each design by length, to the nearest 1 foot. The Engineer will measure between the centers of end posts in each continuous section, including transitions. The Engineer will not deduct expansion assemblies from the measurement.

B Guide Posts

The Engineer will measure guide posts by the number of posts placed. The Engineer will separately measure each type as shown on the Plans.

C Anchorage Assemblies

The Engineer will measure anchorage assemblies by the number of assemblies installed.

D End Treatments

The Engineer will measure end treatments by the number of units of each type installed complete in-place.

2554.5 BASIS OF PAYMENT

The Contract linear foot price for Traffic barrier, Design ___ includes the cost of providing barrier appurtenances and installing the barrier as shown on the Plans, except the Department will separately pay for anchorage assemblies and end treatments as shown in the Plans.

The Contract each price for End treatment of each type includes the costs of providing and installing steel plate beam rail, posts, anchorage, offset blocks, hardware, and other related Materials.

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

Item No.	Item	Unit
2554.502	Guide Post Type ___	each
2554.502	Install Guide Post Type ___	each
2554.502	Anchorage Assembly -___	each
2554.502	End Treatment-___	each
2554.503	Traffic Barrier Design ___	linear foot
2554.503	Permanent Barricades	linear foot
2554.503	Install Traffic Barrier Design ___	linear foot

2557 FENCING

2557.1 DESCRIPTION

This Work consists of constructing fences.

2557.2 MATERIALS

On Contracts not specifying types of Material for metal fencing products, the Contractor may select the type of Material. Use the same type of metal fence components on the entire Project.

Cap tubular metal posts.

If the Contract requires coated metal posts, use the same coating on posts, post supports, rails, gate frames, expansion sleeves, and other hardware items or fittings in accordance with the following:

(1) Zinc coating with zinc coated fence fabric
(2) Aluminum or zinc coating with aluminum coated steel fabric
(3) Vinyl coating with vinyl coated fence fabric

Provide black vinyl coated posts, hardware, and fabric with a low to medium gloss, unless otherwise shown on the Plans.

Use aluminum alloy posts, rails, frames, and other hardware items with aluminum alloy fence fabric.

A brace assembly consists of a single wood or metal brace, installed as a leg brace or as a horizontal brace between two consecutive posts, including the required brace plate or concrete anchor, post anchorages, and guy wires or truss rods. A brace assembly for a chain link fence consists of two brace bars and a truss rod.

A Fence Wire 3376

B Fence Gates 3379

C Fence Posts

C.1 Rolled Steel Posts 3403

C.2 Structural Metal Posts 3406

C.3 Treated Wood Posts 3413

D Hardware and Fittings 3406

E Concrete

Provide concrete in accordance with 2461, “Structural Concrete,” Grade B, Type 3 concrete.

2557.3 CONSTRUCTION REQUIREMENTS

A General

Remove and dispose of Brush, trees, and other obstructions that interfere with construction of the fence in accordance with 1405, “Use of Materials Found on the Project,” 2101, “Clearing and Grubbing,” and 2104.3C, “Removal Operations.” Provide a smooth ground profile at the fence line.

Ensure the bottom of the fence follows the contour of the ground. At small stream crossings, drainage ditches, and other locations where the bottom of the standard size fence cannot conform to the ground contour, construct the fence to span the depression and use extra wire or fabric to close the space below the bottom of the fence, unless otherwise shown on the Plans or directed by the Engineer. Provide and install longer posts with intermediate posts, stakes, braces, extra fabric, or wires to span the depression.

Perform field repairs to fence Materials as recommended by the manufacturer.

B Installing Posts, Rails, and Braces

B.1 General

Set posts plumb, except set posts perpendicular to the slope of the ground at locations as directed by the Engineer.

Install corner posts, pull posts, end posts, and gate posts at locations shown on the Plans or as directed by the Engineer. Provide corner post assemblies at horizontal angle points with deflections greater than 20 degrees. Space pull posts to provide a braced post at points where any of the following occurs:

(1) The vertical alignment deflects by greater than 20 degrees
(2) The post anchorage is necessary to counteract wire uplift
(3) An abrupt grade change on short runs that cannot be avoided by shaping the ground to a uniform contour

When driving fence posts, protect the post tops from damage. Remove and replace posts damaged during installation.

Anchor posts placed on concrete walls, curbs, or other concrete Structures as shown on the Plans.

If placing fence posts in solid rock, set the post at least 12 inch into the rock or with the post bottom at the elevation shown on the Plans, whichever requires the lesser excavation into the rock. Cut the post bottom to provide the height above the ground surface as shown on the Plans. Cut holes in rock to provide a clearance of at least 1 inch around the posts. Fill the holes around the posts with grout consisting of 1 part Portland cement, 2 parts mortar sand, and sufficient water to create the proper consistency. The Contractor may add 0.1 part hydrated lime in the grout.

Place and consolidate concrete around the posts and braces. Allow the concrete to cure for at least 3 Calendar Days before installing the fence wire.

The Contractor may pour the concrete into prebored holes without forming, if no concrete contamination occurs during placement.

Except as otherwise required for posts and braces set in rock or concrete, backfill the annular space around posts set in prebored holes in layers using selected Material from the excavation with each Layer thoroughly compacted to produce a rigid post setting. Use other backfill Material, if required by the Contract.

Dispose of surplus excavated Material in low areas along the fence line or as directed by the Engineer. Neatly finish the adjacent area.

B.2 Metal Post Installations

Set posts for chain-link fabric fencing in concrete as shown on the Plans. The Contractor may drive line posts if the post lengths provide a post embedment of at least 4 feet into the ground.

Drive rolled steel line posts.

The Contractor may provide rolled steel end posts, corner posts, and pull posts, including the required braces, with anchor plates and brace plates. Set the posts in dug holes. The Contractor may omit the anchor and brace plates and set the posts and braces in concrete. Backfill excavations around the posts and braces using the excavated Material. Thoroughly compact the backfill.

Set rolled steel gate posts in concrete.

Provide and install metal post extensions in the lengths directed by the Engineer at the locations shown on the Plans. If post splicing is necessary, use a standard thread and coupling of the same material to thread and join the pipe ends at the splice. Avoid splicing in the exposed upper portion of the post. Provide a suitable plug in the bottom end of each extended post.

B.3 Wood Post Installations

The Contractor may drive posts or set wood posts in prebored holes. Place the larger end of the post in the ground. When driving posts, place the square cut or pointed end in the ground. Except for holes in rock, cut post holes to a diameter providing a clearance of at least 3 inches around the post to allow backfill and compaction.

Provide wood braces in accordance with 3413, “Wood Fence Posts (Treated).” Provide wood braces with diameters at the small end equal to the minimum permissible diameter as shown on the Plans. Ensure the diameter at the small end does not exceed the top diameter of the smaller adjacent post.

C Installing Fence Wire

Install and pull tight the fence wire as recommended by the manufacturer.

C.1 Chain Link Fabric

Place chain link fabric in continuous runs between corner, end, and gate posts. Install the fabric on the side of line posts that face away from the main road except as otherwise directed by the Engineer. Ensure impacts from snow plowing stress the posts rather than the fasteners.

At ends of chain link fabric, thread a stretcher bar through the fabric loops and use clamps to fasten the bar to the posts as shown on the Plans.

Weave pre-bent wire of the same kind as the fabric to make splices in the chain link fabric.

C.2 Barbed Wire and Woven Wire

Unless otherwise directed by the Engineer, place barbed wire and woven wire installed on tangent alignment or on curves no greater than 1 degree on the side of line posts that faces away from the main Road. If placing the fence on horizontal curves greater than 1 degree, place the wire on the side of line posts on the outside of the curve. Offset posts at corners to the inside so that the wire will bear against the post.

Fasten fence wire to end, corner, gate, or pull posts before fastening to intermediate line posts. Stretch woven wire to make longitudinal wires taut and to remove 30 percent of the factory fabricated fence crimp.

When required by the Plans, cut and splice woven wire at the pull posts to obtain and maintain uniform tension in horizontal wires. The Contractor may use a wire crimping tool to increase the number or depth of tension curves to maintain tension in horizontal wires.

Use wire clips or clamps in accordance with 3376, “Fence Wire,” to fasten wires to metal line posts. Use galvanized staples to fasten wires to wood posts. Where the wire loops around end, corner, or pull posts, wrap the wire around the post at least 4 complete turns.

Use U-shaped wire staples at least 1 3/4 inches long in pine posts and at least 2 inches long in cedar posts. The Contractor may use L-shaped staples with serrated, barbed or ring shanks at least 1 inch long.

Diagonally drive U-shaped staples across the wood grain to prevent both points from entering between the same grain. Slope staples upward, against the pull of the wire, in depressions with wire up-lift. Slope staples downward on level ground and over knolls. Staple the wires at corner, end, and pull posts. On line posts, drive the staples to the point that allows movement of the wire. Do not damage the wire while driving the staples.

To splice wire between posts, use an approved splicing sleeve as indicated in 3376, “Fence Wire,” or wrap each wire end around the other wire from 4 turns to 6 turns to form a lasting connection. Use a splicing tool in place of hand wrapping to obtain uniformly tight wraps as directed by the Engineer.

If using splicing sleeves on woven wire, maintain the same horizontal distance between vertical wires as in the fabricated wire. If using the wrap method to splice woven wire, allow the 2 end stay wires to abut each other and enclose the wires within the wrap.

D Installing Gates

Install gates designed to allow locking with a Department-provided padlock and equipped with a padlock keeper at the locations shown on the Plans.

E Electrical Grounds

Install electrical grounds consisting of copper coated steel rods with a Nominal diameter of at least 5/8 inch and a length of at least 8 feet along each fence line at the staked locations.

Drive ground rods to an elevation flush with the ground surface at points directly below or adjacent to the fence wire. Connect each ground rod to the fence with a solid No. 6 copper wire. Use approved type metal clamps as indicated in 3376, “Fence Wire,” to attach the ground wire to the ground rod and to the fence wires to electrically ground each longitudinal fence wire. The Department will not require greater than one connection on woven wire and chain link fabric near the bottom at each ground rod.

Install electrical grounds in any of the following locations:

(1) On each fence line at the point of crossing beneath an electric power line
(2) Two grounds at each pedestrian gate, 1 on each side of the gate opening, as close to the gate posts as practicable
(3) Additional grounds on each fence line to maintain spacing between grounds of 1,500 feet on fences with metal posts and 1,000 feet on fences with wood posts
(4) At least 1 electrical ground on each separate section of fence. For the purposes of the Work specified in 2557, "Fencing," The Department defines a separate section of fence as a run with unbroken electrical continuity
(5) On each separate section of fence, uniformly space electrical grounds and locate a ground within a distance from each end no greater than half of the desired maximum spacing interval

2557.4 METHOD OF MEASUREMENT

A Wire Fence

The Engineer will separately measure fence of each design by length along the bottom of the fence, from center to center of end posts, excluding the lengths of gates as measured between gate posts.

B Brace Assemblies

The Engineer will separately measure wood or metal brace assemblies by the number of each kind constructed complete-in-place, regardless of length, design, or anchorage.

C Electrical Grounds

The Engineer will measure electrical grounds by the number of ground rods and connections provided and installed complete-in-place.

D Gates

The Engineer will measure gates by the number of individual units constructed complete-in-place.

E Metal Post Extensions

The Engineer will measure metal post extensions by length of extensions, based on the difference between the standard driven post length and the actual post length as installed.

2557.5 BASIS OF PAYMENT

The Contract each price for Metal brace assembly includes the cost of the brace plate or concrete anchor, post anchorages, and guy wires or truss rods.

The Contract each price for Electrical ground includes the cost of the ground wire and connectors.

The Department will include the cost of removing and disposing of Brush, tree, and obstructions with relevant Contract Unit Prices for fence construction, unless the Contract provides specific Pay Items for the Work. The Department will include the cost of providing and installing longer fence posts, intermediate posts, stakes, braces, extra fabric, or wires as required with relevant Contract Unit Prices for fence construction, unless the Contract includes specific Contract Pay Items for the Work.

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

Item No.	Item	Unit
2557.502	Pedestrian Gate	each
2557.502	Vehicular Gate-___	each
2557.502	Wood Brace Assembly	each
2557.502	Metal Brace Assembly-___	each
2557.502	Metal Brace Assembly (Chain Link Fence)	each
2557.502	Electrical Ground	each
2557.503	Wire Fence Design___	linear foot
2557.503	Metal Post Extensions	linear foot

2564 TRAFFIC SIGNS AND DEVICES

2564.1 DESCRIPTION

This Work consists of fabricating, providing, and installing traffic signs and devices.

A Definitions

For the purpose of the Work specified in section 2564, "Traffic Signs and Devices," the Department defines:

Extruded Panel
Aluminum extrusions bolted together to support the Sign Panel on larger sign Structures.

Mounting Hardware
Rivets, bolts, washers, nuts, and/or banding for attaching Sign Panels to Extruded Panels or Structures. Also clips for attaching Extruded Panels to sign Structures.

Sign Panel
Sheet aluminum with sign legend sheeting.

Sign Panel Overlay
Replacement of Sign Panel on existing Extruded Panels.

Sign Type A
Large ground mounted sign installed on wide flange steel posts.

Sign Type C
Primarily regulatory, warning, or route marker signs with or without plaques.

Sign Type D
Smaller guide, guide, destination, or informational signs.

Sign Type EA
Exit panels mounted on sign type A.

Sign Type EO
Exit panels mounted on overhead signs.

Sign Type OH
Sign mounted on large sign Structure in which the sign is over the Roadway.

2564.2 MATERIALS

2564.3 CONSTRUCTION REQUIREMENTS

A General

Fabricate and install traffic signs and devices in accordance with the *MN MUTCD* and the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Sign locations and sign Structure post lengths indicated in the Contract are approximate. Locate and stake final sign locations and obtain approval of locations by the Engineer. Determine the final post lengths for signs in accordance with the offsets, mounting heights, and clearances detailed in the Contract and field verification of the proposed or in-place ground slopes. Provide shop drawings for Type A and Type OH Sign Structures.

When repairing signs with legends that are pertinent to traffic, do not extend the down-time for the sign beyond the 8-hour period from 8:00 a.m. to 4:00 p.m., unless providing a replacement sign at no additional cost to the Department.

When the legend on a Sign Panel is not pertinent to existing traffic, delay installation of the Sign Panel until the legend becomes pertinent or install the sign and place an effective cover over the non-pertinent legend. Covered legend shall be uncovered when legend becomes pertinent. Provide opaque covers that do not hold moisture against the sign face. The Department does not approve burlap as an effective cover for retroreflective signs. There is no additional cost to the Department for the Contractor to cover, maintain, and uncover legends on Sign Panels.

Replace topsoil, sodded, and seeded areas disturbed by the Work and dispose of excess excavated Materials as approved by the Engineer.

A.1 Sign Fabrication

Fabricate Sign Panels in accordance with 3352 “Signs.”

Use sheet aluminum for Sign Panels, except use non-reflectorized lexon-black, flexible plastic sign-base Material for cylinder-style delineators.

Provide extruded aluminum in accordance with 3352.2A.2, “Extruded Aluminum, Bolted Type,” mount Sign Panel to extruded aluminum with 3/16 inch stainless steel pull-through rivets as fasteners to attach the Sign Panel to the Extruded Panel. Tightly butt the Sign Panel sections vertically and rivet to the Extruded Panel on centers no greater than 12 inches vertically and horizontally. Rivet the edges and corners of each sheet. Do not place rivets within 1 inch of the Extruded Panel joints. Sign Panel must be flat after attaching to Extruded Panels.

Provide yellow warning signs, yellow markers, yellow delineators, yellow background on Sign Panel Type Overlays, and the yellow background on Type A and Type OH Sign Panels with fluorescent yellow retroreflective sheeting.

Provide non-reflectorized black sign face Material and fluorescent yellow retroreflective sheeting for sign legend for OM1-2 Type 1 Object Markers.

Provide non-reflectorized black sign face Material and red retroreflective sheeting for sign legend for OM4-2 Type 4 Object Markers.

When warning sign plaques are mounted on the same Structure as a warning sign, match the plaque color and sheeting type with the primary warning sign color and sheeting type.

A.2 Temporary Traffic Control

Provide signs for temporary traffic control meeting the requirements of the *Standard Signs and Markings Manual*, *MN MUTCD*, and the Contract. Provide barricades meeting the requirements of *Standard Plate 8000*.

Install nylon washer spacers between the temporary traffic construction Sign Panels and the in-place Sign Panels.

Install temporary traffic control devices before beginning Work. Maintain temporary traffic control devices while in place and remove them if not required.

A.3 Scheduling of Work

Schedule Work in accordance with the following requirements:

(1) Ensure at least one of the following signs is in service at all times for each exit

- (a) Exit sign in the gore
- (b) Exit direction sign just in advance of the gore

(2) Provide at least one directional sign, either an advance guide sign or an “Exit” directional sign for each exit that is in service at all times

(3) Do not remove sign Structures until approved by the Engineer. The Engineer's approval for removing an existing sign is contingent upon compliance with Items 1 and 2 above and upon completion of a constructed, functional replacement sign

(4) Type C and Type D sign replacements are installed the same Work Day that the in-place signs are removed

B Median Barrier Footing

Excavate for footing and construct footing as shown in the Contract. After footing has cured, backfill to proposed ground elevation. Replace any removed pavement and dispose of excess excavation.

Construct footings as required by the Contract and in accordance with 2401.3, "Concrete Bridge Construction, Construction Requirements."

The Contractor may use undisturbed earth to form concrete placement if the soil is stable enough to allow concrete placement as determined by the Engineer and the Contractor takes precautions to prevent contamination of the concrete.

Provide non-metallic conduit and fittings to connect to the non-metallic conduit in adjacent median barrier as detailed in the Contract.

Provide a surface finish and color that matches the adjacent median barrier.

Install sign posts on concrete footings after the concrete has cured for a minimum of 1 Calendar Day.

C Sign Support – Sign Bridge or Cantilever

Provide and install a sign support as required by the Contract and current *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Excavate for foundation and construct foundation as shown in the Contract and in accordance with 2401.3, "Concrete Bridge Construction, Construction Requirements." After foundation has cured, backfill to proposed ground elevation.

Replace any removed pavement and dispose of excess excavation.

Manufacture, fabricate, and install sign support steel in accordance with 2471, "Structural Metals," and as detailed in the Contract.

Provide shop drawings for the sign support Structure in accordance with 2471.3C, "Shop Drawings."

Provide and install overhead sign identification plate.

D Modify Post

Do not splice Type A sign post sections below the friction fuse.

Extend Type A sign posts or panel mounting posts by bolt splicing as required by the Contract and in accordance with 2471, "Structural Metals."

When shortening posts, dispose of removed sections in accordance with 2104, "Removing Pavement and Miscellaneous Structures." The Contractor may use thermal cutting in accordance with 2471, "Structural Metals."

Galvanize post extensions and repair galvanized areas marred by cutting in accordance with 2471, "Structural Metals."

E Install Delineator or Marker

Install salvaged or Department-provided delineator or marker as required by the Contract.

Provide and install the square tubular or flanged channel sign post and attach the delineator or marker with new Mounting Hardware required by the Contract.

F Install Reference Location Sign

Install salvaged or Department-provided reference locations signs as required by the Contract.

Provide and install the square tubular or flanged channel sign post and attach the reference location sign with new Mounting Hardware required by the Contract.

For reference location signs attached to Type C or Type D sign Structures, install the reference location sign on the left sign post with new Mounting Hardware required by the Contract.

For reference location signs mounted back to back, install a nylon washer against the face of each reference location sign to prevent damage to the sheeting Materials.

G Install Sign Panel

G.1 Type A

Install a salvaged or Department-provided Sign Panel attached to Extruded Panels as required by the Contract.

Use new post clips to attach Extruded Panels to posts.

Torque each post clip to between 12 ft lbf and 14 ft lbf when attaching extruded Sign Panels to posts.

G.2 Type C or D

Install a salvaged or Department-provided Sign Panel as required by the Contract.

Install Type C and Type D Sign Panels with new Mounting Hardware.

G.3 Type OH

Install a salvaged or Department-provided Sign Panel attached to Extruded Panels as required by the Contract.

Use new post clips to attach Extruded Panels to panel mounting posts.

Torque each post clip to between 12 ft lbf and 14 ft lbf when attaching extruded Sign Panels to posts.

Use new sign bracket assemblies as shown on the Plans for Type OH Sign Panels installed on sign supports.

G.4 Type EA or EO

Install a salvaged or Department-provided Sign Panel attached to Extruded Panels as required by the Contract.

Install Type EA and Type EO Sign Panels with new flanged channel or S4 by 7.7 panel mounting posts and post clips.

Torque each post clip to between 12 ft lbf and 14 ft lbf when attaching extruded Sign Panels to posts.

H Install Sign

H.1 Type A

Install Type A signs on new H-pile footings with breakaway supports at the locations required by the Contract.

Install new posts below friction fuses. Install new keeper plates, friction fuses, and hardware.

Install salvaged posts above friction fuses and install salvaged or Department-provided Sign Panels attached to Extruded Panels using new post clips.

Torque each post clip to between 12 ft lbf and 14 ft lbf when attaching Extruded Panels to posts.

Installations shall be in accordance with the Contract and details shown on the Plans. Repair damaged galvanized surfaces in accordance with 2471, "Structural Metals."

H.2 Type C or D

Provide and install a new sign Structure for Type C or Type D signs.

Install salvaged or Department-provided Sign Panels as required by the Contract, using new Mounting Hardware.

H.3 Type EA or EO

Provide new panel mounting posts for Type EA and Type EO Sign Panels, and install salvaged or Department-provided Sign Panels attached to Extruded Panels with new post clips as required by the Contract.

Torque each post clip to between 12 ft lbf and 14 ft lbf when attaching Extruded Panels to posts.

H.4 Type OH

Install salvaged or Department-provided overhead sign Structures on new concrete footings in accordance with the torque requirements specified below under 2564.3S.2, " Posts for OH Signs" and as required by the Contract.

Install salvaged Sign Panels attached to Extruded Panels with new post clips as required by the Contract.

Torque each post clip to between 12 ft lbf and 14 ft lbf when attaching Extruded Panels to posts.

If present, remove old 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).

Dispose of removed items in accordance with 2104, "Removing Pavement and Miscellaneous Structures."

Verify that each locking pin fits in the locking pin hole in the handrail hinge while the handrail is in the raised position.

Drill out the handrail hinge to make a proper fit for locking pins that do not fit.

Repair damaged galvanized surfaces in accordance with 2471.3L.1, "Galvanizing."

H.5 Type OH (Bridge Mount)

Install salvaged or Department-provided Sign Panels attached to Extruded Panels with new post clips on new Bridge mount sign Structures as required by the Contract.

Torque each post clip to between 12 ft lbf and 14 ft lbf when attaching Extruded Panels to posts.

If present, remove old 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).

Dispose of removed items in accordance with 2104, “Removing Pavement and Miscellaneous Structures.”

Verify that each locking pin fits in the locking pin hole in the handrail hinge while the handrail is in the raised position.

Drill out the handrail hinge to make a proper fit for locking pins that do not fit. Repair damaged galvanized surfaces in accordance with 2471.3L.1, “Galvanizing.”

I Overhead Sign Identification Plate

Provide and install an overhead sign identification plate for each overhead sign installed as required by the Contract.

Provide a plate that incorporates the overhead sign number.

For post mounted signs, strap–mount the plate on the overhead sign post as required by the Contract. Install the plate on the right-hand post when looking in the direction of traffic flow. If sign faces both directions of travel on a single Structure, provide and install one plate for each direction of travel. Install the plate 6 feet above the base plate elevation facing traffic.

For Bridge-mounted signs install the plate on a 2 pound per foot flanged channel post in accordance with 3401, “Flanged Channel Sign Posts.” Install the plate and post as close to the Bridge as possible and behind the guardrail. If no guardrail is in place, install the plate and post at least 12 feet outside the edge of Shoulder or face of curb. Install the plate so the bottom is 6 feet above the edge of pavement.

Remove the existing plate (if present) when installing new overhead sign identification plates on existing overhead sign Structures.

J Extend Walkway Support

Extend each walkway support on existing Type OH sign Structures as required by the Contract. Galvanize support extensions and repair galvanized areas marred by cutting or welding in accordance with 2471, “Structural Metals.”

K Friction Fuse

Provide and install a friction fuse on each existing Type A sign post as required by the Contract and the following:

(1) Remove the in-place friction fuse, consisting of a friction fuse plate and a hinge plate, and in-place Mounting Hardware, and dispose of these items in accordance with 2104, “Removing Pavement and Miscellaneous Structures”
(2) Provide and install a new friction fuse consisting of a friction fuse plate and a hinge plate. Provide Mounting Hardware as required by the Contract
(3) Repair damaged galvanized surfaces in accordance with 2471.3L.1, “Galvanizing”

L Keeper Plate

Provide and install a keeper plate on each existing Type A sign post as required by the Contract.

Verify sign post dimensions in the field. Immediately before installing keeper plates, clean the base connection plate to remove grit, dirt, and deleterious Material.

Reinstall the post in accordance with base connection bolting procedures shown in the Contract.

Replace missing, damaged, or rusty hardware.

M Delineator

Provide delineator Sign Panel as required by the Contract.

Provide and install the square tubular or flanged channel sign post and attach the Sign Panel with new Mounting Hardware required by the Contract.

N Bridge Number Marker

Provide Bridge number marker Sign Panel as required by the Contract. Provide and install the square tubular or flanged channel sign post and attach the Sign Panel with new Mounting Hardware required by the Contract.

O Infiltration Area Marker

Provide and install a new 3 pounds per foot flanged channel post in accordance with 3401, "Flanged Channel Sign Posts." at the location approved by the Engineer.

Provide and attach the Sign Panel to the flanged channel post with new Mounting Hardware.

P Reference Location Sign

Provide reference location sign as required by the Contract.

Provide and install the square tubular or flanged channel sign post and attach the Sign Panel with new Mounting Hardware required by the Contract.

Affix a Department-provided warning sticker to the backside of each Sign Panel directly above the fabrication sticker. Warning stickers are available at the Department's Transportation District Office specified in the Contract. Provide 30 Calendar Days advance notice before picking up the stickers.

For Sign Panels attached to Type C or Type D sign Structures, install the Sign Panel to the left sign post with new Mounting Hardware.

For Sign Panels mounted back to back, install a nylon washer against the face of each Sign Panel to prevent damage to the sheeting Materials.

Q Object Marker

Provide object marker Sign Panel as required by the Contract.

Provide and install the square tubular or flanged channel sign post and attach the Sign Panel with new Mounting Hardware required by the Contract.

Affix a Department-provided warning sticker to the backside of each Sign Panel directly above the fabrication sticker. Warning stickers are available at the Department's Transportation District Office specified in the Contract. Provide 30 Calendar Days advance notice before picking up the stickers.

R Concrete Footings

R.1 Type A Signs

Provide a rubbed-surface finish on exposed concrete surfaces.

Install sign posts on concrete footings after the concrete has cured for a minimum of 7 Calendar Days.

Construct footings as required by the Contract.

Construct footings in accordance with 2401.3, “Concrete Bridge Construction, Construction Requirements.”

The Contractor may use undisturbed earth to form concrete placement if the soil is stable enough to allow concrete placement as determined by the Engineer and the Contractor takes precautions to prevent contamination of the concrete.

R.2 Type OH Shaft

Provide a rubbed-surface finish on exposed concrete surfaces.

Install sign posts on concrete footings after the concrete has cured for a minimum of 7 Calendar Days.

Construct footings as required by the Contract.

The Contractor may submit an alternate design for approval by the Engineer with the understanding that, if approved, the Department will not adjust the Contract quantities or Unit Prices. If the Engineer approves the alternate design, the Contractor may proceed.

Provide design details for alternate drilled shaft footing designs in accordance with any 1 of the following:

(1) Use a constant diameter shaft at least 6 inches greater than the diagonal dimension of the column base plate. Use the planned longitudinal reinforcement bars without bending. Use either spiral reinforcement or tie bars spaced at 6 inch centers for the full length of the shaft.

(2) Install a horizontal construction joint at the bottom of the tapered section of the shaft about 6 feet below the top. Before placing new concrete above the construction joint, coat the surface of the in-place concrete with a Department-approved bonding agent. Lap vertical reinforcement bars a length equal to 40 times the diameter of the reinforcement bar used.

Construct footings in accordance with 2401.3, “Concrete Bridge Construction, Construction Requirements.”

The Contractor may use undisturbed earth to form concrete placement if the soil is stable enough to allow concrete placement as determined by the Engineer and the Contractor takes precautions to prevent contamination of the concrete.

R.3 Type OH Spread

Provide a rubbed-surface finish on exposed concrete surfaces.

Install sign posts on concrete footings after the concrete has cured for a minimum of 7 Calendar Days.

Construct footings as required by the Contract.

Construct footings in accordance with 2401.3, “Concrete Bridge Construction, Construction Requirements.”

The Contractor may use undisturbed earth to form concrete placement if the soil is stable enough to allow concrete placement as determined by the Engineer and the Contractor takes precautions to prevent contamination of the concrete.

S Structural Steel

S.1 Posts for Type A Signs

Manufacture and fabricate structural steel in accordance with 2471, "Structural Metals," and the following additional requirements.

Provide shop drawings for Type A sign Structures in accordance with 2471.3C, "Shop Drawings."

Provide the riser post, keeper plate, friction fuse, and structural steel posts (H-Pile) as footings for Type A signs in accordance with 2452, "Piling," 2471, "Structural Metals," the Contract, and the following:

(1) Obtain the required bearing capacity in accordance with the Contract and 2452, "Piling"
(2) Splice additional length of H-Pile in accordance with 2452, "Piling," and drive to the bearing capacity required if the driven length of H-Pile specified in the Contract fails to reach bearing capacity
(3) Repair damage to galvanized surfaces in accordance with 2471, "Structural Metals," before back filling

S.2 Posts for OH Signs

Manufacture and fabricate structural steel in accordance with 2471, "Structural Metals," and the following additional requirements.

Provide shop drawings for overhead sign posts in accordance with 2471.3C, "Shop Drawings."

Assemble the posts in the shop before galvanizing. Check posts for straightness, alignment, and dimensions and correct any variations. Galvanize posts in accordance with 3394, "Galvanized Structural Shapes." Galvanize parts and hardware in accordance with 3392, "Galvanized Hardware." Correct warpage from galvanizing before installing structural steel.

Bolt tightening procedure for connecting overhead sign Structures to the concrete foundation:

(1) Verify that the position of the anchor rods and the hole pattern on the baseplate match the Contract.
(2) Verify that the leveling nuts can be turned onto the anchor rods well past the final elevation of the bottom of the leveling nut and backed off by 1 worker using an ordinary wrench without a cheater bar.
(3) Verify that the clearance between the top of the concrete Structure and the bottom of the leveling nut is no more than 1 diameter dimension and no less than 1/2 of the diameter dimension of the anchor bolt or 1 1/4 inch whichever is less.
(4) At the time of installation, clean the anchor rods, washers, and nuts, removing any rust with a steel brush.
(5) Just before installation, lubricate the entire contact surface of the anchor rods, leveling nuts, and washers, along with the faying surface between the nut and the washer. Use Department-approved grease from the *Approved/Qualified Products List* for Bridge products, "Bridge Bearing Lubricant."
(6) Place the leveling nuts on the anchor rods.
(7) Place leveling nut washers on top of the leveling nuts.
(8) Install the post on top of the footings with a crane.

(9) Plumb the post and level the baseplate as detailed in the Contract.

(10) Determine if beveled washers are necessary. Beveled washers are necessary under the leveling or top nut if any face of the base plate has a slope greater than 1:20 or any nut could not be brought into firm contact with the base plate. If any beveled washer is required, the installation crew should disassemble the joint as necessary, add the beveled washer(s), and retighten (in a star pattern) the top and leveling nuts.

(11) Install the top nut washers on the anchor rods.

(12) Lubricate the threads, top of the top washer and bearing surfaces of the top nuts with the same product used in Step 5.

(13) Install the top nuts on the anchor rods and snug tighten in a star pattern. Tighten the leveling nuts to the snug-tight condition in a star pattern. See Table 2564.3-1 for snug tight torques.

(14) Mark the reference position of the bolt, top nut, and baseplate with a permanent marker. See Figure 2564.3-1 for proper match marking (before rotation). Top nuts should be turned in increments (at least 2 full tightening cycles, in a star pattern) to achieve the appropriate nut rotation and required torque listed in Table 2564.3-1. After tightening, verify the nut rotation.

(15) Use a torque wrench to verify that post tightening verification torque values listed in Table 2564.3-1 will not additionally rotate the top nut.

(16) Release the load from the crane.

(17) Use a torque wrench to re-verify that post tightening verification torque values listed in Table 2564.3-1 will not additionally rotate the top nut. If it does, the tightening procedure may not have been followed. The inability to achieve this torque should be interpreted to indicate that the threads have stripped or other fastener problems have occurred and must be reported to the Engineer.

(18) Repeat Steps 15 to 17 between 48 and 96 hours after the original tightening with the torques shown in Table 2564.3-1.

(19) Record all bolt tightening following the above steps in the *High Strength Anchor Rod Installation Record* form, available on the Traffic Engineering website, sign, and submit it to Department.

Table 2564.3-1
Bolt Tightening Requirements

Grade 3385.2, "Anchor Rods, Requirements"	Bolt Diameter (inch)	Snugging Wrench Length (inch)	Snug Torque (foot-pounds)	Verification Torque (foot-pounds)	Rotation After Snug (turn)	Re-tightening Torque (foot-pounds)	Base Plate Thickness (inch)
Type C Grade 105	2 1/4	74	402	2413	1/12	2654	2
Type B Grade 55	2 1/2	53	550	3300	1/12	3630	2

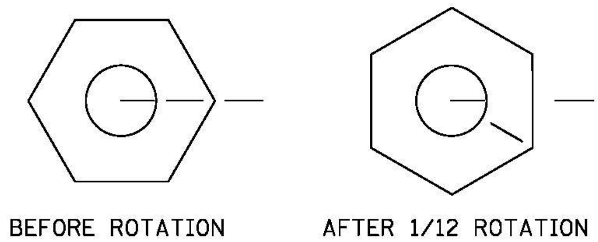


Figure 2564.3-1

Proper before and after markings of turn-of-the-nut tightening.

S.3 Trusses for OH Signs

Manufacture and fabricate structural steel in accordance with 2471, “Structural Metals,” and the following additional requirements.

Provide shop drawings for overhead sign trusses in accordance with 2471.3C, “Shop Drawings.”

Assemble the truss sections in the shop before galvanizing. Check truss sections for straightness, alignment, and dimensions and correct any variations. Galvanize posts in accordance with 3394, “Galvanized Structural Shapes.” Galvanize parts and hardware in accordance with 3392, “Galvanized Hardware.” Correct warpage from galvanizing before installing structural steel.

Ensure main chord angles for overhead sign Structures that are at least 1/2 inch thick, meet a Charpy V-notch impact strength requirement of 15 foot pounds at 40°F.

S.4 Trusses for OH Signs Bridge Mounted

Manufacture and fabricate structural steel in accordance with 2471, “Structural Metals,” and the following additional requirements.

Provide shop drawings for overhead sign Structures in accordance with 2471.3C, “Shop Drawings.”

Assemble the truss sections in the shop before galvanizing. Check truss sections for straightness, alignment and dimensions and correct any variations. Galvanize posts in accordance with 2471, “Galvanized Structural Shapes.” Galvanize parts and hardware in accordance with 2471, “Galvanized Hardware.” Correct warpage from galvanizing before installing structural steel.

Ensure main chord angles for overhead sign Structures that are at least 1/2 inch thick, meet a Charpy V-notch impact strength requirement of 15 foot pounds at 40°F.

S.5 Walkway Supports for OH Signs

Manufacture and fabricate structural steel in accordance with 2471, “Structural Metals,” and the following additional requirements.

Provide shop drawings for overhead sign Structures in accordance with 2471.3C, “Shop Drawings.”

Assemble the walkway sections in the shop before galvanizing. Check walkway sections for straightness, alignment, and dimensions and correct any variations. Galvanize posts in accordance with 3394, “Galvanized Structural Shapes.” Galvanize parts and hardware in accordance with 3392, “Galvanized Hardware.” Correct warpage from galvanizing before installing structural steel.

S.6 Walkway for OH Signs

Manufacture and fabricate structural steel in accordance with 2471, “Structural Metals,” and the following additional requirements.

Provide shop drawings for overhead sign Structures in accordance with 2471.3C, “Shop Drawings.”

S.7 Panel Mounting Posts of OH Signs

Manufacture and fabricate structural steel in accordance with 2471, “Structural Metals,” and the following additional requirements.

Provide shop drawings for overhead sign Structures in accordance with 2471.3C, “Shop Drawings.”

Assemble the panel mounting posts in the shop before galvanizing. Check panel mounting posts for straightness, alignment, and dimensions and correct any variations. Galvanize posts in accordance with 3394, “Galvanized Structural Shapes.” Galvanize parts and hardware in accordance with 3392, “Galvanized Hardware.” Correct warpage from galvanizing before installing structural steel.

T Overhead Sign Structure Repair

Repair an existing overhead sign Structure in accordance with the 2123, “Equipment Rental,” and the following:

Contact the Department's Structural Metals Inspection Unit (DSMIU) to schedule inspection of sign Structures. Perform the inspection before removing the sign Structure from storage, or after salvaging the Structure.

Correct the following conditions, if encountered, as determined by the DSMIU:

(1) Rusted or missing nuts, bolts, or washers
(2) Defective shop and field splices on main chord angles
(3) Missing welds
(4) Cracking welds or structural elements
(5) Section loss on post base plate
(6) Flame gouges on base plate or at bolt holes
(7) Cracks around post handhole
(8) Zinc coating loss or deterioration
(9) Rusting

Perform repairs in accordance with 2471, “Structural Metals.”

Verify that each locking pin fits completely into the locking pin hole in the handrail hinge, while the handrail is in the raised position. For locking pins that do not fit, drill out the handrail hinge to make a proper fit. Repair damage to galvanized surfaces in accordance with 2471.3L.1, “Galvanizing.”

After completing the repairs and before installation, obtain reinspection by the DSMIU.

U Sign Panels

U.1 Type A

Fabricate the Sign Panels in accordance with 3352, “Signs.”

Attach the Sign Panel to the Extruded Panels with stainless steel rivets. Tightly butt the Sign Panels vertically and rivet to the Extruded Panels on 12 inch vertical and horizontal centers. Rivet the edges and corners of each Sign Panel. Do not place rivets within 1 inch of the Extruded Panel joints. Sign Panels must be flat after attaching to Extruded Panels.

Package, deliver, store, and install Sign Panels in accordance with 1607, “Handling Materials,” 3352, “Signs,” and the retroreflective sheeting manufacturer's recommendations.

Attach Extruded Panels to sign posts or panel mounting posts with new post clips and torque each post clip between 12 foot pounds and 14 foot pounds.

U.2 Type C or D

Fabricate the Sign Panels in accordance with 3352, “Signs.”

Package, deliver, store, and install Sign Panels in accordance with 1607, “Handling Materials,” 3352, “Signs,” and the retroreflective sheeting manufacturer's recommendations.

Affix a Department-provided warning sticker to the backside of each sign panel directly above the fabrication sticker. Warning stickers are available at the Department's Transportation District Office specified in the Contract. Give the Transportation District’s contact person 30 Calendar Days advance notice before picking up the stickers.

U.3 Type EA or EO

Fabricate the Sign Panels in accordance with 3352, “Signs.”

Attach the Sign Panel to the Extruded Panels with stainless steel rivets.

Tightly butt the Sign Panels vertically and rivet to the Extruded Panels on 12 inch vertical and horizontal centers. Rivet the edges and corners of each Sign Panel. Do not place rivets within 1 inch of the Extruded Panel joints. Sign Panels must be flat after attaching to Extruded Panels.

Package, deliver, store, and install Sign Panels in accordance with 1607, “Handling Materials,” 3352, “Signs,” and the retroreflective sheeting manufacturer's recommendations.

Provide new flanged channel or S4 by 7.7 panel mounting posts.

Attach Extruded Panels to sign posts or panel mounting posts with new post clips and torque each post clip between 12 foot pounds and 14 foot pounds.

U.4 Type OH

Fabricate the Sign Panels in accordance with 3352, “Signs.”

Attach the Sign Panel to the Extruded Panels with stainless steel rivets.

Tightly butt the Sign Panels vertically and rivet to the Extruded Panels on 12 inch vertical and horizontal centers. Rivet the edges and corners of each Sign Panel. Do not place rivets within 1 inch of the Extruded Panel joints. Sign Panels must be flat after attaching to Extruded Panels.

Package, deliver, store, and install Sign Panels in accordance with 1607, “Handling Materials,” 3352, “Signs,” and the retroreflective sheeting manufacturer's recommendations.

Attach Extruded Panels to sign posts or panel mounting posts with new post clips and torque each post clip between 12 ft lbf and 14 ft lbf.

V Sign Panel Overlay Type A, EA, EO of OH

Fabricate the Sign Panels in accordance with 3352, “Signs.”

Package, deliver, store, and install Sign Panels in accordance with 1607, “Handling Materials,” 3352, “Signs,” and the retroreflective sheeting manufacturer's recommendations.

Remove any in-place Sign Panels on existing Extruded Panels and dispose of them in accordance with 2104, “Removing Pavement and Miscellaneous Structures.”

Install Sign Panel Overlay on existing extruded aluminum panels. Attach the Sign Panel Overlay to the Extruded Panels with 3/16 inch stainless steel rivets.

Tightly butt the Sign Panel Overlays vertically and rivet to the existing Extruded Panels on 12 inch vertical and horizontal centers. Rivet the edges and corners of each Sign Panel Overlay. Do not place rivets within 1 inch of the Extruded Panel joints. Sign Panels must be flat after attaching to Extruded Panels.

Remove in-place post clips and install new post clips. Torque each post clip between 12 ft lbf and 14 ft lbf when attaching Extruded Panels to posts.

2564.4 METHOD OF MEASUREMENT

A Median Barrier Footing

The Engineer will measure Median barrier footing as a complete unit, including excavation, concrete installation, metal reinforcement, anchorage assemblies, conduit, and backfill.

B Sign Support

The Engineer will measure Sign support ____ as a complete unit, including excavation, concrete footings, metal reinforcement, anchorage assemblies, conduit, metal sign Structure, overhead identification plate, and backfill.

C Modify Post

The Engineer will measure Modify post as a complete unit, including removing or adding post length as shown in the Contract.

D Install Delineator

The Engineer will measure Install delineator as a complete unit, including new post and new Mounting Hardware used to install salvaged or Department-provided delineator Sign Panel.

E Install Marker

The Engineer will measure Install marker as a complete unit, including new post and new Mounting Hardware used to install salvaged or Department-provided marker Sign Panel.

F Install Reference Location Sign

The Engineer will measure Reference location sign as a complete unit, including new post and new Mounting Hardware used to install salvaged or Department-provided reference location Sign Panel.

G Install Sign Panel

G.1 Type A

The Engineer will measure Install Sign Panel Type A as a complete unit, including new Mounting Hardware used to install salvaged or Department-provided Sign Panel attached to Extruded Panels.

G.2 Type C or D

The Engineer will measure Install Sign Panel Type C or D as a complete unit, including new Mounting Hardware used to install salvaged or Department-provided Sign Panel.

G.3 Type OH

The Engineer will measure Install Sign Panel Type OH as a complete unit, including new Mounting Hardware used to install salvaged or Department-provided Sign Panel attached to Extruded Panels.

G.4 Type EA or EO

The Engineer will measure Install Sign Panel Type EA or EO as a complete unit, including new Mounting Hardware used to install salvaged or Department-provided Sign Panel attached to Extruded Panels.

H Install Sign

H.1 Type A

The Engineer will measure Install Sign Type A as a complete unit, including installing salvaged or Department-provided Structure and Sign Panel attached to Extruded Panels using new Mounting Hardware.

H.2 Type C or D

The Engineer will measure Install Sign Type C or D as a complete unit, including new post(s), new stringers, and new Mounting Hardware used to install salvaged or Department-provided sign panel(s).

H.3 Type EA or EO

The Engineer will measure Install Sign Type EA or EO as a complete unit, including new panel mounting posts, and installing salvaged or Department-provided Sign Panel attached to Extruded Panels using new Mounting Hardware.

H.4 Type OH

The Engineer will measure Install Sign Type OH as a complete unit, including installing salvaged or Department-provided Structure and Sign Panel attached to Extruded Panels with new Mounting Hardware, new safety chains, components of safety chain snap assemblies, safety rail locking pins, and chains welded to the locking pin heads.

H.5 Type OH (Bridge Mount)

The Engineer will measure Install Sign Type OH (Bridge Mount) as a complete unit, including new Bridge mount Structure, installing salvaged or Department-provided Sign Panel attached to Extruded Panels using new Mounting Hardware, new safety chains, components of safety chain snap assemblies, safety rail locking pins, and chains welded to the locking pin heads.

I Overhead Sign Identification Plate

The Engineer will measure Overhead sign identification plate as a complete unit, including new Mounting Hardware and new Sign Panel.

J Extend Walkway Support

The Engineer will measure Extend walkway support as a complete unit, including adding walkway support extensions as shown in the Contract.

K Friction Fuse

The Engineer will measure Friction fuse as a complete unit, including removing in-place Friction fuse and installing new friction plate, hinge plate, and hardware.

L Keeper Plate

The Engineer will measure Keeper plate as a complete unit, including removing in-place keeper plate and installing new keeper plate.

M Delineator

The Engineer will measure Delineator as a complete unit, including new post, new Mounting Hardware, and new Sign Panel.

N Bridge Number Marker

The Engineer will measure Bridge number marker as a complete unit, including new post, new Mounting Hardware, and new Sign Panel.

O Infiltration Area Marker

The Engineer will measure Infiltration area marker as a complete unit, including new post, new Mounting Hardware, and new Sign Panel.

P Reference Location Sign

The Engineer will measure Reference location sign as a complete unit, including new post, new Mounting Hardware, new Sign Panel, and warning sticker.

Q Object Marker

The Engineer will measure Object marker as a complete unit, including new post, new Mounting Hardware, new Sign Panel, and warning sticker.

R Concrete Footings Type ____

The Engineer will measure Concrete footings type ____ by the cubic yard of concrete based on the dimensions required by the Contract, including footing construction, metal reinforcement, anchorage assemblies, conduit, excavation, and backfill.

S Structural Steel

The Engineer will measure Structural steel items separately by the computed weight of Structural steel incorporated in each item in accordance with the measurement provisions of 2402.4A, “Weight.”

The Engineer will not measure bolts, nuts, rivets, washers, and shims used in the fabrication and erection of signs, and will not apply the provisions of 2402.4A, “Weight,” that provide a percent increase in weight.

S.1 Posts for Type A Signs

The Engineer will measure Structural steel – posts for type A signs by the pound, including providing and erecting posts, keeper plate, friction fuse, and H-piles. The Engineer will base the computed weight on the quantity tables in the Contract.

S.2 Posts for OH signs

The Engineer will measure Structural steel – posts for OH signs by the pound, including providing and erecting posts, truss connection plates, baseplate, overhead sign identification plate, and Lighting System identification plate. The Engineer will base the computed weight on the quantity tables in the Contract.

S.3 Trusses for OH Signs

The Engineer will measure Structural steel – trusses for OH signs by the pound, including providing and erecting truss members. The Engineer will base the computed weight on the quantity tables in the Contract.

S.4 Trusses for OH Signs Bridge Mounted

The Engineer will measure Structural steel – trusses for OH signs Bridge mounted by the pound, including providing and erecting truss members, and fixture mounting channels. The Engineer will base the computed weight on the quantity tables in the Contract.

S.5 Walkway Supports for OH Signs

The Engineer will measure Structural steel – walkway supports for OH signs by the pound, including providing and erecting walkway supports. The Engineer will base the computed weight on the quantity tables in the Contract.

S.6 Walkway for OH Signs

The Engineer will measure Structural steel – walkway for OH signs by the pound, including providing and erecting walkway grating. The Engineer will base the computed weight on the quantity tables in the Contract.

S.7 Panel Mounting Posts for OH signs

The Engineer will measure Structural steel – panel mounting posts for OH signs by the pound, including providing and erecting panel mounting posts. The Engineer will base the computed weight on the quantity tables in the Contract.

T Overhead Sign Structure Repair

The Engineer will measure Overhead sign Structure repair by the number of hours required to complete the repair, including use and operation of Equipment, travel time inside the Project limits, and Work and Materials involved. Overhead sign Structure repair is exempt from 1903, “Compensation for Altered Quantities.”

U Sign Panels

The Engineer will measure Sign Panels Type ____ by square foot based on the Nominal dimensions of the Sign Panels. Signs are considered rectangular for the purpose of measurement except that the Engineer will measure triangular shaped Sign Panels as the actual area of the triangle. The Engineer will not make deductions for rounded corners.

U.1 Type A

Sign Panels Type A includes new extruded aluminum panels bolted together to form the sign base, attaching a new Sign Panel to the Extruded Panels, and attached to posts with new Mounting Hardware.

U.2 Type C or D

Sign Panels Type C or D includes new Sign Panel, new posts, new stringers, new Mounting Hardware, and installing Department-provided warning sticker.

U.3 Type EA or EO

Sign Panels Type EA or EO includes new extruded aluminum panels bolted together to form the sign base, attaching a new Sign Panel to the Extruded Panels, providing and installing the panel mounting posts, and attached to the sign with new Mounting Hardware.

U.4 Type OH

Sign Panels Type OH includes new extruded aluminum panels bolted together to form the sign base, attaching a new Sign Panel to the Extruded Panels, and attached to the sign Structure with new Mounting Hardware.

V Sign Panel Overlay Type ____

The Engineer will measure Sign Panel Overlay Type ____ by the square foot based on the Nominal dimensions on the Sign Panel. Signs are considered rectangular for the purpose of measurement except that the Engineer will measure triangular shaped Sign Panels as the actual area of the triangle. The Engineer will not make deductions for rounded corners. Sign Panel Overlay Type ____ includes removing any existing Sign Panel Overlays or Sign Panels attached to Extruded Panels, new Mounting Hardware for Extruded Panels, and providing and attaching new Sign Panel.

2564.5 BASIS OF PAYMENT

The Department will pay for traffic signs and devices at the Contract Unit Price per unit of measure.

Removal and replacement of existing guardrail for the convenience of the Contractor is included in the Pay Item.

Replacement of topsoil, sodding, and seeding for sign installation or removal Work is included in the Pay Item.

Disposal of excess excavated Materials from sign installation Work is included in the Pay Item.

The Department will pay for traffic signs and devices on the basis of the following schedule:

Item No.	Item	Unit
2564.502	Median Barrier Footing	each
2564.502	Sign Support ___	each
2564.502	Modify Post	each
2564.502	Install Delineator	each
2564.502	Install Marker	each
2564.502	Install Reference Location Sign	each
2564.502	Install Sign Panel Type ___	each
2564.502	Install Sign Type ___	each
2564.502	Overhead Sign Identification Plate	each
2564.502	Extend Walkway Support	each
2564.502	Friction Fuse	each
2564.502	Keeper Plate	each
2564.502	Delineator	each
2564.502	Bridge Number Marker	each
2564.502	Infiltration Area Marker	each
2564.502	Reference Location Sign	each
2564.502	Object Marker	each
2564.507	Concrete Footings (Type ___)	cubic yard
2564.508	Structural Steel	pound
2564.510	Overhead Sign Structure Repair	hour
2564.518	Sign Panels Type ___	square foot
2564.518	Sign Panel Overlay Type ___	square foot

2565 TRAFFIC CONTROL SIGNALS

2565.1 DESCRIPTION

A General

This Work consists of providing and installing Materials and electrical Equipment, or installing Department-provided Materials and electrical Equipment, or both to provide a complete, operating traffic control signal system.

This Work also consists of providing the following as specified in the Contract:

(1) Revised traffic control signal systems
(2) Wood pole span wire traffic control signal systems
(3) Automatic Traffic Recorder (ATR) systems
(4) Temporary Bridge signal systems
(5) Conduit systems
(6) Detection systems
(7) Materials for future signal systems
(8) Interconnect systems
(9) Flasher systems
(10) Emergency Vehicle Pre-emption (EVP) systems or a combination

Refer to 2550.1, “Traffic Management System, Description,” for additional acronyms.

B Qualifications of Workers 2545.1A

C Acronyms 2550.1A

D Definitions

Refer to the *ITE*, the *MN MUTCD*, 1102, “Abbreviations and Measurement Units” and 1103, “Definitions,” for the definitions of words and phrases pertaining to traffic control signal systems and related Work. Refer to *NEMA Standards Publication for "Traffic Control Systems"* for the definitions of words and phrases in conjunction with traffic control signal control Equipment and controller units.

Refer to the *NFPA 70 National Electric Code*, article 100 for additional definitions.

For the purpose of the Work specified in section 2565, “Traffic Control Signals,” the Department defines:

Abandoned
Underground cable or conduit no longer in service and physically disconnected from a system.

Bell End
The end of a piece of rigid PVC conduit that flares out to allow connection of an additional piece of conduit.

Cut Sheet, Catalog Sheet, or Specification Sheet
A document showing a finished product including part numbers and an ordering matrix if required.

End Bell
The rigid PVC conduit fitting that is glued on at the end of a conduit to protect the conductors during pulling operations.

Materials
As defined in the 1103,“Definitions,” and including components, products, Equipment, and structural supports for use in performance of the Work for 2545, “Lighting Systems,” 2565, “Traffic Control Signals,” and Chapter 8, “Electrical Systems Materials, section 3801 through 3850.

Pedestrian Signal Head
A Signal Head, which contains the symbols WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DONT WALK), and countdown numbers that is installed to direct pedestrian traffic at a traffic control signal. The head is comprised of a Pedestrian Signal Housing and a Pedestrian Signal Indication that fits within the housing.

Pedestrian Signal Housing
Polycarbonate housing that protects the light source and other required components. The housing includes an indication mounting door and sun visor.

Pedestrian Signal Indication
Light Emitting Diode (LED) UPRAISED HAND and WALKING PERSON countdown indication module that is installed within the Pedestrian Signal Housing.

Shop Drawing
A detailed document showing how a specific product will be fabricated and constructed. This document will also include required Material specifications and requirements.

Signal Head
An assembly of one or more Signal Sections that is provided for controlling vehicle traffic. This assembly of Signal Sections also includes a backplate (background shield).

Signal Section
The assembly of a Signal Housing, signal lens, if any, and light source with necessary components to be used for displaying the Signal Indication. The section is comprised of two components; a Signal Housing and a Signal Indication that fits within the housing.

Signal Housing
That part of a Signal Section that protects the light source and other required components. Polycarbonate housing that protects the light source and other required components and includes a hinged opening (with visor) in which the Signal Indication is mounted. This is one of two components that make up a Signal Section.

Signal Indication
The illumination of a signal lens or equivalent device. The device is a Light Emitting Diode (LED) indication module that is installed within the Signal Housing. This is one of two components that make up a Signal Section.

Source of Power (SOP)
The electric utility transformer.

Turn-On (Traffic Control Signals)
The time the complete traffic control signal system is accepted by the Engineer and meets the installation, testing, and operational requirements of the Contract. The traffic control signal system must also be placed in automatic operation.

2565.2 MATERIALS

A Conduit and Accessories

Provide concrete mix No. 3G52 if the Contract does not require a specific mix designation.

Construct or replace concrete pavement or base, removed for trenching or construction operations, with concrete mix No. 3G52HE.

I Traffic Control Signal Cabinets

Install anchor rods, nuts, and washers provided with the traffic control signal cabinets.

Only use anodized aluminum pedestal shafts unless otherwise shown on the Plan.

S **Preformed Thermoplastic Pavement Marking 3356**

Provide Crosswalk Preformed Thermoplastic Ground In Enhanced Skid Resistance, unless the surface is concrete, then provide Crosswalk Preformed Thermoplastic Ground in Contrast Enhanced Skid Resistance.

T **Fiber Optic Cables and Pigtails 3815**

U **Traffic Signs**

U.1 **Traffic Signs and Devices 2564**

U.2 **Signs 3352**

U.3 **Square Tubular Sign Posts 3402**

V **Traffic Control Signal Cabinet and Control Equipment**

Provide the traffic control signal cabinet, or other pad-mounted cabinet and control Equipment, as specified in the Contract.

W **Miscellaneous Materials**

If the Contract does not specify requirements for Materials and Equipment, provide the Materials and Equipment as approved by the Engineer.

X **Bent Tube Monotube Signal Bridges 2471**

Fabricate bent pipe monotube signal Bridges as specified in the Contract.

Y **Concrete Walks and Pedestrian Curb Ramps 2521**

Construct 6-inch thick concrete walks around traffic control signal bases as specified in the Contract. If in a curb section, concrete walks may include pedestrian curb Ramps.

Z **Pole Base Connectors**

Use pole base connectors, pins, sockets, and hand crimp tools listed on *Approved/Qualified Products List* under “Signals.”

AA **Loop Detector Sealant Material**

Use loop detector sealant Material listed on *Approved/Qualified Products List* under “Signals.”

BB **Loop Detector Splices**

Use loop detector splice encapsulation kits listed on *Approved/Qualified Products List* under “Signals.”

CC **Rodent Intrusion Barrier 3836**

DD **Signal Service Cabinet Type SSB 3837**

EE **LED Luminaires 3810**

Use LED Luminaires for mounting at 40 feet for traffic signal systems.

FF **Luminaire Wire Holders**

Use luminaire wire holders for signal systems listed on *Approved/Qualified Products List* under “Signals.”

GG **Grounding Electrodes (Ground Rods and Plate Electrodes) 3818**

HH Terminal Blocks

Use terminal blocks when doing a revision to an existing traffic control signal system that has in-place terminal blocks, or on temporary wood pole traffic control signal systems.

Provide terminal blocks consisting of a one-piece phenolic molding with 12 double-point terminals, with strap screw contacts for size 10-32 binder head screws. Provide barriers between terminals at least 1/2 inch high. Ensure the holes for the binder head screws do not extend through the plastic. Provide terminal blocks with slots that fit the spade lugs for terminating conductors. Ensure each terminal block meets the 600 V requirements of NEMA. Provide terminal blocks that are NRTL Listed as compliant with the requirements of UL XCFR2.GuideInfo — Terminal Blocks.

II Sponge Rubber Expansion Joint 3841

JJ Underground Non-Detectable Marking Tape 3806

KK Anti-seize and Lubricating Compound "Bridge Grease" 3842

Apply brush-on anti-seize and lubricating compound to threaded portions anchor rods; bolts; screws; nuts; and the bearing surfaces of nuts, washers, and bolt heads before assembly.

LL Conductor Anti-oxidant Joint Compound 3842

Apply brush-on anti-oxidant joint compound to electrical conductors before assembly.

MM Ferrous Metal Electrically-conductive Corrosion Resistant Compound 3842

Apply brush-on ferrous metal electrically-conductive corrosion resistant compound to threaded portions of metallic conduit before assembly.

NN Light Pole and Luminaire Numbering Labels 3844

OO Arc Flash Warning Labels 3844

PP Available Fault Current Calculation Labels 3844

QQ Pedestal Steel Screw-in Foundation and Fasteners

Provide steel screw foundations with manufacturer supplied bolts, nuts, and washers listed on *Approved/Qualified Products List* under "Signals" for pedestal pole installation on steel screw-in foundations.

2565.3 CONSTRUCTION REQUIREMENTS

A General

Traffic signal structural supports with X and Y coordinates shown on the Plans are the exact locations. Obtain the Engineer's approval before making modifications to these locations. Locations not assigned X and Y coordinates on the Plan are approximate only. The Engineer will establish those locations on the Project.

Keep Roads open to traffic during construction in accordance with 1404, "Maintenance of Traffic." Protect openings or uncompleted Work that may cause a hazard to vehicle or pedestrian traffic in accordance with 1707, "Public Convenience and Safety."

A.1 Compliance with Electrical Codes and Standards

Perform Work meeting the requirements of the NEC, NESC, Minnesota Department of Labor and Industry, Board of Electricity, and State laws and local ordinances governing electrical Work.

Provide Equipment meeting relevant standards and requirements from the following references: *NEMA, Underwriters' Laboratories, Inc. (UL),* and *The Electronic Components Industry Association (ECIA).*

Unless otherwise detailed in Contract documents, provide Materials, Equipment, and workmanship meeting the standards in the current editions of the following references: *AASHTO*, *ANSI*, *ASTM*, *FHWA*, *ICEA*, *IES*, *ITE*, *MnMUTCD*, *NEC*, *NESC*, relevant local laws and ordinances.

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

A.2 Permits and Inspections

Obtain the necessary permits and inspections at no additional cost to the Department.

Perform Work in conjunction with construction of electrical systems and conduit raceways for conveying cables and conductors as specified in the Contract and in accordance with 1702, “Permits, Licenses, and Taxes.” Obtain a permit for the performance of this Work, including the installation of conduits, in accordance with the Minnesota Electrical Act.

A.3 Utility Property and Service 1507

Meet the minimum clearance requirements determined by the electrical utility company, for overhead electrical lines to other overhead Structures and Equipment operations.

A.4 Materials and Electrical Equipment List

Within 15 Calendar Days following the Award of Contract date, submit a list of Contractor-provided Materials and Equipment to the Engineer. Include in the list, the name of the manufacturer, size, and the location where the item is obtained.

Within 15 Calendar Days following the Contract approval-notice mailing date, provide evidence in writing to the Engineer, that orders are placed for components required on the Project.

A.5 Material Samples for Testing

Provide samples of Materials for testing and inspection. The Engineer may accept Materials on the basis of the manufacturer's certification that Material was sampled, tested, and inspected for compliance with the Contract. The Department reserves the right to accept or reject Material on the basis of its own tests and inspections.

A.6 Tests

Perform the tests necessary to demonstrate that the Materials and the installation are in accordance with the Contract, at no additional cost to the Department.

Provide instruments, Equipment, tools, Materials, and labor necessary to perform the required tests, at no additional cost to the Department. Instruments, Equipment, tools, and Materials for performing tests will remain the property of the Contractor after completion of the tests.

A.7 Warranties and Instruction Sheets

Provide new Materials with manufacturers’ warranties.

Submit manufacturers' warranties, instruction sheets, and parts lists, to the Engineer before 1516.3, “Completion of the Work,” or if requested by the Engineer.

Warrant that Materials provided to the Project are free of defects in Materials and workmanship in accordance with the following:

(1) Turn over warranties, offered by the manufacturers as a customary trade practice, to the Department. Name the Department as the obligee on manufacturers' warranties.
(2) Warrant in-service operation of Materials for one year. The one-year in-service warranty period begins on the Turn-On date except the one-year period for Materials placed into operation after the Turn-On of the system begins on the date the Materials are initially, individually placed in service.

A.8 Shop Drawing Submittals.. 2545.3A.2

A.9 MnDOT Approved Products Materials List 2545.3A.1

A.10 Cut Sheets, Catalog Sheets, or Specification Sheets 2545.3A.3

A.11 Installation Requirements

Install Materials and devices in accordance with the Contract and the manufacturer's installation requirements.

A.12 Removal Requirements.. 2104

A.13 Calibration Requirements for Measurement Tools and Test Equipment

Submit documentation for precision measurement tools and test Equipment calibration and certification to the Engineer before using.

Calibrate precision measurement tools and test Equipment annually.

B Maintenance and Operation of New and Existing Electrical Systems

Maintain and keep in operation the new and existing electrical systems within the limits of the Project in accordance with 1514, "Maintenance During Construction," but not including 1404.6, "Traffic Control During and After Winter Suspension," until the Engineer accepts the Project in writing as specified in 1716, "Contractor's Responsibility for Work." Maintain and keep in operation new and existing electrical systems during periods of suspension at no additional cost to the Department.

This Work, including traffic control signals, ATRs, flasher systems, and lighting, or Department-approved temporary replacements, is considered Work included in the Pay Item Traffic control signal system, except if the Engineer directs, or the Contract requires turn-offs. Notify the Engineer at least 48 hours before scheduled turn-offs and before performing Work on existing electrical systems. Do not turn off existing traffic control signal systems without the Engineer's approval and the Engineer's presence.

If damage to new or existing electrical systems occurs due to Contractor operations, within 24 hours repair or replace the damage at no additional cost to the Department, in accordance with 1716, "Contractor's Responsibility for Work," and relevant to Specifications for new construction. Failure to repair or replace damage within 24 hours will result in the Department repairing or replacing and deducting costs from Project money entitled to the Contractor.

The Department will maintain the existing traffic control signal cabinets and control Equipment within the cabinet unless otherwise specified in the Contract.

C Excavation and Backfill

Provide excavation and backfill for the installation of foundations, cable, conduit, handholes, and other items shown on the Plans in accordance with 2451, "Structure Excavations and Backfills." Do not excavate trenches for conduit and holes for foundations and handholes wider than necessary. Install foundations, conduit, and handholes as soon as possible following excavation. Place excavation Material in locations that will not cause damage or obstruct vehicle or pedestrian traffic, or interfere with surface drainage.

Locate trenching at the distance from the edge of the pavement, back of curbing, or edge of surfaced Shoulders as specified in the Contract or directed by the Engineer. Ensure the trenching operation does not cause damage to the pavement, curbing, or surfaced Shoulders. Construct the trench with uniform alignment for accurate referencing of the underground installation.

Relocate cable and conduit to be installed as specified in the Contract where sites designated for underground facilities, guardrail, sign posts, and below ground Structures are planned. Coordinate with the Engineer and obtain the Engineer's approval of the relocations before installing.

If trenching and excavation operations require the removal of concrete pavement or concrete Sidewalk, cut the concrete with a concrete saw to a depth of at least 35 percent of the thickness of the concrete along the removal lines before breaking and removing, or remove the concrete to existing joints.

Backfill excavations around the installed foundations, conduit, and handholes. Use backfill Material similar to adjacent soils and compact backfill Material to the same density. Avoid placing stones immediately adjacent to conduits or direct-buried cable during backfill placement. If specified in the Contract, or directed by the Engineer, use granular Material in designated Layers or portions of the backfill provided in accordance with 2451, "Structure Excavations and Backfills." Restore the following to the original condition as specified in the Contract, to the Engineer's satisfaction, and at no additional cost to the Department:

(1) Roadway surfacing, including concrete pavement, bituminous surface, or gravel surface
(2) Sidewalk
(3) Curb and gutter
(4) Sod
(5) Railroad

Remove and dispose of surplus Material from excavation and backfill outside the Right-of-way in accordance with 2104.3D.3, "Disposal Outside Right-of-way."

D Conduits, Fittings, and Junction Box Installation

D.1 General

Provide conduit and fittings of the type and size as specified in the Contract. The Contractor may install conduit and fittings of a larger size than specified. If the Contract does not specify the size of conduit, provide conduit sized in accordance with the *NEC* so the cross sectional area occupied by the cables and conductors does not exceed 40 percent of the internal cross-sectional area of the conduit for rigid steel conduit or 35 percent for non-metallic conduit.

Install conduit in accordance with the *NEC*. In a single conduit run, provide conduit of the same size and type, continuous from outlet to outlet. The Contractor may incorporate special conduit fittings for pulling cables and conductors or making short radius bends, as necessary, in the run.

Prevent conduit from being damaged. Rigidly support conduit that will be encased in concrete or masonry in position during casting.

Install non-metallic conduit End Bells on HDPE or Rigid PVC conduit before installing cables and conductors to prevent damage.

Install threaded insulated grounding bushings with lay in ground lugs on RSC conduit before installing cables and conductors to prevent damage. Use lay in ground lugs constructed of stainless steel, copper, tin plated copper, brass, or bronze.

Install expansion and deflection/expansion devices at each Structure expansion joint as specified in the Contract or directed by the Engineer.

Install cables and conductors in conduit, unless otherwise specified in the Contract.

If installing conduit for future use, do not install the Equipment grounding conductor.

D.2 Conduit Placement

Install conduit in a straight run entering into handholes and foundations. Ensure handholes and foundations are in line with the general direction of the conduit run.

D.2.a Above Ground

Secure conduit attached above ground to wood poles with U-shaped 2-hole pipe straps meeting the requirements of the current edition of the *NEC* and spaced no more than 4 feet apart.

Secure conduit attached above ground to metal poles with at least 3/4 inches wide stainless steel banding, spaced no more than 5 feet apart.

Support conduit within 3 feet of each termination or fitting.

Secure conduit attached above ground to cabinets, bridges, and other Structures as specified in the Contract and to the Engineer's satisfaction.

D.2.b Underground

Place conduit using the trenching method, vibratory plow, or by directional boring.

Only place conduit under existing pavement or Sidewalk by directional boring. If a distortion greater than 1/4 inch is created in the existing surface, remove the distortion and restore the Roadway or Sidewalk to the original condition at no additional cost to the Department.

Except under existing pavements, when placing high Density polyethylene (HDPE) continuous length conduit use trenching, vibratory plow, or directional boring installation methods.

If plowing HDPE conduit, provide a vibratory plow with a feed blade that is capable of performing the following:

(1) Breaks the ground
(2) Places the conduit to a predetermined depth
(3) Guides the conduit into the bottom of the break through the guide blade chute so that little or no stress is placed on the conduit during installation to avoid damage
(4) Does not pull the conduit in place
(5) Closes the break in the ground

Only use RSC or Rigid PVC conduit between foundations and the nearest handhole. HDPE conduit may not be used in foundation or Equipment pad.

Do not use the trenching method, vibratory plow, or push conduit with a pneumatic compaction tool to place conduit under existing concrete, bituminous surfaces, and railroads.

Grout the voids that result from Abandoned boring operations through a Roadbed or Sidewalk at no additional cost to the Department and as approved by the Engineer.

If placing conduit underground below new or reconstructed Roadway surface areas and Sidewalk which has not been paved, use the trenching method to place the conduit at a uniform depth below the adjacent ground line and backfill and compact before placing new Roadway surfaces or new Sidewalk, as approved by the Engineer. Obtain the Engineer's approval of the trench before installing the conduit.

Place Department furnished ball markers at open ends of conduit under Roadways or slope pavement that do not terminate in handholes, pads, and foundations.

Place underground conduit at least 18 inches below the surface of a ground area and at least 24 inches below Roadway surfaces.

Place underground conduit under railroad tracks at least 42 inches below the bottom of railroad ties, or as required by the railroad company.

If approved by the Engineer, the Contractor may change conduit runs as specified in the Contract to avoid underground obstructions.

Provide underground conduit runs with provisions for draining moisture. Slope horizontal conduit runs to drain at a rate of at least 0.25 percent, or 3 inches per 100 foot. To drain the low points, not including the open ends of conduit runs, install a standard tee conduit fitting and nipples, at least 6 inches long. Extend the fitting and nipple into a hole 24 inches by 24 inches deep. Backfill the hole with crushed rock or Department-approved granular Material.

Position conduit, terminating in handholes or concrete foundations, so the conduit extends inside the handholes, pole bases, cabinet bases, or Structure bases by 2 inches to 3 inches. Slope the conduit toward the access opening. Slope the conduit out of the foundation, toward the handhole opening for drainage.

Locate conduit couplings at least 6 inches from the Structure surface.

Place conduit entering existing concrete foundations by sawing and breaking the concrete or core drilling so conduit enters the Equipment pad or foundation below the adjacent ground surface and projects from 1 inch to 2 inches above the top of the Equipment pad or foundation and inside the pole base or cabinet. Return the foundation to its original condition by patching with concrete as approved by the Engineer.

Thread conduit, stubbed out of a concrete foundation for future use if installing RSC. Cap stubbed conduit on the open ends with standard pipe caps or rigid PVC caps, based on the type of conduit. Extend conduit from 18 inches to 24 inches out of the concrete foundation underground in the direction shown on the Plans or as directed by the Engineer.

Following installation of cables and conductors, seal the open ends of conduit entering Equipment pads and foundations, using duct seal compound NRTL classified under general use tapes.

D.3 Conduit Bends

Provide conduit bends, except factory bends, with a radius of at least six times the Nominal diameter of the conduit. Make conduit bends without damaging the conduit and without reducing the internal diameter of the conduit.

For bends in conduit runs, provide the minimum radius necessary, but do not exceed 360 degrees of bend per run between handholes, foundations, or both.

D.4 Rigid Steel Conduit and Intermediate Metal Conduit

D.4.a Joints

Thread the ends of the conduit and use a standard threaded conduit coupling to join standard length conduit. If cutting standard length conduit, thread and ream the ends to remove burrs and rough edges.

Butt or bring together the full circumference of the conduit ends with a coupling to provide effective electrical continuity for the length of the conduit run.

Paint coating on conduit damaged by handling or installing with rust preventative paint as approved by the Engineer.

Brush on ferrous metal electrically-conductive corrosion-resistant compound in accordance with 3842, "Electrical Systems Compounds and Lubricants," to threaded portions of RSC and IMC including the fittings.

D.4.b Open Ends

Cap the open ends of conduit in handholes and conduit extending above concrete foundations with standard conduit caps, or other method approved by the Engineer, until wiring installation. Install a threaded insulated grounding bushing with lay in ground lugs for RSC on the open ends when caps are removed. Provide grounding bushings in accordance with the UL 467 for grounding and bonding Equipment. Provide grounding bushings with lay in ground lugs sized to accommodate a 6 AWG conductor for bonding. Apply anti-oxidant joint compound to the lug and bonding conductor before assembling.

Cap the open ends of conduit that terminates on the side of wood poles or other Structures with weatherhead entrance fittings.

D.4.c Existing Conduit

Clean and blow-out existing underground conduit, incorporated into a new or revised electrical system, with compressed air before placing new cables and conductors. Replace old insulated grounding bushings and bonding jumpers with new insulated grounding bushings with lay in ground lugs sized to accommodate a 6 AWG conductor, and bonding jumpers in existing handholes to maintain a continuously grounded and bonded system.

If placing new handholes in existing conduit runs, cut the conduit and extend it into the new handhole as approved by the Engineer. Thread the open ends of conduits, install new insulated grounding bushings with lay in ground lugs sized to accommodate a 6 AWG conductor for bonding, and bond the conduit as specified in the Contract.

D.5 Rigid PVC Conduit

D.5.a Joints

Trim the inside and outside of cut ends of rigid PVC conduit to remove rough edges. Use standard sized couplings or rigid PVC conduit with an attached preformed coupling. Clean rigid PVC conduit sections with a joint cleaner and cement joints with a PVC cement. Allow the PVC cement to set for 6 hours before pulling conduit through a directional-bored channel. Butt or bring together the full circumference of the conduit ends with a coupling. Use long-line couplings to join conduit sections if placing rigid PVC conduit under existing Roadway surfaces.

D.5.b Open Ends

Immediately cap or plug the open ends of rigid PVC conduit to prevent the entrance of moisture until the installation of the cables and conductors. Before installing cables and conductors, provide rigid PVC conduit with standard PVC conduit End Bells and End Bells for HDPE, continuous length conduit to prevent damage to the cables and conductors.

Cap or plug the open ends of rigid PVC conduit, not containing conductors, using standard sized PVC conduit caps or plugs.

D.5.c Conduit Encasement

If specified in the Contract use of the trenching method for rigid PVC conduit, place in granular or concrete encasement. For granular encased rigid PVC conduit, ensure the bottom and sides of the trench are free of sharp irregularities before placing conduit. Backfill the first 6 inches of the trench with granular Material meeting the requirements of 3149, “Granular Material.” For concrete encased rigid PVC conduit, extend the trench width 3 inches from each side of the conduit. Provide mix No. 3F52 concrete, or an equivalent, and encase the conduit 3 inches on each side.

D.6 Conduit on Bridges (Concrete Encased, Hanging, and Surface Mounted)

Provide PVC coated hot-dipped galvanized rigid steel conduit and fittings in accordance with 3805, “PVC Coated Hot Dipped Galvanized Rigid Steel Conduit (PVC Coated RSC),” and install as shown on the Plans, as approved by the Engineer, and as follows:

(1) No exposed metal
(2) Do not cut or alter PVC protective sleeves on fittings and couplings
(3) Apply a corrosion compound in accordance with *NEC* 300.6 on conduit threads
(4) Repair damaged PVC coating in accordance with manufacturer’s instructions
(5) Use fittings from the same manufacturer as the conduit
(6) Support the conduit in accordance with the *NEC*
(7) Installers trained and certified by the manufacturer or the manufacturer’s representative every two years

Before installation submit an unexpired manufacturer certified installer card for each Contractor employee directly performing the installation.

Provide conduit hangers, clamps, straps, U-bolts, strut and bar supports, threaded rod, inserts, and miscellaneous hardware in accordance with the *NEC* and 3805.2C “Hangers and Supports for PVC Coated Hot Dipped Galvanized Rigid Steel Conduit” for hanging and surface mounted conduit.

Install the conduit hangers, clamps, straps, U-bolts, strut and bar supports, threaded rod, inserts, and miscellaneous hardware as shown on the Plans and as approved by the Engineer. Ensure the installation allows for conduit expansion, contraction, and deflection.

D.7 Expansion and Deflection/Expansion Coupling Fittings for Conduit on Bridges

Provide expansion and deflection/expansion coupling fittings in accordance with 3839, “Conduit Expansion and Deflection/Expansion Coupling Fittings,” for conduit runs encased in concrete, hanging, or surface mounted.

Install expansion and deflection/expansion coupling fittings as shown on the Plans or, if not shown, as directed by the Engineer.

Set the internal bushing for expansion coupling fittings in conduit runs in accordance with the manufacturer’s installation instructions. If the manufacturer does not provide instructions for setting the internal bushing, then position the internal bushing in the middle of the expansion joint coupling fittings to allow for equal movement in both directions.

Wrap the expansion and deflection/expansion coupling fittings encased in concrete with sponge rubber expansion joint in accordance with 3841, “Sponge Rubber Expansion Joint,” and as shown on the Plans or, as directed by the Engineer. Ensure the outer seam of the wrap is on the bottom side of the expansion and deflection /expansion fittings assembly. Secure the wrap in place before concrete pouring operations.

Protect the sliding mechanism of expansion coupling fittings from concrete contamination when encasing in concrete.

D.8 Junction Boxes Attached to Bridges and Retaining Walls

Provide junction boxes in accordance with 3838, “Junction Boxes,” or as shown on the Plans.

Install junction boxes as shown on the Plans. If the Plan does not specify, install as directed by the Engineer with anchorages, supports, and hardware to allow removal of the junction box. Install junction boxes surface mounted to concrete with masonry anchorages or powder activated studs with the hardware necessary to allow removal of the junction box.

Provide the manufacturer supplied drain fitting and install as close to the bottom of the enclosure as possible.

D.9 Rigid PVC Conduit Attached to Wood Poles

Securely fasten Rigid PVC conduit to wood poles by appropriate type conduit straps that meet the current edition of the *NEC*. Space the conduit straps 3 feet to 4 feet apart.

D.10 Liquid Tight Flexible Non-Metallic Conduit (LFNC-B)

Securely fasten liquid tight flexible Non-Metallic conduit with appropriate type conduit straps as specified in the Contract and in accordance with the current edition of the *NEC*.

E Handholes

Install handholes as specified in the Contract and as approved by the Engineer. The Contractor may install additional handholes at no additional cost to the Department.

Set the tops of handholes so the cover is 1 inch below grade, except in Sidewalk.

Set the cover flush with the Sidewalk in accordance with ADA requirements.

To facilitate drainage, set handholes on a compacted Aggregate drain bed, 2 feet larger in diameter or square of the handhole enclosure, and 12 inches deep, using coarse filter Aggregate in accordance with 3149.2H, "Coarse Filter Aggregate."

Backfill handholes after installing the cover.

Install conduits entering handholes through the side wall of the handhole.

Drill conduit holes into the side walls of handholes no more than 1 inch larger than the size of conduit being installed.

Remove excess Material inside of existing handholes that are to be used in the new system.

Use a caulking compound or other type of sealant compatible with the handhole Material to the Engineer's satisfaction.

After the cables and conductors have been installed in the handhole place a Department provided ball marker as follows:

(1) Use a Department-furnished ball marker
(2) Cut 3/4 inch PVC conduit to length to allow the ball marker to be installed within 6 inches from the top of the handhole when the conduit is stood vertically against the side of the handhole
(3) Drill 1/4 inch hole through the top of the conduit providing 2 holes
(4) Attach the ball marker with a 3/16 inch nylon cable tie wrap using the drilled holes to the conduit
(5) Place the ball marker attached to the conduit against the sidewall of the handhole in a vertical position

Use red ball markers for handholes containing conductors with an operating voltage of > 50 volts.

Use orange ball markers for handholes containing conductors with an operating voltage of ≤ 50 volts and communications circuits.

For placing pre-cast concrete handholes in accordance with *Standard Plate 8117* with metal frame and cover, in areas not surfaced with concrete, support handholes with concrete to the Engineer's satisfaction.

Bond and ground the metal ring and cover in accordance with the *NEC* Article 314.30.

F Concrete Foundations and Equipment Pads

Except for portions of concrete foundations that extend into solid rock, use forming tubes or wood forms with the following characteristics to construct concrete foundations in accordance with 2411, "Minor Concrete Structures."

Use a forming tube for only the upper half of the foundation for cast in-place. If soil conditions or method of installation do not allow for a partial length forming tube to be used, a full length forming may be used instead. Obtain the Engineer's approval before installing a forming tube for the full length of the foundation.

Remove the top portion of the fiber forming tube at finished grade level or Sidewalk after 24 hours of placing concrete.

Brace entering conduits, anchor rods, ground rod electrodes, and other Equipment in position with a rigid metal template to ensure proper location and projection as specified in the Contract. Remove the template after 24 hours of placing the concrete.

Use portable vibrators and hand spading to consolidate the concrete to form a smooth, dense surface free of air or water blisters.

Cover the Structure with white polyethylene sheeting in accordance with 3756, "Plastic Curing Blankets."

Install precast concrete foundations in drilled shafts when soil conditions allow and in accordance with 2545.3E.1 "Precast Concrete Foundations."

Replace foundations and Equipment pads at no additional cost to the Department if anchor rods, conduits, and ground rod electrodes are missing, improperly located, or projection heights do not meet the requirements in the Contract. Do not alter the transformer base plate openings and anchor rod holes to accommodate misaligned anchor rods, conduits, and ground rod electrodes. Do not alter foundations, conduits, anchorages, or ground rod electrodes if misfits between the assembly of the pole and foundation occur.

If unstable foundation conditions are encountered, the Contractor may alter concrete foundation construction to secure a stable foundation. Obtain the Engineer's approval before altering concrete foundation construction. If obstructions such as solid rock are encountered that prevent concrete foundation construction as planned, the Contractor may adjust the foundation dimensions as specified in the Contract or directed by the Engineer, to provide a stable foundation.

Backfill and compact the conduit trench and around the foundation.

Use erosion prevention products to reinforce vegetation around the foundations and Equipment pads in accordance with 3885, "Rolled Erosion Prevention Products."

F.1 PA Pole Foundations *Standard Plates 8120 and 81*26

Construct foundations in drilled shafts. Excavate a hole with an auger of sufficient size to the dimensions of the foundation specified in the Contract. Minimize over excavation. Protect the sides of the drilled shaft from collapsing.

Pour concrete as soon as possible after the excavation to prevent loose or soft Materials from accumulating at the bottom of the shaft that would affect the performance of the foundation. Remove loose Materials at the bottom of the shaft and groundwater before placement of concrete.

Use a continuous fiber forming tube for the upper portion of the foundation above grade and maximum 4 feet below grade. Pour concrete directly against the soil of the drilled shaft if the sidewalls remain firm and stable.

A continuous full length fiber forming tube may be used to prevent the sidewalls of the shaft from collapsing with the approval of the Engineer at no additional cost to the Department. "Full length" means more than half the depth of the drilled shaft.

When a full length fiber forming tube is needed to prevent the drilled shaft from collapsing, refer to the Frost Depth Zone Table 2565.3-1 and cut four 3 inches by 12 inches rectangular holes into the fiber forming tube before installing into the drilled shaft. Cut 2 rectangular holes approximately 180 degrees apart, 6 feet to 7 feet below grade if the Project Site is located in Zone 1, and 4 feet to 5 feet below grade if the Project Site is located in Zone 2.

Rotate the forming tube 90 degrees and cut 2 more rectangular holes 180 degree apart approximately 1 foot lower from the first 2 holes.

Table 2565.3-1
Frost Depth Zone*

Zone	Depth of Holes Below Grade
1	6 feet – 7 feet
2	4 feet – 5 feet
* Refer to The Office of The Revisor of Statutes website for frost depth zone requirements, MN Administrative Rules 1303.1600 footing Depth for Frost Protection, to determine appropriate frost depth zone.	

During placement of the concrete, ensure concrete fills the shaft area and any void area outside the fiber forming tube that is below grade.

If soil or rock conditions not suitable for standard foundations are present, or if conditions are marginal, contact the MnDOT Bridge Evaluation and Fabrication Methods Engineer and the MnDOT Foundations Unit for a foundation design that can be used as an alternative to the standard foundation design.

Foundation design is based on installing in a drilled shaft. Any variation to the drilled shaft requires an approval by the District Soils Engineer. If a drilled shaft foundation is not possible, obtain approval from the District Soils Engineer to conduct open excavation for the foundation before starting the Work.

F.2 Equipment Pads

Construct concrete Equipment pads at the location staked by the Engineer and as shown on the Plans.

Install the Equipment pad for the Department provided traffic control signal cabinet and control Equipment as part of the Equipment pad using Department provided anchor rods, nuts, and washers to mount the cabinet.

Install the Equipment pad for the signal service cabinet type SSB as part of the Equipment pad concrete foundation using anchor rods, nuts, and washers supplied by the SSB cabinet manufacturer.

G Loop Detectors

Provide preformed rigid PVC or saw-cut inductive loop detectors as specified in the Contract. Install complete loop detectors with the following:

(1) An electrical conductor embedded loop or group of loops installed in the Roadway as specified in the Contract
(2) A loop detector lead-in cable to the traffic control signal cabinet or other cabinet

G.1 Installation

Splice the loop detector Roadway conductor to the loop detector lead-in cable in accordance with *Standard Plates 8130 or 813*2 and as follows:

(1) Cut the drain wire off the loop detector lead-in cable at the point where it exits the cable jacket at the end of the cable assembly that will be installed in the loop detector splice kit
(2) Ensure the loop detector lead-in cable jacket is encased in the loop detector splice encapsulation Material forming a water tight seal

(3) Terminate the loop detector lead-in cable assembly located in the traffic control signal cabinet in the appropriate terminals as shown on the cabinet print

G.1.a Preformed Rigid PVC Loop Detector

Provide loop detectors encased in rigid PVC conduit in accordance with *Standard Plate 8132*.

G.1.b Saw-Cut Loop Detectors

Provide saw-cut loop detectors in accordance with *Standard Plate 8*130.

The Engineer may make minor adjustments to the size or shape of the loop detector in the field at no additional cost to the Department.

Make an individual saw cut from each loop detector to the conduit leading to the handhole.

G.2 Loop Detector Test Report

Submit three copies of a signed and dated loop detector test report to the Engineer. Include the following information in the report for each loop detector and lead-in cable system provided and installed as specified in the Contract:

(1) Project numbers, Intersection, and location identification
(2) Loop detector number shown on the Plans
(3) Width and length dimensions of the loop detector, in inches, as installed
(4) Number of turns of wire in loop detector as installed
(5) Meet the following continuity test results for each detector circuit as tested at 2 locations:

    (a) Less than 0.5 Ω, from lead to lead for loop detectors, as measured at the handhole or junction box before splicing the loop detector lead-in cable
    (b) Less than 5 Ω for loop detector and lead-in cable systems at the Intersection traffic control signal cabinet after splicing the handhole or junction box
    (c) An ohm reading at the Intersection traffic control signal cabinet greater than the ohm reading measured at the loop detector adjacent handhole or junction box

(6) Inductance test results from 50 microhenry to 900 microhenry for each loop detector and lead-in cable system
(7) Insulation resistance test results of at least 100 mega-ohm as performed at 500 VDC between one loop detector lead-in cable conductor and the “Equipment Ground Bus” in the cabinet

Perform the continuity test, inductance test, and insulation resistance test at the Intersection traffic control signal cabinet before terminating the loop detector lead-in cable conductors on the terminal facilities. Perform loop detector tests in the Engineer’s presence at no additional cost to the Department.

The Engineer will distribute the 3 final loop detector test reports for the intersection as follows:

(1) The original to the official Project file
(2) One copy to the traffic control signal cabinet
(3) One copy to the Department's Electrical Services Unit or maintaining agency

If a loop detector or lead-in cable system fails any of the loop detector tests, replace parts or the entire loop detector and lead-in cable system at no additional cost to the Department as directed by the Engineer. Repeat and record the loop detector tests for the "revised" loop detector and lead-in cable system.

Each loop detector and lead-in cable system must pass the loop detector tests and must be operational as approved by the Engineer. Regardless of the test results, the Department may test each loop detector and lead-in cable system with Department owned test Equipment.

H Bonding and Grounding

Provide bonding, grounding, grounding electrodes, grounding electrode conductors, Equipment grounding conductors, bonding jumpers, and grounding connections in accordance with *NEC*.

Provide grounding of the system and neutral at the service cabinet.

Provide conductors for Equipment grounding, grounding electrodes, and bonding jumpers in accordance with 3815.2B.5, "Grounding Conductors."

Use NRTL- listed stainless steel, copper, tin plated copper, brass, or bronze connectors for bonding and grounding unless otherwise specified in the Contract.

H.1 Grounding Electrodes

Provide grounding electrodes in accordance with 3818, "Grounding Electrodes."

H.2 Bonding and Grounding

Form a continuous bonded and grounded system using the following:

(1) Metal conduit
(2) Metal traffic control signal pedestals
(3) Mast arm poles
(4) Light Poles
(5) Service Equipment
(6) Metal junction boxes
(7) Down guys
(8) Span wire
(9) Microwave and sonic detector units
(10) Cabinets
(11) Pedestrian push button stations

H.3 Pole Base Bonding and Grounding

Use a brass, bronze, or stainless steel bolt a minimum of 3/16 inch in diameter installed in the lower part of the shaft or base to attach the grounding and bonding jumper to metal traffic control signal pedestals, mast arm poles, and Light Poles.

Do not use a solder or sheet metal strap connection.

Use an NRTL-listed, reusable screw-type, active clamping ground lug with a tang that connects to the 5/16 inch signal pole base grounding stud to attach the 6 AWG stranded, insulated green grounding conductor to metal traffic control signal pedestals and mast arm poles to the signal pole base.

Terminate the 6 AWG stranded, insulated green conductor on the "Equipment Ground Bus." Ground the "Equipment Ground Bus" to the signal service ground rod electrode with at least 6 AWG stranded, insulated green grounding electrode conductor.

Provide and connect a 6 AWG stranded, insulated green Equipment grounding conductor from the “Equipment Ground Bus” in the traffic control signal cabinet or other type cabinet to the ground bus of the service cabinet and to each incoming conduit insulated grounding bushing lug or each incoming 6 AWG stranded, insulated green conductor.

When connecting the daisy chain 6 AWG stranded insulated green grounding conductor that runs from the adjacent signal pole ground rod electrode to the next signal pole ground rod electrode, exothermically weld it to the ground rod electrode with a T type connector utilizing a 3 or 4 wiretap connection. Use a 2 wiretap connection at the end of the daisy chain run.

Bond the 6 AWG stranded, insulated green grounding conductor to the signal pole base 5/16 inch grounding stud using a NRTL listed re-usable screw type active clamping ground lug with a tang.

H.4 Exothermic Welding

Bond ground rod electrodes to the 6 AWG stranded, insulated green conductor coming from the traffic control signal cabinet and running to the signal pole base using exothermic welding.

The exothermic welding is achieved by:

(1) Stripping off enough insulating Material from the 6 AWG stranded green insulated grounding wire to ensure the insulation does not burn or melt during the welding process
(2) Use a manufacturer’s specific sized mold for exothermic welding of a 6 AWG stranded copper wire being welded to a non-threaded 5/8 inch copper clad ground rod electrode. Use a T type configuration with a 4 wiretap, 3 wiretap, or 2 wiretap for the mold as specified in the Plans
(3) Strict adherence to the weld manufacturer’s instructions for Material preparation, when welding and testing of the exothermic weld

H.5 Ground Rod Electrode Installation

Drive ground rod electrodes at service points and locations required by the Contract. Install ground rod electrodes and grounding connections in accordance with the *NEC*. Place the ground rod electrode for PA85, PA90, PA100, and BA series signal poles in the nearest handhole adjacent to the signal pole foundation as required by the Contract. Provide pedestal foundations with a ground rod electrode placed inside the pedestal foundation slightly off center in the pedestal foundation as required by the Contract before casting the concrete foundation. Ground the signal poles by bonding together the 6 AWG, stranded, insulated green grounding conductor that runs from the traffic control signal cabinet to the ground rod electrode and through to the pole base. Install the ground rod electrode in the handhole with the top of the ground rod 3 inches below the bottom of the handhole cover as specified in the Contract.

When ground rod electrodes are required to be installed outside of the foundation and rock is encountered preventing the ground rods from being installed vertically, follow the installation requirements for rod electrodes in accordance with the *NEC*. If it is not possible to install ground rods according to the installation requirements of the *NEC*, install plate electrodes in accordance with 3818, “Grounding Electrodes,” as directed by the Engineer.

If installing the ground rod electrode in concrete foundations, install the top of the ground rod electrode from 2 inches to 3 inches above the foundation. Bond the service Equipment to the ground rod electrode.

Use exothermic welding to bond ground rod electrodes to the 6 AWG stranded, insulated green grounding conductor from the traffic control signal cabinet to the signal pole base.

Use a 6 AWG standard green insulated grounding electrode conductor to bond metal poles, pedestals, cabinets, and other Structures requiring a grounding conductor to the ground rod electrode as specified in the Contract. Attach one end of the bonding jumper to the lower part of the pole, pedestal, cabinet, or Structure shaft or base. Use an exothermic weld to attach the other end of the bonding jumper to the ground rod electrode as specified in the Contract.

If five 6 AWG stranded green insulated grounding conductors need to be spliced to a ground rod as shown on the Plan, then provide exothermic welded connections in accordance with the manufacturer’s installation requirements and the following:

(1) Provide or prepare a mold to bond 4 conductors to a ground rod that accommodates:

 (a) A 5/8 inch ground rod
 (b) A 6 AWG stranded green insulated bonding jumper conductor 3 inches to 4 inches long
 (c) Three 6 AWG stranded green insulated grounding conductors

(2) Insert the ground rod, 1 end of the bonding jumper, and grounding conductors into the mold and position them for the connection
(3) Perform the exothermic weld to produce a permanent electrical connection
(4) Provide or prepare a mold designed to bond three 6 AWG conductors
(5) Insert the other end of the bonding jumper from the previous weld and the remaining 2 grounding conductors into the mold and position them for connection
(6) Perform the exothermic weld to produce a permanent electrical connection

H.6 Replacement RSC Threaded Insulated Grounding Bushings

In addition to the required bonding and grounding jumper and required threaded insulated grounding bushings with lay in ground lugs on open ends of new RSC, provide and install new bonding and grounding jumpers and new threaded grounding conduit bushings on open ends of in-place RSC at the in-place locations as directed by the Engineer.

H.7 Anti-Oxidant Joint Compound

Apply anti-oxidant joint compound in accordance with 3842, “Electrical Systems Compounds and Lubricants,” to bonding and grounding connections before assembly and after final connection.

I Wiring

Install cables, conductors, and wiring in accordance with the *NEC*.

Use insulated spade lugs or pole base connectors for terminal connections of conductors.

Tape the ends of un-terminated spare conductors with vinyl electrical tape to prevent exposure to moisture.

Leave 3 feet of slack cable in each handhole through which a run of cable passes.

Leave 24 inches of slack cable or conductors in each mast arm pole base, Light Pole base, and traffic control signal pedestal base.

Install unmetered service conductors in a separate conduit system.

Run conductors of a branch circuit in a single conduit.

Continuously run cables and conductors without splices from the terminal appliances in the traffic control signal cabinet to the pole base connectors, terminal blocks, or other terminal appliances.

Continuously install loop detector lead-in cable without splices or terminals from the loop detector conductor and lead-in cable splice to the traffic control signal cabinet or other type cabinet.

Continuously install interconnect cable between cabinets without splices. Run the cable in straight lines with a minimum number of bends in the cable run.

Provide the size and quantity of conductors in each cable and the number of cables in a given conduit run as shown on the Plans.

Wire the electrical system in accordance with the field wiring diagram as shown on the Plans. Identify cables as shown on the field wiring diagram in handholes, junction boxes, traffic control signal pedestal bases, mast arm pole bases, Light Pole bases, and cabinets. Except for the individual conductors terminated at the cabinet fuse panels, wrap white vinyl adhesive tape around the cable to identify cables and conductors. Handwrite labels with a black permanent marker as approved by the Engineer or use a label maker with labels suitable for use in wet locations. Wrap the labels from a label maker around the cable in 1 complete revolution with minimum 1/10 in overlap.

Place machine printed labels, embossed plastic labels, vinyl adhesive pre-printed labels, or sleeve type labels around each conductor to identify the individual conductors terminated at the cabinet fuse panels. Place labels on each cable terminated at the terminal appliances located inside the traffic control signal cabinet (i.e. RED 2-1, YEL 2-1, GRN 2-1, RLTA 5-1, YLTA 5-1, GLTA 5-1, RRTA 4-1, YRTA 4-1, GRTA 4-1, DWK P6-1, WLK P6-1, etc., or the like, indicating the Signal Indication and the Signal Head number). Apply the label within 3 inches of the terminal point. Provide an identification strip for terminal blocks in traffic control signal pedestal bases and pole bases as part of the terminal block. Identify each conductor in a similar manner as above to label the Signal Indication it serves.

Using a black permanent marker, label both sides of pole base connectors with Signal Head number.

I.1 Underground Wiring

To avoid damaging the cable and conductor insulation, hand pull cables and conductors through conduit raceways. Clean the conduit at the time of installation. Tape the ends of cables and conductors to exclude moisture until spliced or terminated.

Hand pull cables and conductors through rigid PVC conduit without splitting or damaging the rigid PVC conduit due to "pull rope abrasion." Replace the damaged portion of the rigid PVC conduit as approved by the Engineer.

Use the trenching method or a vibratory plow to direct bury interconnect cable not placed in conduit to a depth of at least 36 inches, except where required to enter a handhole. If the Contract specifies the interconnect cable to enter a handhole, install the cable in the side of the handhole from 6 inches to 8 inches above the bottom of the handhole. Maintain a depth of at least 36 inches within 2 feet to 3 feet of the handhole.

If plowing direct buried interconnect cable, provide a vibratory plow with a feed blade that is capable of performing the following:

(1) Breaks the ground
(2) Places the cable to a predetermined depth
(3) Guides the cable into the bottom of the break through the guide blade chute so that little or no stress is placed on the cable during installation to avoid damage
(4) Does not pull the cable in place
(5) Places non-detectable marking tape 12 inches to 18 inches above the cable or conduit
(6) Closes the break in the ground

Submit the plowing method to the Engineer for approval before installing the cable.

Install underground non-detectable marking tape 12 inches to 18 inches above the interconnect cable or conduit.

Place any direct buried cable that enters or exits handholes in a conduit sleeve at least 3 feet long.

I.2 Cabinet Field Lead Wiring

Do not cut a field lead entering a cabinet shorter than the farthest terminal in the cabinet. After completing field connections to the cabinet terminal, dress and band together the field leads to provide an orderly arrangement within the cabinet.

I.3 Splices

Do not splice conductors unless specified in the Contract or approved by the Engineer. If specified in the Contract only splice in handholes, control cabinets, junction boxes, or in bases of poles. Do not splice underground cable unless specified in the Contract. Use an approved epoxy splice kit for underground cable splices as specified in the Contract.

Provide splices for conductors and cables as specified in the Contract. Electrically and mechanically secure splices without solder, except loop detector splices. Use connector types with splices as specified in the Contract and as follows:

(1) Do not use pressure spring type connectors
(2) Splice loop detectors as specified in the Contract

I.4 Aboveground Wiring

For cables and conductors installed above ground, except where run on overhead span wire, use one of the following methods:

(1) Conduit attached to wood poles, metal poles, cabinets, or other Structures
(2) Inside metal poles, pedestals, cabinets, or other Structures

Provide slack of 5 percent of the span length when installing overhead span wire.

When installing cables and conductors on span wire, using straps with spacing less than 18 inch for lacing. Provide weather-resistant, black nylon, non-metallic straps with a loop tensile strength of at least 250 pounds. Submit the non-metallic straps to the Engineer for approval before installation.

I.5 Pole Base Connectors

Provide Department-approved pole base connectors for terminating signal conductors in mast arm pole bases, traffic control signal pedestal bases, and other bases with vehicle and Pedestrian Signal Indications or Pedestrian Signal Indications.

Assemble pole base connectors in accordance with manufacturer's instructions.

Use a Department-approved hand crimp tool to install pole base connectors as specified in the Contract.

I.6 Signal and Pedestrian Head Terminal Block Wiring

For horizontally mounted terminal blocks in the Signal Head, terminate the forks of the spade lugs facing down on the terminal block for the signal control cable running from the pole base into Signal Head. Form a loop with the conductors at least 3 inches above the terminal block and then loop the conductors back down to exit the head for termination in the pole base.

For vertically mounted terminal blocks, terminate the spade lugs for the signal control cable running from the pole base into Signal Head and loop the conductors to extend up from the terminal block at least 3 inches above the terminal block and then loop the conductors back down to exit the head for termination in the pole base.

After the conductors have been properly terminated, spray the spade lugs and the entire terminal block with an approved pole base terminal block coating. The coating of the terminal block includes spraying the terminal connections and the exposed wire ends where crimped to the spade connector.

Only use Department-approved pole base terminal block coatings listed on *Approved/Qualified Products List* under "Signals."

I.7 Terminal Blocks

Where specified in the Contract for retrofit Projects with in-place terminal blocks, or temporary wood pole traffic control signal systems, provide each mast arm pole base, traffic signal pedestal base, and other bases or poles with vehicle and Pedestrian Signal Indications or Pedestrian Signal Indications with a NRTL listed terminal block for terminating field conductors and traffic signal conductors.

The terminal blocks, screws, and spade lugs in each base shall be covered with an approved electrical insulating coating. Provide Pole Base Terminal Block Coatings listed on the *Approved/Qualified Products List* under "Signals."

Remove the white plastic marking strip from the terminal block before applying the approved electrical insulating coating. After coating the terminal block, reinstall the white plastic marking strip.

Install terminal blocks in bases so that the terminal block screws face the door opening and are accessible.

J Service Equipment Installation

Install service Equipment in accordance with the *NEC* and local laws and ordinances governing service Equipment installations.

Refer to the Plans for the approximate location of service points. The Engineer or the electric utility company will determine the exact location of service points.

Install signal service cabinets Type SSB as specified in the Contract.

Install Lighting Service Cabinets as specified in the Contract.

Install the Department provided rubber gasket sections between the bottom of each cabinet base and the Equipment pad. Leave one 1/2 inch gap in the gasket to ensure proper water drainage.

Position the photoelectric control to face north. The photoelectric control may face east or west only if facing it north is not an option due to service cabinet orientation.

When installing service Equipment on a wood pole, install the meter socket directly above the service disconnect. Terminate risers near the top of the wood pole or Structure. Cap risers with a weatherhead to prevent the entrance of water. Extend power conductors beyond the weatherhead with an additional 4 foot length for a drip loop, to allow the electric utility company to connect to the service conductors from the Source of Power. The electric utility company will perform connections at no additional cost to the Contractor, unless otherwise specified in the Contract.

For installation on a mounting bracket assembly, locate the meter socket and disconnecting means as specified in the Contract.

Provide lugs for terminating conductors sized for the associated conductors. Do no trim strands of conductors to fit into undersized lugs.

Arrange for the service point connection with the electric utility company.

J.1 Service Cabinet Arc Flash Hazard Labeling

Provide arc flash warning labels in accordance with 3844, “Labels.”

K Vehicle and Pedestrian Signal Head Installation

K.1 Pedestal Mounted (With Signal Bracketing)

Mount vehicle and pedestrian Signal Heads on top of traffic control signal pedestals as specified in the Contract. Install symmetrically arranged and securely assembled pedestal mounted assemblies plumb and level. Provide for internal wiring within the pedestal shaft signal brackets and pipe fittings.

Place a pedestal mounted vehicle Signal Head directly above the pedestal slipfitter collar. Attach with a bracket to the top of the vehicle Signal Head and to the pedestal shaft.

K.2 Vertical Pole Shaft Mounted (With Signal Bracketing)

Mount vehicle and pedestrian Signal Heads on a vertical pole shaft if shown on the Plans. Provide threaded 1 1/2 inch half-couplings capable of receiving threaded 1 1/2 inch signal brackets and provide for internal wiring within the vertical pole shaft. Weld the half-couplings into the vertical pole shaft 10 feet above the pole foundation. Position threaded couplings on the vertical pole shaft as specified in the Contract.

Mount vehicle and pedestrian Signal Heads as shown on the Plans. Provide plumb, securely assembled pole mounted assemblies that allow for internal wiring within the vertical pole shaft, signal brackets, and pipe fittings.

K.3 Vertical Pole Mounted (With Angle Mount Plumbizer)

Use angle mount plumbizers to plumb the vehicle and pedestrian Signal Heads mounted on vertical pole shafts.

Assemble the signal and pedestrian heads and angle mount plumbizers in accordance with manufacturer installation instructions.

Attach two vehicle Signal Sections below the mount. Attach the remaining vehicle Signal Sections above the mount. Attach the Signal Head and the angle mount plumbizer assembly to the pole as specified in the Contract.

Mount the pedestrian head below the Signal Head mount as specified in the Contract.

Install an angle and straight mount cap on the unused upper side of the angle mount when installing Pedestrian Signal Indications.

Use extended threaded pole adaptors if attaching a cluster head (dog house) style Signal Head assembly at the mount.

Use Signal Head mounting spacers if attaching four sections or five sections at the mount.

K.4 Pedestal Mounted (With Two Vehicle Straight Mount Plumbizers)

Use a straight mount plumbizer to mount vehicle and pedestrian Signal Heads plumb on pedestal shafts.

Attach two separate Signal Sections below the mount attach the remaining vehicle Signal Sections above the mount. Attach the Signal Head and the straight mount plumbizer assembly to the pole as specified in the Contract.

Use a universal hub to attach the straight mount plumbizer to the pedestal shaft. Using the manufacturer’s specific installation tool for captive fastener installation, attach the universal hub to the pedestal shaft in accordance to the manufacturer’s instructions. Install a PVC wireway between the universal hub and the entrance of the straight mount plumbizer.

Mount the pedestrian head on the bottom of the straight mount plumbizer as specified in the Contract. Use a universal hub to attach the straight mount plumbizer to the pedestal shaft. Using the manufacturer’s specific installation tool for captive fastener installation, attach the universal hub to the pedestal shaft in accordance with the manufacturer’s instructions. Install a PVC wire way between the universal hub and the entrance of the straight mount plumbizer.

Mount the pedestrian head below the Signal Head mount as specified in the Contract.

Install an angle and straight mount cap on the unused upper side of the angle mount when installing Pedestrian Signal Indications.

Use Signal Head mounting spacers if attaching four Signal Sections or five Signal Sections at the mount.

K.5 Mast Arm Mounted (With Straight and Angle Mount Plumbizer)

Use angle mount plumbizers to mount vehicle Signal Heads on traffic control signal mast arms at the extended end of the mast arm. Use straight mount plumbizers to mount vehicle Signal Heads at the mid arm position of the mast arm. Mount two Signal Sections below the mount and the remaining Signal Sections above the mount.

Mount two Signal Sections below the mount and the remaining vehicle Signal Sections above the mount. Attach the Signal Head and the straight mount or angle mount plumbizer assembly to the pole as specified in the Contract.

Use Signal Head mounting spacers if attaching four Signal Sections or five Signal Sections at the mount.

Provide vertical clearance from the bottom of the Signal Heads, including the backplates, to the pavement from 17 feet to 19 feet.

K.6 Signal and Pedestrian Indication Labeling

Label the Indications with the installation date as follows:

Place a date of installation on the back of the Indication.

Provide labels for the date of installation on the back of the Indication meeting the following requirements:

(1) Record the installation date on white self-adhering label
(2) Machine printed numbers
(3) Black text 1/2 inch tall
(4) Month/Year numeric format
(5) Suitable for placement in wet locations
(6) Paper based labels are not acceptable
(7) Place inside on the back of the Indication

K.7 Bagging

Use “gunnysacks” or other Material approved by the Engineer to bag vehicle and pedestrian Signal Heads after installation and until traffic control signal activation to indicate that the traffic control signal is not in operation. Maintain bagging as approved by the Engineer.

K.8 Anti-Seize and Lubricating Compound

Brush anti-seize and lubricating compound in accordance 3842, “Electrical Systems Compounds and Lubricants,” onto the threaded portions of signal bracketing, pipe fittings, mounting hardware, angle and straight mount plumbizer threaded nipples, and any threaded metallic fittings before installation.

K.9 Signal and Pedestrian Indication Documentation

For each signal and pedestrian Indication, submit to the Engineer, 4 copies of manufacturer’s warranty information showing the required 5 year warranty period (from date of installation), product invoice, and documentation showing name of manufacturer, model number, and serial number.

L LED Luminaire Installation

Provide LED luminaires as shown on the Plan. Wire luminaires continuously, without splices, from the Source of Power to the luminaire as specified in the Contract.

Provide a Department-approved wire holder that supports the luminaire cable/conductors within the end of the pole tenon near the connection point of the luminaire fitter.

Label each luminaire in accordance with 2545.3M.2.c, “Labeling Luminaires”

If a photocontrol unit is required orient the unit to face north.

After the luminaire shaft extension (davit pole) has been installed on the signal mast arm pole:

(1) Place the luminaire on the luminaire shaft extension tenon
(2) Place a level on the area provided on top of the luminaire, or if provided use the luminaire internal leveling bubble
(3) Level the luminaire side-to-side and front and front-to-back
(4) Tighten the luminaire fitter connection bolts to the recommended torque level provided by the manufacturer

M Wood Pole Installation

Place wood poles in the ground to a depth equal to 20 percent of the pole length. Excavate 8 inches larger than the diameter of the base of the pole and keep free from loose Material. Hoist the pole into place without damage. Plumb and rake as directed by the Engineer. Provide backfill utilizing selected Material as specified in 2451, "Structure Excavations and Backfills." Compact each Lift in accordance with 2451, "Structure Excavations and Backfills." Place the wood pole so that a void area does not display between the wood pole and backfill at the ground plane when placed under load.

N Traffic Control Signal Pedestal Installation

Use U-shaped, galvanized, metal shims in accordance with *Standard Plate 8129* to plumb traffic control signal pedestals as approved by the Engineer. Install traffic control signal pedestals on pedestal foundations *Standard Plate 8112*. Orient the pedestal base so the access door is 180 degrees from the Roadway centerline.

Install pedestal base and shaft in accordance with manufacturer's requirements.

If a separate (standalone) wind collar is provided drill a 5/16 inch pilot hole for a 5/16 by 3/4 roll pin. Install the roll pin to prevent the pedestal shaft from turning in the pedestal base.

Fill any gaps as a result of using leveling shims that exceed a 1/8 inch between the foundation and the pedestal base with 100 percent clear silicone sealant. Do not completely seal around the perimeter between the foundation and the pedestal base.

O Traffic Signal Mast Arm Pole Installation

Assemble and tighten the transformer base and pole in accordance with the pole manufacturer's installation instructions, and the *2015 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Install mast arm poles in accordance with 2545.3H "Pole Installation" and as specified in the Contract.

Hoist mast arm poles without mast arms attached into position.

Orient the transformer base so the access door is placed 180 degrees from the mast arm.

Attach no appurtenances (such as pedestrian push buttons, signs, etc.) to the transformer base that requires the drilling of holes in the transformer base.

Place 100 percent clear silicone sealant between the pole base plate where it meets the transformer base top to ensure a moisture proof seal between the pole and the transformer base.

Assemble and tighten the transformer base and pole in accordance with the pole manufacturer's installation instructions, and *the 2015 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Install mast arms, brackets, and other attachments to the vertical pole shaft without damage.

Ensure a moisture-free seal between access openings and covers use a clear, 100 percent silicone sealant to seal the access opening covers on the mast arm pole.

Repair and restore damaged areas to original condition as specified in the Contract or as approved by the Engineer.

Repair damage to galvanized finish in accordance with *ASTM A780 Annex A2, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings*. Only use zinc-rich paints found on *Approved/Qualified Products List* for “Signals.”

Install rodent intrusion barrier in accordance with 2545.3T, “Rodent Intrusion Barrier.”

Provide and install pedestrian push buttons as shown on the Plans.

O.1 APS Push Button Station

Install APS push button stations as shown the Plans.

Follow manufacturer’s installation instructions including cleaning and insertion of the anchor with adhesive.

Follow epoxy manufacturer’s required cure time prior to installing the pedestrian push button pedestal base.

Do not exceed manufacturer’s maximum torque values when tightening nuts holding the pedestal base.

Install a continuous 6 AWG green insulated grounding conductor from the pedestrian pedestal base grounding lug to the nearest handhole.

Exothermic weld 6 AWG green insulated grounding conductor to the ground rod installed in the handhole.

O.2 APS Pole Mounting Adaptors

Install APS pole mounting adaptors as shown on the Plans.

Do not install the APS pole adaptors on the pole above the transformer base access cover.

Do not install the APS pole adaptor on the transformer base.

Installation of the APS Pole mounting adaptor will require four 1/4-20 stainless steel bolts 1 inch long, flat washers, and lock washers.

Install the adaptor as follows:

(1) Drill and tap four 1/4-20 holes in the signal pole for APS pole adaptor mounting
(2) Paint the freshly drilled holes with zinc-rich paint found on the *APL* for “Signals”
(3) Provide a rubber grommet in the 1/2 inch hole to protect the 2C 14 AWG (Loop Lead-in)
(4) Place 100 percent clear silicone sealant between the pole and the mounting flange before assembly

Follow the APS button manufacturer’s installation instructions.

O.3 APS Pushbutton Mounting Spacers

Install APS pushbutton mounting spacers as shown on the Plans.

Installation of the APS Pushbutton will require 2 or 3 of the mounting spacers depending on the APS pushbutton manufacturer used.

When 3 spacers are required 1 will be used as a wire way for the low voltage communications cable.

Where the APS communications cable enters the aluminum pedestrian shaft a nonconductive sleeve is required to prevent abrasion to the cable assembly.

O.4 APS Push Button Units

Install accessible pedestrian push button units at the locations as shown on the Plans.

Each push button unit contains three custom components:

(1) Sign with Braille
(2) Push button with direction arrow
(3) Custom voice message as specified in the Contract

Ensure the button is placed at the correct location. Mount the button facing the pedestrian landing and parallel to the crossing.

Apply an approved electrical insulating coating to the APS wire termination blocks, after wire installation.

Provide electrical insulating coatings listed on *Approved/Qualified Products List* under "Signals."

Apply a bead of 100 percent clear silicone sealant around the top of the push button station housing where the push button comes in contact with the pole shaft.

P Crosswalk Pavement Markings

Provide and install preformed thermoplastic in accordance with 2582, "Pavement Markings."

Q Sign Installation

Q.1 Sign Post Mounted

Install in accordance with 2564 "Traffic Signs and Devices."

Q.2 Sign Panel Warning Stickers

Install Department furnished warning stickers on new sign panels in accordance with 2564.3, "Traffic Signs and Devices, Construction Requirements."

R Traffic Control Signal Cabinet Installation

Securely mount cabinets on Equipment pads to the concrete as approved by the Engineer.

Install rubber gasket sections, Department or Contractor provided, between the bottom of the aluminum cabinet flange and the Equipment pad. Leave a 1/2 inch gap in the gasket for water drainage.

S Fiber Optic Cable Installation

Install fiber optic cable in accordance with 2550.3A, "Cable Installation."

T Emergency Vehicle Preemption (EVP) Installation

Install EVP detectors and EVP confirmatory indicator light atop traffic control signal mast arms and, if specified in the Contract, atop traffic control signal pedestal shafts in accordance with the following:

(1) Install the detector, confirmatory indicator light, wiring, and connections in accordance with manufacturer's instructions
(2) Inform the Engineer of obstructions in line with the detector before installation
(3) Attach the detector and confirmatory indicator light to the traffic control signal mast arm or traffic control signal pedestal shaft to the satisfaction of the Engineer

(4) Provide any extension hardware with the same outside diameter as the traffic control signal bracketing framework, and use a reducer conduit fitting to attach the detector and indicator light assembly to the traffic control signal mast arm
(5) Paint extension hardware the same color as the traffic control signal mast arm; do not paint the detector and confirmatory indicator light assembly
(6) Securely tighten hardware
(7) Install and mount the detector and confirmatory indicator to ensure the watertight integrity of the assembly
(8) Provide a 6 inch vertical separation between the detector and confirmatory indicator light combination
(9) Install the detector shield tube with the drain hole at the bottom
(10) Do not splice detector cables from the EVP detector on the mast arm to the traffic control signal cabinet
(11) Mark the detector cable in the traffic control signal cabinet with its street and direction association
(12) Make one-way or two-way EVP detectors and one-way or two-way EVP indicator lights operational when the signal system is initially turned on
(13) Ensure each approach of the intersection detects an approaching Emergency Vehicle at a minimum distance of 1800 feet

T.1 EVP Confirmation Lamp Holder Modification

Disassemble the rubber washer and stainless steel holding clip on the lamp side of the Department-approved lamp holder. Remove the fiber washer from behind the rubber washer. Reinstall the rubber washer and stainless steel holding clip.

Install LED EVP confirmation indications in each confirmation lamp holder. Apply manufacturer-supplied dielectric grease to the indication base threads and pin at the time of installation.

U Painting

If specified in the Contract provide mast arm poles, traffic control signal mast arms, luminaire vertical pole shaft extensions, and luminaire mast arms, painted at the manufacturer.

Paint metal Structures and metal components of traffic control signal systems with finish coat paint if specified in the Contract and in accordance with 2478, “Organic Zinc-Rich Paint System,” and the following:

(1) Apply paint meeting the requirements of 3532, “Exterior Polyurethane Paint,” on mast arm pole vertical shafts, traffic control signal pedestal shafts, pedestal slipfitter collars, pedestal reinforcing collars (wind collars), signal brackets and pipe fittings, and pedestrian push button stations.
(2) For the first two coats, apply aluminum paint meeting the requirements of 3533, “Aluminum Polyurethane Paint,” to traffic control signal mast arms, luminaire vertical pole shaft extensions, and luminaire mast arms.

Remove any protective wrap provided by the manufacturer during shipping immediately after receipt of the shipment on the Project. Protect the factory applied finish when erecting the painted mast arm pole. Provide a collar for handling the pole made of a Material that will protect the painted finish of the pole.

Except for touch-up painting, do not field paint the mast arm poles. Use touch up paint provided by the manufacturer to repair and restore nicks, scratches, paint chips, or other damage to the finish as approved by the Engineer.

Do not field paint unpainted aluminum components of a traffic control signal system.

If a manufacturer's shop coat paint is accepted or specified in the Contract, make every effort during installation to protect the factory applied finish. Repair and restore damage to the finish as approved by the Engineer.

Use equivalent manufacturer's shop coat paint and field touch-up any damaged finish as approved by the Engineer.

V Existing Materials and Electrical Equipment

V.1 Removing and Salvaging

Remove and salvage electrical systems in accordance with 2104, “Removing Pavement and Miscellaneous Structures,” and as specified in the Contract at locations specified in the Contract or directed by the Engineer. Do not damage the removed and salvaged Materials and electrical Equipment during removal.

Take ownership of Materials and electrical Equipment of an existing electrical system required to be removed but not salvaged and dispose of the Materials and Equipment outside the Right-of-way, subject to 2104.3D.3, “Disposal Outside Right-of-way,” and as specified in the Contract.

V.2 Reinstalling

Where installing salvaged Materials and electrical Equipment at new locations provide and install Materials required to complete the new installation.

If the Engineer determines that existing Materials and electrical Equipment are unsatisfactory for reuse, replace the unsatisfactory Material with new Materials and electrical Equipment. If the salvaged Material was not damaged by removal the cost of the new Material and Equipment will be paid for as Extra Work in accordance with 1402, “Contract Revisions.”

V.3 Stockpiling

The Contractor may stockpile Materials and Equipment of an existing electrical system required to be removed and not reused on the Project until its removal outside the Right-of-way. Stockpile as approved by the Engineer.

W Field Testing

Before completing the Work, perform a functional test demonstrating to the Engineer that the traffic control signal components are fully functional. Do not activate the traffic control signal until completion of field tests and the Engineer approves the results.

Before final acceptance, provide the Engineer manufacturer’s warranties, instructions, and wiring diagrams of the Materials and Equipment provided to the Project.

X Activating Signals

Before activating traffic control signal systems, aim vehicle and pedestrian Signal Heads as directed by the Engineer. Notify the Engineer at least 48 hours before the scheduled traffic control signal activation.

Department personnel will activate the traffic control signal system unless otherwise directed by the Engineer. Provide assistance at the time of the Turn-On to ensure the traffic control signal system is operating correctly and safely. Provide parts and labor to correct malfunctioning components of the traffic control signal system. This requirement does not include Department-provided Material and components, except if damaged by the Contractor. Do not activate the signal system before the Engineer approves the operational signal system and its components, including the emergency vehicle preemption and the traffic control interconnection.

Do not turn the signal system ON, OFF, or in flashing mode unless approved by and in the presence of the Engineer.

Y Restoration and Cleanup

Replace or repair Sidewalks, curbs, gutters, pavements, base Materials, sod, or plants damaged or removed during the Contractor's operations as approved by the Engineer. Maintain reconstruction Work as approved by the Engineer until final acceptance.

Z Available Fault Current Calculations

Provide available fault current calculations as required by Article 110.24 of the *NEC* and as follows:

Provide calculations for the available fault current at the line side of the meter socket for each service.

Provide calculations for the available fault current at the first device connected to the line side of the 480/240 to 240/120 single phase step down transformer when present.

Provide and install labels for the calculation results meeting the requirements of 3844, "Labels."

2565.4 METHOD OF MEASUREMENT

The Emergency vehicle preemption system is measured as an integral unit complete-in-place and operating.

The Traffic control interconnect is measured as an integral unit complete-in-place and operating.

The APS push button station is comprised of the base, aluminum shaft, aluminum dome cap, mounting of hardware and components, anchor adhesive, wiring, connections, the APS push button, and other miscellaneous items required for a complete installation of the APS push button station with APS push button.

The APS push button and sign includes sign with Braille message, mounting, mounting hardware, wiring, connections, mounting of the APS push button, and other miscellaneous items required for a complete installation of the APS push button and sign.

The APS cabinet control unit is the complete APS cabinet control unit including interface boards and required wiring harnesses, mounting hardware, wiring, connections, mounting and installation of the APS cabinet control unit and other miscellaneous items required for a complete installation of the APS cabinet control unit.

The APS pole Mounting adaptor includes the APS pole mounting adaptor, mounting, mounting hardware, wiring, connections, mounting of the APS push button and sign, and other miscellaneous items required for a complete installation of the APS push button and sign mounted on an APS push button mounting spacer.

The APS push button mounting spacers includes three APS push button pole mounting spacers, mounting, mounting hardware, wiring, connections, mounting of the APS push button and sign, and other miscellaneous items required for a complete installation of the APS push button and sign mounted on a set of APS push button mounting spacers.

The Traffic control signal system is an integral unit complete-in-place and operating. The complete installation at one Intersection is considered as one unit.

2565.5 BASIS OF PAYMENT

The Department will pay for new Traffic control signal systems on the basis of the following schedule:

Item No	Item	Unit
2565.501	Emergency Vehicle Preemption System	lump sum
2565.501	Traffic Control Interconnect	lump sum
2565.502	APS Push Button Station	each
2565.502	APS Push Button & Sign	each
2565.502	APS Cabinet Control Unit	each
2565.502	APS Pole Mounting Adaptor	each
2565.502	APS Push Button Mounting Spacers	each
2565.516	Traffic Control Signal System	system

2571 PLANT INSTALLATION AND ESTABLISHMENT

2571.1 DESCRIPTION

This Work consists of providing, installing, and establishing trees, shrubs, vines, perennials, and turf of the species, variety, grade, size or age, and root category specified for the locations shown on the Plans, including planting or transplanting plants provided by the Department.

Perform this Work in accordance with the *Inspection and Contract Administration Manual for MnDOT Landscape Projects* (*ICAMMLP*), current edition at the time of letting.

2571.2 MATERIALS

A Nursery Plant Stock **3861**

Provide plants of the species shown on the Plans in the variety, grade, and size or age indicated.

A.1 Investigations and Supply of Planting Stock and Materials

By submitting a proposal and accepting Award of the Contract in accordance with 1205, “Examination of Proposal Package and Site of Work,” the Contractor assures commitments from suppliers, and delivery of the plant stock and Materials required to complete the Contract.

A.2 Plant Stock and Materials Documentation

Provide the following plant stock and Materials documentation:

(1) Fifteen Working Days prior to beginning plant installation and establishment Work, provide the Engineer with a Department-preliminary *Certificate of Compliance for Plant Stock, Landscape Materials, and Equipment* (copy of form provided in the current edition of *ICAMMLP*)

(2) At least five Working Days before plant stock delivery to the Project, provide the Engineer with the following:

(a) A copy of a valid nursery stock, dealer or grower certificate, registered with the Minnesota Department of Agriculture (MDA), a current nursery certificate or license from a state or provincial Department of Agriculture for each plant stock supplier, or both

(b) Documentation certifying that plant Material shipped from out-of-state nursery vendors subject to state and federal quarantines, is free of currently regulated pests, including Emerald Ash Borers, and Gypsy Moths. To determine if Minnesota vendors are subject to quarantines, call the MDA Supervisor of Nursery Inspection and Export Certification at (651) 201-6388

(c) An updated Certificate of Compliance, signed by the Contractor's authorized representative

(3) Upon delivery of plant stock and Materials to the Project, provide the Engineer with the following:

(a) Bills of lading or shipping documents for plant stock and landscape Materials delivered to the Project
(b) An updated and signed Certificate of Compliance, if necessary, to reflect deviations from the previous Certificate of Compliance documentation

(4) As a condition for authorization of payments, provide the Engineer with vendor invoices or billing statements for plant stock and Materials used on the Project

The Engineer will consider Work performed with plant stock, Materials, or Equipment that was misrepresented in the documentation, as unauthorized Work.

A.3 Substitutions

The Engineer may allow substitutions in accordance with 1605, "Substitute Materials." Upon receipt of written documentation that plants shown on the Plans are not available in quantities to fulfill the Contract requirements, the Engineer, in consultation with the Project designer, may authorize specific substitute plants or may extend the Contract Time to ensure availability of the plants shown on the Plans. Provide substitutions equal to or better than the initially specified Materials.

2571.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Landscape Specialist

Provide a Landscape Specialist, certified by the Department, to perform or supervise plant installation and establishment Work. Provide documentation of the Certified Landscape Specialist prior to beginning plant installation and establishment Work. Landscape Specialists may obtain certification by completing the 1-day Department Landscape Project Inspection and Administration Training Class and passing a test administered by the Department's Environmental Planning and Design Units. Full certification is valid for 3 years. Landscape Specialists may obtain provisional certification for 1 year by passing a test after completing the Department's online training class.

A.2 Notices by Contractor

Notify the Engineer at least 3 Calendar Days before planned deliveries of initial and replacement planting stock to the Project to allow for inspection scheduling. Notify the Engineer at least 24 hours before beginning or changing distinct operations. Include the following in the notice:

(1) The Project number
(2) Engineer's name
(3) Notification date
(4) Intended dates and times for the operations
(5) The planned locations of Work

Provide notifications in writing, using confirmable e-mail or facsimile transmissions.

A.3 Unauthorized Work

The Engineer will consider Work performed as follows to be unauthorized Work:

(1) Without required and acceptable documentation and notifications
(2) Without supervision by a certified landscape specialist
(3) Without conducting required and acceptable competency tests
(4) In conflict with the working hours of the Contract

A.4 Required Equipment

Provide Equipment meeting the requirements of 1805, “Methods and Equipment,” and with the following available on the Project at all times:

(1) At least 1 portable compaction tester capable of measuring compaction in the soil to at least 18 inches deep
(2) At least 1 soil recovery probe, or a soil moisture probe for assessment of soil moisture conditions
(3) At least 1 tree caliper with measurement readings in inches

B Preconstruction Work

Preconstruction Work includes:

(1) Attending a landscaping preconstruction meeting
(2) Submitting landscaping preconstruction documentation
(3) Mobilizing Equipment and supplies to the landscaping Project
(4) Protecting existing vegetation, resources, and property in accordance with the Plans, Special Provisions, and 1712, “Protection and Restoration of Property,” 2031, “Field Office and Laboratory,” 2557, “Fencing,” and 2572, “Protection and Restoration of Vegetation”

C Staking Planting Holes and Beds

Stake the exact locations and layouts for the landscape designer and Engineer’s approval.

To remedy unanticipated, localized, or seasonal conditions that may hinder plant establishment, the Contractor may request the Engineer’s approval to:

(1) Relocate plantings
(2) Make plant substitutions
(3) Modify soil or drainage characteristics

D Preparing Planting Holes and Planting Beds

To prevent site compaction and damage, do not Work in planting holes and bed areas if the soil moisture is greater than field capacity.

D.1 Utilities

Before cultivating soil or excavating holes on the Project, meet the requirements of 1507, “Utility Property and Service.”

The Contractor may request the Engineer’s approval to relocate plantings to avoid unanticipated conflicts with utilities.

D.2 Weed Control and Soil Cultivation

Apply herbicide to actively growing vegetation beginning in spring or fall. Before cultivating individual planting holes and bed areas, kill turf and weed growth within the limits of planting areas that will receive mulch in accordance with the following:

(1) Mow existing vegetation to at least 3 inches at least 7 Calendar Days before spraying herbicide. Remove the cuttings. Allow the vegetation to regrow to a height from 4 inches to 8 inches before applying the herbicide.

(2) At least 3 Calendar Days before applying herbicide, submit to the Engineer, labels of the intended herbicides and a copy of a valid MN Pesticide Applicator License, including Category A and Category J.

(3) Spray and kill turf and weeds, including the top growth and roots, only within designated areas using a non-selective, non-residual post emergent herbicide containing 41 percent glyphosate as the active ingredient. Ensure personnel, licensed by the MDA and experienced in the use of chemical pesticides perform the Work in accordance with the manufacturer’s instructions and recommendations. Apply the herbicide to dry foliage on actively growing vegetation. Apply the herbicide in August or early September before the fall or spring Plant Installation Period (PIP) as required by the Contract. If an August or September application is not possible for the spring PIP, apply the herbicide in late April or early May. If precipitation occurs within 6 hours after applying herbicide, reapply herbicide as needed to achieve 100 percent kill.

(4) Before beginning soil cultivation Work, schedule and perform a competency test to the satisfaction of the Engineer. The Engineer considers a satisfactory competency test one that demonstrates acceptable soil cultivation, incorporation of soil additives, compaction levels, and soil drainage in 1 planting bed area and 1 individual tree planting area.

(5) Before placing soil additives as shown on the Plans, use a spading machine to deep cultivate the planting hole and bed areas by loosening the soil to at least 12 inches deep and a compaction level of no more than 200 psi to this depth, as measured from the finished grade elevation of the soil. The Engineer may approve other Equipment to address site constraints, if requested by the Contractor. For hydraulic spade-type, machine-moved tree-transplanting, the Engineer will not require planting hole cultivation, other than loosening the soil outside the soil-ball perimeter in accordance with the Standard Plans shown on the Plans.

(6) Unless otherwise shown on the Plans, add 4 inches of Grade 2 compost, in accordance with 3890, “Compost” and other soil additives shown on the Plans or as requested by the Contractor and approved by the Engineer, over the cultivated planting hole and bed areas and use a spading machine to incorporate it to a depth of at least 12 inches, as measured from the finished grade elevation of the soil.

(7) Use a compaction tester to ensure compaction in the planting hole and bed areas does not exceed 200 psi to a depth of at least 16 inches. If Contractor-operations result in zones of hardpan or excessively compacted soil, repeat deep cultivation or de-compact the subsoil in accordance with 2106.3I, “Finishing Operations,” specifically the requirements for turf establishment areas, at no additional cost to the Department.

(8) Ensure drainage in the planting hole and bed areas. For suspected drainage problems, perform a percolation test by filling a 16 inches deep planting hole with water and measuring the time it takes the water to drain from the hole. The Engineer considers adequate drainage equal to or greater than a percolation rate of 1/2 inch per hour. If drainage does not meet these requirements, request approval from the Engineer to relocate or delete affected planting locations or proceed with Extra Work using one or a combination of the Standard Plans for poorly drained soils, as shown on the Plans.

(9) Apply Temporary Erosion Control Measures in accordance with the NPDES Permit, SWPPP notes, and 2573, "Storm Water Management." The Contractor may use Type 6 wood chip mulch at a depth no more than 1 inch for temporary erosion control in prepared planting bed areas.

D.3 Wet Soils, Rock, and Debris

If the Contractor encounters excessively wet soils, bedrock, or excessive quantities of boulders and construction debris, the Contractor may request the Engineer's approval to relocate or delete plantings, or modify soil or drainage characteristics in accordance with the alternative options in the Standard Plans shown on the Plans.

E Delivery and Storage of Plants

Before installation, the Engineer will provide for inspection and acceptance of plant stock delivered to the Project in accordance with the current edition of the *ICAMMLP* and 3861, "Plant Stock."

Install plant stock on the day of delivery to the Project unless using temporary storage methods. Before installation, keep the roots of plants completely covered with a moisture-holding Material consisting of wood chips, straw, sawdust, moss, or soil. Keep the moisture-holding Material continuously moist and protect it from drying winds, direct sunlight, excessive heat, freezing, low humidity, inadequate ventilation, and animal or human harm. Remove tree trunk sleeves prior to inspection, acceptance, and planting. The Engineer will consider plants with damage that occurred or was discovered during temporary storage, unacceptable. Do not store plants from one planting season to the next.

E.1 Pruning — Top Growth and Roots

Immediately before planting, prune the roots of bare-root plants, except seedlings, and the top growth of deciduous plants. Cut-back broken or badly bruised roots and dry root tips to sound, healthy tissue. Prune to remove dead, rubbing, damaged, diseased, and suckering branches, and to improve plant symmetry, structure, and vigor. Prune coniferous trees and shrubs only to remove damaged growth or a competing leader.

Prune in accordance with the horticultural practices specified in the current edition of the *ICAMMLP* and the Standard Plans on the Plans.

Do not prune oak trees during the oak wilt season from April through July, to prevent the spread of oak wilt disease. Immediately treat accidental cuts or wounds to oaks with a wound dressing in accordance with the Standard Plans shown on the Plans. Keep wound-dressing Material on the project during the oak wilt season.

E.2 Buried Root Flares

The Engineer will consider container-grown and balled and burlapped plant stock unacceptable if provided with more than 4 inches of soil depth above the root flare. The Engineer may accept plants provided with no more than 4 inches of excess soil above the root flare if the excess soil can be removed without damaging the root system of the plants.

E.3 Excessive Roots

Reject containerized or balled and burlapped plants with roots extending at least 4 inches beyond the container or burlap.

F Installation of Plants

F.1 General

Before proceeding with plant installation Work, schedule and perform a competency test demonstrating acceptable plant installation methods to the Engineer's satisfaction and in accordance with the Plans and Standard Plans, for each plant Pay Item and root category on the

Project. The Engineer considers a satisfactory competency test to be one that demonstrates acceptable handling of plants, digging of holes and beds, installation of plants, initial watering, installation of protection Materials and mulching.

Before digging planting holes, rake temporary erosion control wood chip mulch off prepared planting areas to prevent wood chip contamination of the planting soil in the holes.

The Contractor may respread wood chip mulch formerly used as temporary erosion control around plants to a depth no greater than 1 inch following plant installation, if newly provided and acceptable Type 6 mulch is applied over the top to the depth shown on the Standard Plans in the Plans.

Dig planting holes to the configuration and minimum dimensions shown in the Standard Plans on the Plans. If the soil moisture is greater than field capacity, do not Work in planting holes and beds.

Ensure drainage in the planting hole and bed areas. For a suspected drainage problem, perform a percolation test by filling a 16 inches deep planting hole with water and measuring the time it takes the water to drain from the hole. The Engineer considers adequate drainage equal to or greater than a percolation rate of 1/2 inch per hour. If drainage does not meet these requirements, request approval from the Engineer to relocate or delete affected planting locations or proceed with Extra Work using one or a combination of the Standard Plans for poorly drained soils as shown on the Plans.

G Watering

Provide watering Equipment and forces on the Project capable of completely watering plants as often as necessary to maintain soil moisture in the root zones.

Within 2 hours of installation, saturate the backfill soil of each plant with water. After settling, provide additional backfill to fill in the voids.

H Mulch

Before placing mulch, fine grade and level the planting bed soils with hand tools. Place mulch Material in accordance with the Plans and Standard Plans no more than 7 Calendar Days after plant installation. Mulch contaminated with soil during installation or otherwise not complying with the requirements of 3882, “Mulch Material,” is unacceptable. Remove unacceptable mulch from the Project.

I Protection of Installed Trees

Use protective Materials to ensure the healthy growth and survival of installed trees. Tree protection measures to address fall/winter environmental conditions must be removed the following spring.

I.1 Staking and Guying

Unless staking and guying is shown on the Plans, only stake and guy trees if necessary to maintain the trees in a plumb condition. The following circumstances may warrant staking and guying:

(1) Excessive soil moisture
(2) Light-textured soil
(3) Steep slopes
(4) Exposure to excessive wind
(5) The likelihood of vandalism

Install staking and guying in accordance with the Standard Plans shown on the Plans.

Remove staking and guying within 1 year of initial installation.

I.2 Rodent Protection

Place rodent protection around deciduous, pine, and larch trees in accordance with the Standard Plans shown on the Plans.

I.3 Seedling Tree Shelters

Install seedling tree shelters in accordance with the Standard Plans shown on the Plans.

J Cleanup and Restoration Work

Perform the following cleanup and restoration Work on an ongoing basis and as the final step of the initial planting operations:

(1) Remove excess Materials, rocks, and debris from the Project

(2) Repair turf in disturbed areas with seed mixes as shown on the Plans or to match in-place turf

(a) Immediately before sowing seed or laying sod, prepare soil as specified in 2574.3, "Construction Requirements"

(b) Uniformly broadcast a Type 4 natural base fertilizer, as specified by 3881.2B.4, "Type 4 - Natural Based Fertilizer," that provides nitrogen at an application rate of 43 lb/acre

(c) Lay sod, or uniformly broadcast seed at 1.5 times the rate specified in Table 3876.2-1. Provide seed in accordance with the requirements of 3876, "Seed" and perform seeding in accordance with Table 2575.3-1

(d) Rake and firm seeded areas to ensure seed contact with the soil

(e) Broadcast or disc anchor Type 1 mulch in all seeded areas

(3) Install erosion control measures to prevent erosion

K Plant Establishment Period

K.1 Establishment Period

A Plant Establishment Period (PEP) of at least 2 calendar years begins on the date that initial planting operations on the Project are completed and continues until final acceptance of the Project, unless otherwise shown on the Plans.

K.2 Establishment Work

Keep plants in a healthy growing condition in accordance with the current edition of the *ICAMMLP* throughout the establishment period and submit landscape Contractor scouting reports in accordance with item 1 of 2571.3K.2.a, "All Plants." Perform plant establishment Work throughout the growing seasons from April through October and as necessary during the dormant seasons from November through March. The Engineer may perform random inspections throughout the PEP to verify compliance. The Engineer will consider the Contractor non-compliant if the Contractor does not maintain plants throughout the PEP and does not submit scouting reports.

K.2.a All Plants

In plant establishment Work, perform the following:

(1) Scout to assess the condition of the plants and the planting site and factors that may influence plant health, vigor, and establishment success. Scout these conditions at least every two weeks during the growing season and at least every month during the dormant season

(2) Submit a written scouting report to the Engineer via e-mail by the 1st and 15th of each month during the growing season from April to October and by the 1st of each month during the dormant season from November to March. The Engineer will use the report-frequency and content to assess plant establishment compliance. The report may include scanned copies of the Plan sheets with the Contractor notes, copies of the report form found in the current edition of the *ICAMMLP*, or both. Include the following in the report:

(a) The Project number
(b) Engineer's name
(c) Name of Contractor's responsible scout or representative
(d) Dates Work was performed
(e) Work locations
(f) Work completed
(g) Prevailing weather conditions
(h) Soil moisture assessments
(i) Insect, animal, vehicular, weather, or other damage
(j) Disease problems
(k) Treatment recommendations
(l) Assessment of overall plant conditions including weed competition and control

(3) Maintain soil moisture in accordance with the watering guidelines of the Standard Plans shown on the Plans
(4) Repair, adjust, or replace staking and guying, planting soil, rodent protection, seedling tree shelters, and other items in accordance with the Plans
(5) Maintain healthy, vigorous plants; free of harmful insects, fungus, and disease without the use of systemic insecticides such as neonicotinoids
(6) Remove dead, dying, and unsightly plants. Provide and install replacement plants in accordance with 2571.3K.2.b, "Replacement Requirements"
(7) Maintain plants in a plumb condition at the planting depth shown on the Standard Plans in the Plans
(8) Maintain planting areas in a weed-free condition as follows:

(a) Remove weeds, top growth, and roots within the mulch limits by hand pulling. Pre-water mulched areas to ensure weed top growth and roots are entirely removed. Ensure weeding operations do not contaminate the mulch or Project with weed seed, weed-laden soil, or propagating weed parts. Remove State and County regulated noxious weeds to at least 5 feet beyond the mulch limits. Remove weed parts or weed-laden Material from the Project to avoid the spread of weed infestations
(b) Do not spray chemicals for weed control in mulched planting areas during the PEP. The Contractor may apply a non-selective, non-residual post-emergent herbicide containing 41 percent glyphosate, as the active ingredient with a surfactant on a spot treatment basis with a brush or wick applicator. The Contractor may also apply a broad-spectrum

dichlobenil based granular, pre-emergent herbicide in accordance with product labeling and manufacturer's recommendations

(c) Do not weed whip or weed clip as weed control

(d) Mow turf bands around the mulch limits at least 5 feet beyond the limits and at least 4 inches high if the turf height exceeds 9 inches adjacent to mulched planting areas

(e) Mow turf areas installed as part of the Project when the growth exceeds 18 inches high. Mow turf from 6 inches to 12 inches high. Control State and County-listed noxious weeds

(9) Prune to remove dead, rubbing, damaged, or diseased branches, unwanted suckers, and to improve plant form and structure

(10) Prevent or repair rutting and other damage that may lead to soil erosion and weed infestation

(11) Perform plant establishment operations consistent with plant care and horticultural practices detailed in the current edition of the *ICAMMLP*

(12) Remove excess Material, obsolete temporary erosion control devices, rocks, and debris from the Project

K.2.b Replacement Requirements

Within the first year of the 2-year PEP, determine which plants need replacing. Replace dead, defective, or missing plants and Materials in accordance with initial installation requirements, including plants lost due to accidents, vandalism, theft, rodent damage, damage caused by the Contractor, or if ordered by the Engineer, at no additional cost to the Department. Conduct plant replacement operations during the month of May or September, based on the start of the PEP. At least 7 Calendar Days before plant replacement, submit a summary report of proposed plant replacements to the Engineer. Include by attachment, copies of Plan sheets with the proposed replacement quantities and locations identified and a Department Certificate of Compliance for Plant Stock, Landscape Material, and Equipment, in the report. Using brightly colored paint, mark on site plants requiring replacement.

Provide replacement plants and Materials that are equal to or better than the initial Material required by the Contract.

If less than a full year remains in the PEP, do not replace plants unless the PEP is extended by a Change Order to provide at least one full year of establishment care.

L Acceptance of Work

L.1 Acceptance of Preconstruction Work

The Engineer will accept the preconstruction Work after the Contractor secures commitments for required Materials, submits a Department Certificate of Compliance for Plant Stock, Landscape Materials, and Equipment, participates in a preconstruction meeting, obtains the Engineer's approval for the Progress schedule, moves Equipment and supplies to the Project, and provides protection for existing plants.

L.2 Acceptance of Preparation of Planting Holes and Beds

For the Engineer's acceptance of preparation of planting holes and beds, complete a competency test, other specified staking, initial weed control, soil cultivation including incorporation of additives, and temporary erosion control Work.

L.3 Acceptance of Initial Planting Operation

The Engineer will accept initial planting operations based on the following:

(1) Plant stock acceptance
(2) Completion of a competency test
(3) Installation of individual plants
(4) All Material and Work items shown in the initial planting operations chapter of the current edition of the *ICAMMLP*, including but not limited to watering, tree protection Materials, mulching, proper drainage, pruning, staking and guying, fertilizing, erosion control, seeding, and clean up, in accordance with 1516.2, “Project Acceptance.”

L.4 Final Acceptance

As a condition for terminating the PEP and conducting the final inspection, the Engineer may require the Contractor to bring the plant establishment Work into compliance.

On or about the date of termination of the PEP, the Engineer will perform a final inspection of the Project.

Upon final acceptance, the Engineer will not require further Contractor-care of plantings.

The Engineer will make final acceptance at the completion of the two-year PEP and based on a final inspection of the completed Project.

2571.4 METHOD OF MEASUREMENT

The Engineer will measure plants separately by the number of acceptable plants for each Contract Item in accordance with 2571.5G, “Payment Schedule.”

2571.5 BASIS OF PAYMENT

The Department will make payment for plant installation and establishment at a percentage of the Contract Unit Price per item unit of measure for all costs relating to furnishing, installing, and establishing, the required plants and associated Materials as specified and shown on the Plans.

The Department may make full payment, reduced payment or no payment of no more than the maximum eligible partial payment percentage at any payment phase (initial, interim, final) based on the performance of the Contractor and in accordance with 1906, “Partial Payment,” and 1908, “Final Estimate and Payment – Conditions and Process.”

A Initial Payment

The Department will make payment for plant installation and establishment at a percentage of the Contract Unit Price for each plant for completion of the following Work:

A.1 Preconstruction Work

The Department will pay no more than 10 percent of the Contract Unit Price for each plant with the completion and acceptance of preconstruction Work as defined in the Preconstruction Work Checklist in the current edition of the *ICAMMLP*.

A.2 Preparation of Planting Holes and Beds

The Department will pay no more than 15 percent of the Contract Unit Price for each plant with the completion and acceptance of preparation of planting holes and beds Work as defined in the Preparation of Planting Holes and Beds Checklist in the current edition of the *ICAMMLP*.

A.3 Initial Planting Operations

The Department will pay no more than 45 percent of the Contract Unit Price for each plant with the completion and acceptance of initial planting operations Work as defined in the Initial Planting Operations Checklist in the current edition of the *ICAMMLP*.

B Interim Payment

At the end of the first calendar year of the PEP, and after completion and acceptance of the Contractor's Work and continuous compliance with the plant establishment requirements as defined by the Plant Establishment-Year One Checklist in the current edition of the *ICAMMLP*, the Engineer may authorize no more than 15 percent of the Contract Unit Price for each plant.

C Final Payment

The Department will make final payment after final inspection and acceptance of the completed Project at the end of the PEP. The Engineer may authorize no more than 15 percent of the Contract Unit Price for each plant as defined by the Plant Establishment Year 2 Checklist in the current edition at the time of letting of the ICAMMLP. The total final payment includes the Plant Establishment Year 2 payment, assessments and reduced payments, if any, and Incentive payment, if eligible.

The Department will not pay for replacement plants, unless authorized by the Engineer.

The Department may continue to withhold any percentage of initial and interim payments from the final payment.

The Department will require a prompt refund of any overpayment, if the final voucher shows that the total of initial and interim payments made exceeds the total amount due the Contractor.

D Incentive Payment

When 90 percent or more of all plants installed within the initial plant installation period (PIP) and related Contract operations have been continuously acceptable throughout the Contract period, the Department will make an Incentive payment of 10 percent of the total final Contract Unit Price for plant installation and establishment.

The Department considers replacement plants, replaced during the initial PIP, to be initially installed plants. Replacement plants made during the PEP are not eligible for Incentives.

E Withholdings

E.1 Plant Stock and Materials Documentation

If the Contractor does not provide the documentation required by 2571.2A.2, "Plant Stock and Materials Documentation," the Department may withhold a percentage of the PIP payment as described in checklist B2, in accordance with the current edition of *ICAMMLP*.

E.2 Plant Establishment Period

The Department may withhold a percentage of the PEP payment as described on checklist B9-B10, in accordance with the current edition of *ICAMMLP*.

F Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Plant Installation and Establishment. The amounts of these adjustments are deemed reasonable.

The Department may make full payment or apply a monetary deduction of no more than the maximum eligible partial payment percentage at any payment phase (initial, interim, final) based on the performance of the Contractor (see Payment Checklist in the current edition of the *ICAMMLP*).

The Engineer will determine which plants to accept for payment at the Contract Unit Price or at a monetary deduction.

G Schedule

The Department will pay for plant installation and establishment on the basis of the following schedule:

Item No.	Item	Unit
2571.502	Coniferous Tree Size & Root Category	each
2571. 502	Deciduous Tree Size & Root Category	each
2571. 502	Ornamental Tree Size & root Category	each
2571. 502	Transplant Tree (Spade Size*)	each
2571. 502	Coniferous Shrub Size & Root Category	each
2571. 502	Deciduous Shrub Size & Root Category	each
2571. 502	Transplant Shrub	each
2571. 502	Transplant Vine	each
2571. 502	Vine Age or Size & Root Category	each
2571. 502	Perennial Age or Size & Root Category	each
2571. 502	Transplant Perennial	each

NOTE: State Root Category: Seedling, Bare Root, Machine Moved, Container Grown, Balled and Burlapped

* Spade size: 42 inch, 60 inch, 78 inch, 85 inch, 90 inch.

2572 PROTECTION AND RESTORATION OF VEGETATION

2572.1 DESCRIPTION

This Work consists of protecting and preserving vegetation from damage and restoring vegetation damaged by the Contractor's operations.

2572.2 MATERIALS

A Plant Materials .... 2571 and 2575

B Temporary Fence

Provide temporary fence meeting the following characteristics and requirements:

(1) At least 4 feet
(2) Conspicuous in color (see Standard Detail Sheet for Protection and Restoration of Vegetation)
(3) Commercially available snow fence or other fencing Material approved by the Engineer

C Water

Provide municipal potable water or harvested ground water for irrigation.

D Rooting Topsoil Borrow 3877

E Tree Growth Retardant (TGR)

Provide the TGR paclobutrazol or an equal approved by the Engineer.

2572.3 CONSTRUCTION REQUIREMENTS

A Protecting and Preserving

Protect and preserve the following:

(1) Specimen Trees
(2) Threatened and endangered plants listed on the Federal and State threatened and endangered species list
(3) Vegetation as required by the Contract
(4) Trees, Brush, and natural scenic elements within the Right-of-way and outside the limits of clearing and grubbing in accordance with 2101.3, “Clearing and Grubbing, Construction Requirements”
(5) Other vegetation as directed by the Engineer

Do not place temporary Structures, store Material, or conduct unnecessary construction activities within 25.25 feet outside of the dripline of trees designated for preservation, unless otherwise approved by the Engineer.

Do not place temporary Structures or store Material, including common borrow and topsoil, outside of the construction limits in areas designated for preservation, as required by the Contract or as approved by the Engineer.

Do not place or leave waste Material on the Project, including bituminous and concrete waste that would interfere with performing the requirements of 2106.3D, “Preparation of Embankment Foundation,” or 2575, “Establishing Vegetation and Controlling Erosion.” The Department defines concrete waste as excess Material not used on the Project, including Material created from grinding rumble strips. Dispose of excess Material in accordance with 2104.3D, “Disposal of Materials and Debris.”

A.1 Temporary Fence

Place temporary fences to protect vegetation before starting construction. Place temporary fence at the construction limits and at other locations adjacent to vegetation designated for preservation as required by the Contract or as approved by the Engineer. The Department will provide tree protection signs. Place tree protection signs in accordance with any of the following:

(1) Along the temporary fence at 50 foot intervals
(2) At least 2 signs per fence
(3) As directed by the Engineer

Do not remove the fence until all Work is completed or until approved by the Engineer.

Ensure the fence prevents traffic movement and the placement of temporary facilities, Equipment, stockpiles, and supplies from harming the vegetation.

A.2 Clean Root Cutting

Cleanly cut tree roots at the construction limits as required by the Contract or as directed by the Engineer.

Immediately and cleanly cut damaged and exposed roots. Cut back damaged roots of trees designated for protection to sound healthy tissue and immediately place topsoil over the exposed roots. Immediately cover root ends exposed by excavation activities with 6 inches of topsoil as measured outward from the cut root ends. Immediately (within 5 minutes) treat cut oak roots with a wound dressing Material consisting of latex paint or shellac. Limit cutting to a minimum depth necessary for construction. Use a vibratory plow, or other approved root cutter in accordance with the Standard Detail Sheet for Protection and Restoration of Vegetation, before excavation.

A.3 Watering

Water root-damaged trees during the growing season that root damage occurs, and water Specified Trees if required by the Contract or directed by the Engineer. Maintain adequate but not excessive soil moisture by saturating the soil within the undisturbed portion of the dripline of impacted or identified trees to a depth of 20 inches. Use a soil recovery probe to check the soil moisture to a depth of 20 inches, and adjust the intervals and frequency of watering in accordance with prevailing moisture and weather conditions.

A.4 Rooting Topsoil Borrow

Place rooting topsoil borrow instead of common topsoil borrow within the dripline of Specimen Trees as required by the Contract or as directed by the Engineer.

Place the topsoil to avoid over-compaction as approved by the Engineer. Establish turf consistent with the adjacent areas as approved by the Engineer.

A.5 Utility Construction

Bore under roots of trees designated for preservation for utility installations within the tree protection zone in accordance with the following:

Table 2572.3-1
Tree Protection Zone

Tree diameter at 4.5 feet above ground, inch	Minimum distance from face of tree trunk, feet	Minimum depth of tunnel, feet
<2	2	3
2–4	4	3
>4–9	6	3
>9–14	10	3
>14–19	12	3.25
>19	15	4

Do not perform open trenching within the tree protection zone.

Bore under areas of native prairie and protected plant species as required by the Contract or as directed by the Engineer.

A.6 Pruning

Provide an arborist certified by the International Society of Arboriculture to prune trees as required by the Contract or as directed by the Engineer in accordance with 2571.3E.1, “Pruning – Top Growth and Roots.” Ensure the arborist removes dead, broken, rubbing branches, and limbs that may interfere with the existing and proposed Structures.

A.7 Destroyed or Disfigured Vegetation

Restore vegetation designated on the Plans for preservation that is damaged or disfigured by the Contractor’s operations at no additional cost to the Department. Restore the damaged vegetation to a condition equal to what existed before the damage. The Engineer may assess damages against the Contractor for damage to vegetation not restored to the previous condition. The Engineer will assess the value of damages to trees and landscaping at not less than the appraisal damages as specified in the Council of Tree and Landscape Appraisers *Guide for Plant Appraisal*. The Engineer will determine and assess damages of other vegetation.

A.8 Oak Trees

Avoid wounding of oak trees during April, May, June, and July to prevent the spread of oak wilt. If the Engineer determines that Work must take place near oak trees during those months, immediately (within 5 minutes) treat resulting wounds with a wound dressing Material consisting of latex paint or shellac. Blend paint colors with the bark color. Maintain a supply of approved wound dressing on the Project at all times during this period.

A.9 Tree Growth Retardant (TGR)

Provide an arborist certified by the International Society of Arboriculture to treat trees with the TGR as required by the Contract or as directed by the Engineer. Ensure the arborist applies the TGR paclobutrazol as a basal drench or soil injection and in accordance with the label directions. Provide the Engineer with the product label and Material Safety Data Sheet for the product used.

A.10 Other Vegetation Protection Measures

Provide other vegetation protection measures including root system bridging, compaction reduction, aeration, irrigation systems, J-barriers for Specimen Tree protection, and retaining walls as required by the Contract or as directed by the Engineer.

B Quarantined Wood.. 2101.3D.4

C Plant Installation 2571

D Disposal of Material and Debris.. 2104.3D

2572.4 METHOD OF MEASUREMENT

A Temporary Fence

The Engineer will measure temporary fence placed, maintained, and removed by length along the bottom of the fence between end posts.

B Clean Root Cutting

The Engineer will measure clean root cutting by length along the plow line. The Engineer will determine the beginning and ending points for clean root cutting as the intersection of the construction limit and the dripline of the tree or Brush or in accordance with lines shown on the Plans.

C Water

The Engineer will measure water by volume used to protect and restore vegetation. The Engineer will not measure water otherwise used in performing the Work, such as for maintenance of sod.

D Rooting Topsoil Borrow

The Engineer will measure rooting topsoil borrow by loose volume as required by the Contract.

E Pruning

The Engineer will measure pruning by the hours of actual pruning Work.

F Tree Growth Retardant (TGR)

The Engineer will measure TGR by volume of Material applied for the size of the tree treated. The Engineer will determine the volume of TGR required by the diameter at breast height (DBH) of each tree treated. DBH is defined as 4.5 feet above ground level. The Engineer will use a diameter tape measure to measure DBH.

2572.5 BASIS OF PAYMENT

The Department will include the cost of the following with other relevant Contract Items:

(1) Boring under roots in the tree protection zone, dressing of wounds, and disposal of Material and debris
(2) Pruning made necessary to allow for the Contractor's operations

The Department will pay for protection and restoration of vegetation based on the following Unit Prices, in the absence of Contract Unit Prices:

Table 2572.5-1
Protection and Restoration of Vegetation Items

Item	Unit Price
Temporary fence	$2.50 per foot
Clean root cutting	$3.50 per foot
Water	$3.00 per 100 gallon
Prune trees	$75.00 per hour
Tree growth retardant	$8.00 per diameter inch

The Department will pay for protection and restoration of vegetation on the basis of the following schedule:

Item No.	Item	Unit
2572.503	Temporary Fence	linear foot
2572.503	Clean Root Cutting	linear foot
2572.506	Tree Growth Retardant	gallon
2572.506	Water	gallon
2572.510	Prune Trees	hour

The Department will pay for rooting topsoil borrow (3877, "Topsoil Material,") on the basis of the schedule in 2574.5B, "Soil Preparation, Schedule."

2573 STORM WATER MANAGEMENT

2573.1 DESCRIPTION

This Work consists of managing storm water runoff and Project related water discharges to minimize sediment pollution and managing the discharges associated with dewatering and basin draining activities.

2573.2 MATERIALS

A Water Treatment **3875**

B Mulch **3882**

C Silt Fence **3886**

D Flotation Silt Curtain **3887**

E Temporary Slope Drain **3892**

F Sandbags **3893**

G Sediment Control Log **3897**

H Flocculants **3898**

2573.3 CONSTRUCTION REQUIREMENTS

A General

Manage stormwater by routing of water, temporary diversions/flumes, bypasses, and avoidance measures. Schedule, construct, maintain, or install temporary sediment control and storm water management measures as required by the Contract.

Adjust the installation location of temporary stormwater management and sediment control devices, as shown on the Plans, to better accommodate the actual field conditions and increase the effectiveness of a device.

A.1 Erosion Control Supervisor

Provide an Erosion control supervisor with a valid Minnesota Erosion and Stormwater Construction Site Management certification, authorized to represent the Contractor regarding meeting contractual requirements for erosion and stormwater management and Work in public waters. The certification is obtained from a Department approved provider.

The Erosion control supervisor shall be available to the Work site within 24 hours of initial disturbance and at the site daily when Work is taking place until final stabilization. The following list describes the duties of the Erosion control supervisor:

(1) Implements the Quality Control program per 1717, “Air, Land, and Water Pollution”
(2) Ensures proper installation, functionality, and maintenance, clean-up, and removal of all erosion and sediment control Best Management Practices (BMPs) and in accordance with manufacturer’s recommendations
(3) Implements the erosion and sediment control schedule
(4) Coordinates the Work of Subcontractors and ensures the full execution of erosion and sediment control measures for each operation and stage of Work
(5) Oversees the Work of Subcontractors and ensures the Subcontractors undertake erosion and sediment preventive measures at each stage of the Work
(6) Attends construction meetings to discuss the Erosion Control Schedule and inspections
(8) Provides for erosion and sediment control methods for temporary Work not shown on the Plans
(10) Ensures effective preventative BMPs are in place, recommends BMP changes for the Engineer’s approval, and amends the SWPPP per 1103, “Definitions,” or construction Plan sheets to document changes
(11) Ensures acquisition of and compliance with applicable permits for borrow pits, dewatering, and temporary Work in rivers, lakes, and streams
(12) Ensures the full installation of erosion and sediment control Work before suspension of the Work
(13) Coordinates with federal, State, and local regulatory agencies on resolution of erosion and sediment control issues resulting from the Work
(14) Ensures that proper cleanup occurs from vehicle tracking on paved surfaces locations where sediment leaves the Right-of-way
(15) Ensures daily compliance with environmental laws, permits, and Contract requirements
(16) Ensures that installers of erosion and sediment control have proper certifications per 2573.3A.2, “Certified Installers”

The Erosion control supervisor is authorized to install, fix, or repair erosion or sediment control practices when a certified installer is unavailable.

A.2 Certified Installers

Provide a certified installer to install or to direct installations of erosion or sediment control practices and for the following:

(1) Seeding
(2) Sodding
(3) Mulching
(4) Silt fence or other perimeter sediment control device installations
(5) Rolled Erosion Prevention Products (REPP) installation
(6) Hydraulic erosion control product installation
(7) Silt curtain installation
(8) Ditch check installation
(9) Compost installation

Provide at least one installer with a valid Minnesota Erosion and Stormwater Construction Installer Certification at the time of installation. The certification is obtained from a Department approved provider.

A.3 Areas of Environmental Sensitivity

Schedule and phase construction in and around Areas of Environmental Sensitivity (AES), as shown on the Plans to minimize the potential of sediment entering into these areas. Use measures such as hand clearing and grubbing, limiting bare soil exposure time, expediting construction Activities, and immediately establishing final vegetation to minimize sediment loss potential.

A.4 Construction of Temporary Sediment Basins and Traps

Construct temporary sediment basins concurrently with the start of soil disturbing Activities. Direct storm water runoff from drainage areas to the basins. Stabilize the exposed side slopes of the basins. Provide an outlet to the basin that discharges water from the surface, separates floatables, and provides scour protection or energy dissipation.

A.5 Temporary Sediment Control Measures

Install perimeter, inlet, and exit sediment control measures before, or in conjunction, with soil disturbing Activities.

Recover sediment, restore property to the pre-existing conditions for loss of sediment off the Project, or both at no additional cost to the Department.

A.6 Dewatering and Pumping

Provide a water treatment Plan for turbid or sediment laden water. Submit the water treatment Plan to the Engineer before pumping. Do not begin Work until the Engineer accepts the water treatment Plan including any Contractor required permits. Include in the water treatment Plan the use of sediment traps, vegetative filter strips, flocculants, or other water treatments per 3875, “Water Treatment.”

Protect the discharge location of the dewatering process from erosion. Unless otherwise required by the Contract, provide and install the BMPs to control erosion and suspended sediment during the dewatering or pumping operation.

A.7 Suspension of Grading

Shape exposed soil and incorporate temporary and Permanent Erosion Control Measures as approved by the Engineer before suspending grading operations.

A.8 Related Work

Control drainage, erosion, and pollutants on the Work related to the Project including: Designated Haul Roads, temporary construction, waste disposal sites, plant and storage locations, and borrow pits other than commercially operated sources. Maintain the area, shape the area, install temporary BMPs, replace topsoil, and establish vegetative cover on areas where the potential for pollution has been increased due to the Contractor's operations. Waste disposal sites, borrow pit areas, or other related Work located outside of the Right-of-way may require separate permits.

B Silt Fence Installation

B.1 Type PA Preassembled

Install preassembled Silt fence with attached wooden stakes in small areas less than 1/4 acre. Pound stakes at least 1.5 feet into the ground. Install the geotextile with the selvage edge on top. Place the bottom edge of the geotextile into a trench 6 inches deep and 6 inches wide. Backfill and tamp the trench for compaction.

B.2 Type MS Machine Sliced

Mechanically install the geotextile with the selvage edge on top. Place the geotextile directly behind the soil-slicing blade as it works to achieve consistent placement and depth. Do not plow soil if using the slicing method. Roll the wheels of a tractor or skid steer on each side of the geotextile at least 2 times to compact the soil immediately next to the geotextile.

Install posts adjacent to the back face of the geotextile with the post studs facing away from the geotextile fabric. Secure each post by inserting 3 plastic ties through the geotextile. Space the posts a maximum of 6 feet on center.

B.3 Type HI Hand Installed

Install the geotextile by hand with the selvage edge on top in areas inaccessible by a machine. Install the bottom 8 inches to 12 inches of the geotextile with one of the following methods:

(1) Place the geotextile fabric into a trench 6 inches deep and 6 inches wide with the bottom edge of the geotextile wrapping back up to the soil surface. Backfill and compact soil
(2) In areas where soils prohibit hand trenching, place the geotextile on the ground on the front face and covered with crushed rock or p-gravel at least 12 inches wide and 6 inches high to provide for as a filter

Install posts adjacent to the back face of the geotextile with the post studs facing away from the geotextile fabric. Insert 2 plastic ties to secure it to each post. Space the posts a maximum of 6 feet on center.

B.4 Type SD Super Duty

Place the bottom edge of the geotextile from 4 inches to 6 inches underneath the face of the median barrier exposed to direct storm water runoff. Place the median barriers end to end to minimize the gap between each barrier. Attach the geotextile to the face of the barrier with wire or plastic ties and tie to each eyelet on the barrier.

B.5 Type TB Turbidity Barrier

Use turbidity barriers to isolate the Work zone from the watercourse. Install the turbidity barrier as close to the Work area as possible but not in expected water depths greater than 2 feet deep (includes wave heights). Do not trench the geotextile into the watercourse. Anchor at least a 1 feet flap folded up-gradient with sandbags per 3893, "Sandbags," to seal the bottom edge. In the top edge, insert a steel support cable into a 2 inch double stitch sleeve and fastened to steel fence posts per 3403, "Hot-Rolled Steel Fence Posts."

Install posts adjacent to the back face of the geotextile with the studs facing away from the geotextile fabric. Secure each post by inserting 3 plastic ties through the geotextile.

Before removing the turbidity barrier, remove and dispose of Material not originally in the isolation zone in a location approved by the Engineer.

C Bale Barrier Installation

Trench bales into the ground 4 inches and stake with 2 wood stakes per bale. Provide the stakes in a length that allows the placement of the stake so the top of the stakes remains flush with the top of the bale when embedded into the ground at least 10 inches. Provide Type 3 mulch per 3882 "Mulch Material, "for bale Material unless otherwise specified in the Plans. Place bale joints tight together. Provide a categories 20 or 30 rolled erosion prevention product as a wrap around the bales extending 1 foot at the base on each side. Provide staples to secure blanket to ground.

D Sandbag Barrier Installation

Install sandbags on a level contour. Sandbags installed a minimum of 6 feet back from the toe of the slope to allow ponding, and to provide room for sediment storage. Stack sandbags at least three bags high. Butt ends of bags tightly together and overlap butt joints of rows beneath with each successive row. Stack bags in trapezoidal shape with respect to the side profile.

E Filter Berm Installation

E.1 Type 1, Type 2 (Compost, Slash Mulch)

For slope breaks and perimeter control, install filter berms along the contour of the slope and perpendicular to sheet flow. Install the filter berms so the beginning and end of the installation points slightly up the slope to create a "J" shape at each end to contain runoff from above and prevent it from flowing around the ends of the berm. For slopes that receive runoff from above, place a filter berm at the top of the slope to control the velocity of the flow running onto the slope, and to spread the runoff into sheet flow.

For ditch checks, install perpendicular to the ditch gradient such that the top of the berm in the middle of the ditch is lower in elevation than the bottom of the terminating points on the ditch side slopes.

Upon formation, immediately seed compost filter berms.

E.2 Type 3 (Rock Weeper)

Line the bottom of the rock weeper with a Type IV geotextile per 3733, "Geosynthetic Materials." Provide a rock weeper that forms a trapezoidal-shaped berm. Install coarse filter Aggregate per 3149, "Granular Material," on the front half of the berm. Install Class I riprap per 3601, "Riprap Material," on the back half of the berm.

For ditch checks, install perpendicular to the ditch gradient. Construct the center section of the rock weeper 6 inches lower than the end points of the weeper at the ditch side slopes to form a weir.

For permanent ditch checks, reduce the height to 16 inches and modify the side slopes to 1:6 (Vertical:Horizontal).

E.3 Type 4 (Topsoil)

For perimeter control, construct a topsoil berm using topsoil salvaged from the Project. Immediately following formation, stabilize the berm with seed and mulch or an equivalent approved by the Engineer.

E.4 Type 5 (Rock)

Install Class II riprap on top of a Type IV geotextile liner per 3733, "Geosynthetic Materials." Configure riprap in a trapezoidal-shaped berm.

For ditch checks, install perpendicular to the ditch gradient. Construct the center section of the rock berm 6 inches lower than the end points of the rock berm at the ditch side slopes to form a weir.

For permanent ditch checks reduce the height to 16 inches and modify the side slopes to 1:6 (Vertical:Horizontal).

F Sediment Control Log Installation

F.1 Straw, Wood Fiber, and Coir

Place logs on smooth prepped soils and prepare a shallow trench for the sediment control log to be placed. Backfill and compact the upgrade side of the sediment control log with soil. Stake logs through the back half of the log at a 45 degree angle with the top of the stake pointed upstream. Stakes shall be spaced every 2 feet. If using more than 1 sediment control log for length, overlap the ends 6 inches and stake both ends.

F.2 Wood Chip, Compost, and Rock

Place logs on smooth, prepped soils or paved surfaces and ensure no gaps are between logs and soil or paved surface. Install logs along contours with ends turned up slope in a J-hook manner.

F.3 Wood Fiber and Blanket System

For Ditch checks install rolled erosion prevention category 25 per 3885, "Rolled Erosion Prevention Products," (REPP) or as shown in Plan, at least 1 role width, perpendicular to the ditch flow. Bury the leading edge in a trench 4 inches deep and 4 inches wide. Backfill and compact the trench with soil. Staple the REPP at spacing no greater than 1 foot on center.

Place the sediment control log type wood fiber per 2573.3F.3, "Wood Fiber and Blanket System," without the trench, on top of the REPP. If using more than 1 sediment control log for length, overlap the ends 6 inches and stake both ends. Follow additional ditch check installation as per 2573.3F.4, "Ditch Checks."

F.4 Ditch Checks

Follow installation above for sediment control log type wood fiber, wood chip, compost, or rock and place perpendicular to flow and in a crescent shape with ends facing upstream. Use logs with a center section of the ditch check 1 log diameter lower than the ends. Space stakes every 1 foot. Provide 2 stakes in a crisscross pattern at each location with the sediment control log in-between.

G Flotation Silt Curtain Installation

Provide a flotation silt curtain meeting the following requirements and characteristics:

(1) Contains connecting devices at each end so that sections can be joined together

(2) Contains connecting devices designed to prevent silt from permeating through the connection and at the specified strength to prevent ripping out
(3) Installation shall reach the bottom of the water body
(4) Offset connection joints between rows when more than 1 row is installed

G.1 Still Water

Secure both ends of a light duty floating silt curtain to land with steel fence posts per 3403, "Hot-Rolled Steel Fence Posts," and extend the curtain at a 45 degree angle from both ends. Anchor the curtain in the waterway with at least 40-pound anchors at intervals no greater than 100 feet along the length of the curtain. Mark each anchor with a buoy in navigable waters. Keep the curtain as tight to the Work area or shoreline as possible not to exceed 1/4 of a stream width.

G.2 Moving Water

Secure both ends of a heavy duty floating silt curtain per 3887, "Flotation Silt Curtain," to land with steel fence posts per 3403, "Hot-Rolled Steel Fence Posts," and extend the curtain at a 45 degree angle from both ends. Anchor the curtain in the waterway with at least 150-pound anchors at intervals no greater than 50 feet along the length of the curtain. Mark each anchor with a buoy in navigable waters. Keep the curtain as tight to the Work area or shoreline as possible not to exceed 1/4 of a stream width.

H Construction Exit Controls

Select Exit controls from the following list of stabilized construction exits:

(1) Slash mulch
(2) Crushed rock
(3) Temporary paving
(4) Reinforced geotextile
(5) Sheet pads
(6) Floating Road
(7) Timber pad
(8) Rumble pad

Use construction exit control BMPs at exit locations to minimize vehicle tracking of sediment from the Project onto paved surfaces. Install BMPs during the initial phase of the Project.

Select construction exit BMP based on Project Site conditions, soil type, vehicle size, time of year, and duration of use. Used Materials generated by the Project as construction exit controls whenever possible. Maintain exit controls during the Project.

Clean paved Streets at the end of each Working Day, or more frequently as necessary to provide safety to the traveling public.

H.1 Wheel Wash Off

Provide a wheel wash off system in addition to stabilized exit controls when Project Site conditions warrant.

I Culvert End Controls

I.1 Inlet

Provide Culvert inlet end sediment trap and volume controls consisting of the BMPs and devices for temporary impoundment and treatment of construction stormwater upstream. Culvert inlet end controls apply to median Culverts, centerline Culverts, box Culverts, and entrance Culverts.

I.2 Outlet

Provide Culvert outlet ends with energy dissipation devices, transition devices, or both.

J Storm Drain Inlet Protection

Implement BMPs and devices to protect storm drain inlets for all stages of Work to prevent passage of sediments into and through underground drainage systems.

Protect storm drain inlets, including manholes, catch basins, curb inlets, and other type inlets constructed for the ingress of surface water runoff into underground drainage systems.

Install storm drain inlets with sediment capture devices before soil disturbing activities. Provide effective storm drain inlet protection until the completion of paving or final stabilization of soils.

Prevent or minimize the potential for unsafe flooding or siltation problems. Clean out devices regularly and provide devices with an emergency overflow to reduce the flooding potential. Place devices without creating driving hazards or obstructions.

K Flocculants

Apply flocculants in conjunction with installed sediment and erosion control BMPs. Do not apply flocculants directly to public waters (i.e. lakes, wetlands, streams). Apply flocculants in a contained area and assure thorough mixing into the water. Before applying a flocculant, test the pH and temperature of the storm water. Apply flocculant within the manufacturer's specified ranges. Allow from 15 to 20 minutes retention time for clay size particles to settle, ensuring that the discharge of the treated water is visually the same as the receiving water.

K.1 Liquid Flocculant

Hydraulically apply liquid flocculant over the surface of the water to be treated. Dilute the liquid flocculant concentrate to form a stock solution. Apply the stock solution at the manufacturer's recommended rate to yield 1 ppm in the final treated water volume.

K.2 Flocculant Sock

Securely anchor the flocculant sock in an area where the water to be treated will flow over the sock. Do not leave flocculant socks in standing, stagnant water.

K.3 Granular Flocculant

Mix granular based flocculant with water in a tank to form a stock solution. Hydraulically apply the stock solution at the manufacturer's recommended rate to yield 1 ppm in the final treated water volume.

L Temporary Slope Drains

Provide temporary slope drains to convey concentrated runoff down the face of a cut or fill slope to reduce erosion on or below the slope. Provide a minimum slope on pipe of 3 percent. Size the pipe to the appropriate drainage area. Maximum allowable drainage area is 5 acres per slope drain. Provide an earthen dike to channel the flow to the temporary slope drain. Construct the top of the earth dike 1 foot higher than the top of the inlet pipe. Provide anchors for the pipe and space no greater than 8 feet apart. Use a watertight connection to attach the flared end section to the inlet end of drain pipe. Extend temporary pipe beyond the toe of slope and terminate in a 4 foot level section where practicable. Provide a riprap apron outlet and sediment trap for energy dissipation.

M Maintenance

Keep all devices functioning properly and maintained in accordance with the Contract. Repair or replace plugged, torn, displaced, damaged, or nonfunctioning devices. Remove sediment from sediment control devices when the sediment reaches 1/2 of the height of the device. Replace or repair devices damaged or compacted by Equipment. Perform repair or sediment removal within 24 hours of discovery or as soon as field conditions allow access.

M.1 Filter Berms

Expand, enlarge, or augment the filter berm with additional erosion and sediment control practices if concentrated flows bypass or breach the berm or to maintain the dimensions of the berm.

M.2 Sediment Basins and Traps

Drain the basin and remove the sediment when the depth of sediment collected in the basin reaches 50 percent of the storage volume determined by the outfall device. Complete drainage and removal within 72 hours or as soon as field conditions allow access. Remove sediment to the original designed or excavated grade or as necessary to restore the function of the device. Restore stabilized condition of side slopes and access Road.

Clean out and shape temporary sedimentation basins intended for use as permanent water quality management basins as shown on the Plans.

M.3 Storm Drain Inlet Protection Devices

Clean, remove sediment, or replace storm drain inlet protection devices on a routine basis to ensure the full functionality of the devices for the next rainstorm event.

M.4 Culvert Inlet End Control Devices

Clean, remove sediment, or replace Culvert inlet end control devices on a routine basis to ensure the full functionality of the devices for the next rainstorm event.

N Water Treatments

Use properly sized floating head skimmers to withdraw collected waters from the surface. Tether floating skimmer to maximize surface water withdraw and maintenance functionality. Install stop system to prevent floating head embedment into sediment. Install and attach skimmer pipe outfall to new or existing Structure, berm underdrain, or as site conditions allow.

O Removal of Temporary Devices

Remove temporary sediment control devices after completing the Work unless otherwise required by the Contract or directed by the Engineer. All removed Materials become the property of the Contractor.

Spread accumulated sediment to form a suitable surface for turf establishment or dispose of the sediment. Shape the area to permit natural drainage as approved by the Engineer.

Remove the Silt curtain upon completion of Work. Do not allow resuspension of sediment or loss of trash and oil into the water during the Silt curtain removal.

Remove sediment control logs upon completion of Work. Outer shell Material must be removed completely and contents of logs may be left in place and spread out over the ground to decay.

P Workmanship and Quality

To qualify for payment, perform corrective actions when the quality and workmanship fails to meet the Material, installation, or maintenance requirements in the Contract.

2573.4 METHOD OF MEASUREMENT

A Bale Barriers

The Engineer will measure the bale barriers by the length installed. The rolled erosion prevention product wrap is included in the linear measurement.

B Silt Fence

The Engineer will measure Silt fence along the base of the fence from outside to outside of the end posts for each section of fence.

C Sandbag Barriers

The Engineer will measure sandbag barriers by surface area based on actual measurement taken along the length of the barrier times its height. If the Contractor installed more than 1 thickness of sandbags the Engineer will measure the surface area of each Layer of thickness and add it to the quantity.

D Flotation Silt Curtain

The Engineer will measure flotation Silt curtain by length installed.

E Temporary Sediment Traps

The Engineer will measure sediment trap excavation by volume. The Engineer will measure overflow devices separately.

F Temporary Slope Drains

The Engineer will measure temporary slope drains by length installed. The diversion mound and apron inlet of the pipe are included in the Pay Item temporary slope drain. The Engineer will measure Materials used to provide an outlet separately.

G Sediment Removal

The Engineer will measure sediment removal from temporary sediment traps and basins by backhoe hours or vac-truck hours. The spreading and hauling of sediment are included in the Pay Item sediment removal.

H Sediment Control Logs

The Engineer will measure types; straw, wood fiber, coir, wood chip, compost, and rock, by the effective length installed. The Engineer will not include overlaps in the measurement.

The Engineer will measure types; wood fiber and blanket system by length installed. The Engineer will not include overlaps in the measurement.

I Culvert Inlet End Controls

I.1 Each

The Engineer will measure Culvert inlet end controls by measuring the number of individual Culvert inlet ends protected throughout the Work regardless of the type or number of devices used at each Culvert end.

J Storm Drain Inlet Protection

J.1 Each Storm Drain inlet

The Engineer will measure storm drain inlet protection by the number of individual inlets protected over the life of the Contract regardless of the types of number of devices used at each storm drain inlet.

J.2 Lump Sum

The Engineer will measure storm drain inlet protection as lump sum. Lump sum shall include all Materials and labor necessary to provide proper inlet protection through the life of the Contract regardless of quantities and types required.

K Flocculants

The Engineer will measure liquid flocculant by the volume of liquid flocculant concentrate used. The Engineer will not include the water used to dilute the concentrate.

The Engineer will measure flocculant sock by each provided.

The Engineer will measure granular flocculant by the weight used and placed. The Engineer will not include the water used to dissolve and dilute the granular flocculant.

L Construction Exit Controls

The Engineer will measure construction exit controls by the lump sum including the cost of protecting each exit over the life of the Contract regardless of types or quantities. Wheel wash of systems will be measured separately.

M Water Treatment

The Engineer will measure floating head skimmer by the each that includes the cost of size determination and associated Material, Work, and connections to the outfall drainage Structures for the life of the Contract regardless of adjustments made for rate control and sediment accumulation.

2573.5 BASIS OF PAYMENT

The Contract Pay Items for stormwater management will include the Material, Equipment, installation, maintenance, and removal as required by the Contract to complete the Work. For items of Work not included in the schedule of Contract Pay Items, the Department will pay Unit Prices for the relevant items of Work.

The Department will provide partial payment of temporary sediment control devices properly installed at no greater than 50 percent of the Contract Unit Price for each relevant Pay Item unless otherwise required by the Contract. The Department will pay the remaining partial payment after proper maintenance and removal of the device.

The Department will withhold from monies owed to the Contractor for each improperly installed or maintained device where the Contractor failed to remove sediment, and the Engineer has ordered this corrective action.

A Filter Berms

The Contract Pay Item for topsoil Filter berm includes seed and mulch.

The Contract Pay Item for rock or rock weeper filter berm when converted from temporary to permanent conditions includes the cost to modify the berm dimensions.

B Storm Drain Inlet Protection

The Contract Pay Item for the inlet protection devices includes the cost of removing and disposing of trapped sediment or sediment deposited in or plugging drainage systems protected by the devices.

C Silt Fence

The Contract Pay Item for the Silt fence includes removal and disposal of trapped sediment.

The Department will withhold from monies owed to the Contractor for each section of Silt fence not maintained at discharge points or where damaged by the public or the Contractor, and the Engineer has ordered this corrective action.

D Water Treatments

The lump sum price for Water treatments includes the development of the water treatment Plan, protection of trees, repair and replacement of damaged sections, and removal of sediment deposits.

E Construction Exit Controls

The wheel wash systems will be paid for separately for each system.

F Sediment Traps

The Department will pay for removal of sediment from sediment traps by backhoe or vac-truck by the hour. Sediment spreading and disposal are included in the Pay Item sediment trap excavation.

G Erosion Control Supervisor

The Department will provide partial payment no greater than 50 percent of the Contract lump sum price for Erosion control supervisor upon satisfactory completion of either half the allowable Project Working Days or half the anticipated Project duration time as approved by the Engineer. If providing partial payment, the Department will pay the remaining percentage upon performance of duties as approved by the Engineer and completion of the Work.

The Department will withhold from monies owed to the Contractor for failure to provide a certified Erosion control supervisor or failure to perform Erosion control supervisor duties.

H Schedule

The Department will pay for temporary sediment control items on the basis of the following schedule:

Item No.	Item	Unit
2573.501	Erosion Control Supervisor	lump sum
2573.501	Water Treatment	lump sum
2573.501	Stabilized Construction Exit	lump sum
2573.501	Storm Drain Inlet Protection	lump sum
2573.502	Culvert End Control	each
2573.502	Flocculant Sock	each
2573.502	Storm Drain Inlet Protection	each
2573.502	Water Treatment Type ___	each
2573.502	Wheel Wash Off	each
2573.503	Bale Barrier	linear foot
2573.503	Filter Berm Type ___	linear foot
2573.503	Floatation Silt Curtain Type ___	linear foot
2573.503	Sediment Control Log Type ___	linear foot
2573.503	Silt Fence, Type ___	linear foot
2573.503	Temporary Slope Drain	linear foot
2573.506	Liquid Flocculant	gallon
2573.507	Sediment Trap Excavation	cubic yard
2573.508	Granular Flocculant	pound
2573.510	Sediment Removal Backhoe	hours
2573.510	Sediment Removal Vac Truck	Hours
2573.518	Sandbag Barrier	square foot

2574 SOIL PREPARATION

2574.1 DESCRIPTION

This Work consists of providing temporary shaping and grading, and preparing the soil for permanent turf establishment to reduce the risk of soil erosion. Temporary shaping and grading includes directing water flow and breaking up soil fine enough to install temporary erosion control Materials. Preparing the soil for permanent turf includes soil tilling and soil additives.

2574.2 MATERIALS

A Lime **3879**

B Topsoil Borrow **3877**

2574.3 CONSTRUCTION REQUIREMENTS

A General

Prepare the soil to minimize soil erosion and to provide a media for plant and root establishment. Perform soil preparation operations for permanent seed and sod and for temporary conditions.

A.1 Temporary Grading

Shape embankment to remove clods of soil greater than 3 inches diameter and ruts, erosion rills, or washouts deeper than 3 inches prior to installing temporary erosion control Materials in locations where the final Grading Grade has not been established.

A.2 Soil Tracking

Perform soil tracking on embankments to create horizontal grooves on an exposed slope using a stair-stepping backhoe bucket procedure or run tracked construction Equipment up and down the slope. Perform the stair-stepping procedure parallel to the contour of the land.

Perform subsoil tracking on slopes steeper that 1:2 (Vertical:Horizontal) to scarify the surface per 2106.3I “Finishing Operations” or for temporary grading operations.

Perform topsoil tracking on topsoil for slopes steeper than 1:2 (Vertical:Horizontal) when placing topsoil in those areas.

A.3 Soil Bed Preparation

Prepare the soil surface to provide a smooth, moist, and evenly textured foundation before sowing seed or placing sod. Complete the tilling after applying soil amendments to the soil. Use cultivating Equipment such as discs, harrows, field diggers, or tillers capable of loosening the soil to a depth of at least 3 inches on all areas except for slopes steeper than 1:2 (Vertical:Horizontal). Till the soil surface to remove track imprints from wheeled or tracked Equipment. Operate cultivating Equipment on slopes at right angles to the direction of surface drainage. Soil clods, lumps, and tillage ridges 3 inches high or less may remain in place for seeding operations. Soil clods, lumps, and tillage ridges 1.5 inches high may remain in place for sodding operations. Multiple passes of the Equipment may be needed to meet these requirements.

A.4 Subsoiling

Deep rip soils before placing topsoil on areas where topsoil placement depth is greater than 6 inches otherwise after topsoil is placed in the following areas:

(1) Where the subsoil has been compacted by Equipment operations
(2) Staging areas, old Roadbeds to be vegetated

Subsoil infiltration basins before placing topsoil borrow Type G per 3877, “Topsoil Material.”

Deep rip soil in in one direction on the contours perpendicular to the flow of water or as shown in the Plans. Use a multi-shanked, parallelogram or single tooth implement to create channels. Do not use disc cultivators, chisel plows, or spring-loaded Equipment to perform subsoiling. Space channels from 12 inches to 36 inches apart except as shown on the Plans.

Create channels to provide a depth from 16 inches to 20 inches or as shown on the Plans. For saturated soil, delay subsoiling operations until soil dries to at least field capacity.

Observe a minimum setback as directed by the Engineer for the following subsoiling exceptions:

(1) Areas within the dripline of existing trees
(2) Over utilities
(3) Where trenching or drainage lines are installed
(4) Where compaction is required by design (abutments, footings, or inslopes)
(5) Inaccessible slopes

B Infiltration, Filtration, and Bioretention Areas

Construct sites after stabilizing contributing drainage areas. Stabilize areas draining to infiltration sites. Prevent sediment laden runoff from entering infiltration site during construction. Use light tracked Equipment to excavate, grade, shape, and place soil loosely as shown on the Plans. Minimize tracking and compacting over the infiltration areas. Prevent excavated Material from reentering the basin during the Work.

C Topsoil

Place and shape topsoil to the depths as shown on the Plans. Remove all rocks and debris exceeding 3 inches on topsoil surface.

Salvaged topsoil excavation Material per 2106 "Excavation and Embankment – Compacted Volume Method," shall be stockpiled on the Project Site or at a suitable location approved by the Engineer. Test stockpiled topsoil in accordance with the testing procedures for soil fertility in 3877, "Topsoil Material." Complete the testing at least 1 month before placement. Use these test results to determine pH adjustments and fertilizer, soil additives, and compost needs for plant establishment. The Engineer will determine adjustments to the existing topsoil for plant establishment based on the test results.

Topsoil Material sources must be approved by the Engineer prior to blending and delivery. Before blending individual components to create a topsoil borrow, verify that each component meets the Specification requirements.

D Applying Soil Amendments

Do not place commercial fertilizer, liming Material, and soil additives on frozen ground or snow. Apply fertilizers after the runoff from spring snowmelt.

Use mechanical spreading devices to uniformly apply fertilizers, compost, liming Materials, and additives at the rates required by the Contract before placing seed or sod. Till the soil at least once within 24 hours of placing fertilizer, compost, lime, or soil additives. Apply seed within 48 hours of fertilizing.

The Department based the lime application rates on 1,000 pounds effective neutralizing power (ENP) per ton of agricultural liming Material. Adjust the actual lime application rate to meet the above rate.

The Contractor may use Grade 1 compost instead of commercial fertilizer, as approved by the Engineer. Apply the compost at an equivalent nutrient application rate to the rate for commercial fertilizer shown on the Plans.

E Acceptance of Work

Notify the Engineer at least 24 hours before beginning and changing soil preparation operations. Till soil amendments into the soil before seeding operations. The Engineer will reject soil preparation not verified by inspection as unauthorized Work per 1512, "Unacceptable and Unauthorized Work."

The Engineer will accept filter topsoil when placed in infiltration, filtration, or bioretention areas after an infiltration test demonstrates an acceptable infiltration rate per 3877, "Topsoil Material."

F Workmanship and Quality

The Engineer may require corrective action for the conditions not meeting Contract requirements to qualify for payment. Perform corrective actions when the quality and workmanship fails to meet the Material, installation, maintenance, or removal requirements.

2574.4 METHOD OF MEASUREMENT

A Fertilizer

The Engineer will measure fertilizer by the weight of each type applied. If the Contractor provides fertilizer with different type than as shown on the Plans, the Engineer will adjust the application rate of the fertilizer provided to meet the equivalent type proportions of the fertilizer shown on the Plans.

B Lime

The Engineer will measure agricultural Lime by weight applied.

C Soil and Root Additives

The Engineer will measure soil and root additives by the weight or volume applied.

D Compost

The Engineer will measure Grade 1 compost by weight applied.

The Engineer will measure Grade 2 and Grade 3 compost by loose volume.

E Topsoil Borrow

The Engineer will measure topsoil borrow by loose volume as required by the Contract.

F Subsoiling

The Engineer will measure Subsoiling by area successfully loosened.

G Soil Tracking

Topsoil tracking is included in soil preparation operations. Subsoil tracking is included in finishing operations per 2106, "Excavation and Embankment – Compacted Volume Method." Measure tracking on slopes not part of soil preparation or finishing operations by the area.

H Soil Bed Preparation

The Engineer will measure soil bed preparation by area.

2574.5 BASIS OF PAYMENT

The Contract Pay Items for soil preparation will include the Material and installation as required by the Contract to complete the Work. For items of Work not included in the schedule of Contract Pay Items, the Department will pay Unit Prices for the relevant items of Work.

A Erodible Surface

The Department shall withhold $3500 per acre within the grading construction limits, excluding the Roadbed areas where clearing and grubbing operations expose soils to erosion. The Engineer will determine the areas open to erosion before approving each partial withholding release.

The Engineer may divide the Project into separate control areas for release of the withholding.

The Department may release the withholding for erodible surface area in accordance with Table 2574.5-1:

Table 2574.5-1
Partial Release

Control Area Surface Condition	Withholding Reduced
Possible erosion damage or water pollution exists	No release until fixed
Rough grading completed and permanent topsoil placed	50 percent
Permanent stabilization completed	25 percent
Vegetation established and accepted	25 percent

B Schedule

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

Item No.	Item	Unit
2574.505	Soil Bed Preparation	acre
2574.505	Soil Tracking	acre
2574.505	Subsoiling	acre
2574.506	Compost Tea	gallon
2574.506	Plant Hormones	gallon
2574.507	Compost Grade *	cubic yard
2574.507	______ Topsoil Borrow	cubic yard
2574.508	Fertilizer Type ____	pound
2574.508	Activated Charcoal	pound
2574.508	Hydrophilic Polymers	pound
2574.508	Iron Sulfate	pound
2574.508	Mycorrhizal Inoculum	pound
2574.508	Rhisobium Inoculum	pound
2574.509	Compost, Grade 1	ton
2574.509	Lime	ton

* Specify type 2 or 3

2575 ESTABLISHING VEGETATION AND CONTROLLING EROSION

2575.1 DESCRIPTION

This Work consists of applying temporary soil covers and establishing a perennial ground cover to reduce the risk of soil erosion.

Temporary soil covers include mulch, establishment of an annual vegetative cover, rolled erosion prevention product, and hydraulic soil stabilizers. Establishment of a perennial vegetative cover includes seeding, sodding, mulching, and any other specified Work.

2575.2 MATERIALS

A Seed 3876

B Compost 3890

C Sod 3878

D Riprap Material 3601

E Mulch 3882

F Rolled Erosion Prevention Products 3885

2575.3 CONSTRUCTION REQUIREMENTS

A General

Minimize soil erosion and prevent damage from sedimentation by using the Best Management Practices (BMP) to cover bare soils in temporary and permanent conditions. Use temporary erosion control BMPs, including limiting the amount of exposed erodible soils and providing for proper exposed soil stabilization for slopes, ditches, storm drain and Culvert outlets, and storm water discharge points from erosion. Use permanent erosion control BMPs to provide the final stabilization of exposed slopes. Properly prepare soils in accordance to 2574, “Soil Preparation.”

A.1 Exposed Soil Stabilization

Stabilize areas of exposed soils that are larger than 2 acres in size using temporary seed mixtures and erosion control products. Use rapid stabilization methods to temporarily stabilize contiguous areas of exposed soil that are less than 2 acres in size and are:

(1) Within 200 feet of a surface water
(2) Within 200 feet of Areas of Environmental Sensitivity (AES)
(3) Required by the Contract

Schedule, construct, or install stabilization measures on exposed soil areas as shown on the Plans or as required by the Contract.

A.2 Growing Seasons

Schedule and install temporary and permanent seed or sod in areas at the optimum growing time for proper turf establishment.

A.2.a Seeding Dates

Plant seed mixtures during the seasons of planting for the various seed mixtures in accordance with Table 2575.3-1:

Table 2575.3-1
Season of Planting

Seed Mixture Number	Spring	Fall
21-112	—	August 1 – October 1
21-111	May 1 – August 1	—
22-111, 22-112*	April 1 – July 20	July 20 – October 20
25-121, 25-131, 25-141, 25-151*	April 1 – June 1	July 20 – September 20
25-142*	April 1 – September 1	—
Any mix beginning with a 3	April 15 – July 20	September 20 – October 20
* For the portion of Minnesota north of, and including TH 2, plant seed mixtures 22-111 to 25-142 from April 15 to September 20.		

Provide temporary stabilization when outside the season of planting dates of the specified permanent seed mixture

Request to adjust dates in writing by no more than 10 Calendar Days to shorten or extend the exclusion dates when conditions warrant. The Engineer may approve the request or direct the Contractor to seed outside the seeding dates.

A.2.b Sodding Dates

Sod growing days are any Calendar Day between April 15 and November 1. Avoid installing lawn and mineral sod between June 10 and August 10. Avoid installing salt tolerant sod between June 10 and November 1. The Engineer may adjust these dates to shorten the excluded periods when conditions are favorable to active growth, or to lengthen the excluded period when conditions for establishment are unfavorable.

Provide temporary stabilization when outside the sodding dates.

A.3 Winter Season

During the winter season, perform erosion control operations to protect the site through the end of the spring snowmelt season. Such practices include Dormant Seeding and sodding, snow seeding and mulching, and frozen ground mulching. Both Dormant Seeding and sodding are performed during the period when soil temperatures will not allow seeds to germinate and when normal plant rooting will not occur.

A.4 Substitutions

The Engineer may allow substitutions in accordance with 1605, "Substitute Materials" for the following Materials; plastic, geotextile, mulch, Rolled erosion prevention, and hydraulic erosion control products. The Engineer, in consultation with Office of Environmental Stewardship Erosion and Storm Water Management Unit, may authorize requested substitutions for specific locations shown in the Plan. Provide substitutions equal to or better than initially specified Material.

B Placing Seed

Store the seed from time of purchase until installation at 50°F and 50 percent humidity. Protect the seed from moisture until sowing. Do not use wet or moldy seed. Apply seed within 48 hours of fertilizer application.

Sow the seed uniformly at the adjusted bulk rate of application for each mixture. Adjust the bulk seeding rate needed to achieve the required PLS rate for the mixture in accordance with 3876, "Seed" and the following formulas:

(1) Bulk Application, pound = $\frac{PLS, lb}{\%PLS}$

(2) percent PLS = percent germination × percent purity

Immediately after seeding firm the seedbed with a cultipacker to provide seed to soil contact. Do not broadcast seed with wind velocities greater than 15 mph.

B.1 Temporary Seeding

Perform temporary seeding in addition to temporary mulching on graded areas with topsoil and unable to receive permanent seeding or slopes and topsoil berms left idle for longer than 21 Calendar Days. Use cover crop and mid-term stabilization seed mixtures as shown in 3876, "Seed," Table 3876.2-1 for temporary seeding.

Prepare the soil in accordance with 2574.3A, "Soil Preparation, General," and 2574.3B, "Infiltration, Filtration, and Bioretention Areas," except for stockpile and berms where no soil preparation is needed.

B.2 Seeding Turf Mixes

Mechanically sow or hydraulically apply non-native seed mixes (any mix beginning with a number 2) uniformly at the adjusted bulk application rate of each mixture. Only use hand operated mechanical spreaders on areas too small for or inaccessible by the specified Equipment.

If using an agricultural type seed drill, operate the drill in a general direction at right angles to the direction of surface drainage and sow the seed shall to a depth no greater than 3/8 inches.

B.3 Seeding Native Mixes

Seed native mixes (any mix beginning with a number 3) with a native seed drill, a drop type seeder, or a hydro seeder uniformly at the adjusted bulk application rate of each mixture. Use a drill capable of accurately metering the types of seed planted and capable of maintaining a uniform mixture of seeds during drilling. Use a drill with disc furrow openers and a packer assembly to compact the soil directly over the drill row. Seed native mixes in rows spaced no greater than 8 inches apart. Place seeds to a final planting depth from 1/8 inch to 3/8 inch. Perform drill seeding at a right angle to surface drainage. A drop type seeder equipped with a separate seed box for the fluffy seed and a soil packer assembly may be used in lieu of a drill with disc openers. Use a cyclone or spinner type seeder on areas no greater than 1 acre or on areas inaccessible to other Equipment, as approved by the Engineer.

B.4 Hydro-seeding

Use a hydro-seeder capable of continuous agitation action to uniformly distribute the seed at the adjusted bulk application rate of each mixture. Add 50 pounds of Type Hydraulic Mulch per 3884, “Hydraulic Erosion Control Products,” as a tracer for each 500 gallons of water in the hydro-seeder tank. Use flood type nozzles and manufacture’s recommended water volume.

Once the seed has been added to the tank mixture a one hour time limit is set for spreading the mixture on the soil. Once the one hour is passed the excess mixture must be discarded.

Perform hydro-seeding separate from placing hydraulic erosion control products (hydro-mulching).

B.5 Interseeding

Perform interseeding if seeding into temporarily mulched areas or if drilling additional seed into previously seeded areas. Use an interseeding drill containing trash rippers and at least one box for fine seed and one box for larger seeds or fluffy seeds. Operate the drill to slice through the thatch layer and make a furrow 1 inch wide and from 3/8 inches to 1 inch deep in the underlying soil. Place seeds in the furrows through the drill seed disc openings. Drop the seed onto the ground surface from the fine seed box. Place the large or fluffy seed to a final planting depth from 1/4 inch to 3/8 inch.

B.6 Permanent Seeding into Temporarily Mulched/Blanketed Areas

Permanently seed areas previously temporarily mulched. Without performing additional tillage or site prep Work, the Contractor may use an interseeding drill to drill seed directly into temporarily mulched or temporarily seeded areas. In lieu of using an interseeding drill, the Contractor may lightly disc the mulched areas before seeding. Apply fertilizer within 24 hours before interseeding or light disking. Leave the existing cover in-place to serve as mulch. Permanently seed into areas with rolled erosion prevention products using the hydro-seeding application as described in 2575.3B.4, “Hydro-seeding,” but with the following modification: hydro-seed into the installed rolled erosion prevention products with the nozzle 6 feet from installed surface cover, forcing the seed and water through the product.

B.7 Winter Seeding

Dormant seed after the fall seeding date and when soil temperatures 1 inch below surface are no greater than 40°F.

Perform snow seeding over the top of snow allowing the seed to melt through the snow to the soil and germinate upon warm up in the spring.

C Applying Mulch

Mechanically spread mulch to provide a uniform distribution over all exposed soil at the application rate to provide 90 percent uniform soil coverage. If non-uniform distribution occurs, remulch areas or remove the excess coverage.

Do not operate mulch-blowing Equipment on slopes steeper than 1:2.5 (Vertical:Horizontal) or on slopes that will rut the soil surface. Use blower attachments to apply the mulch without traversing the slopes. Do not mulch with wind velocities greater than 15 mph.

Areas within 10 feet of the Shoulder immediately mulch, and anchor the mulch in a continuous operation after seeding. If traffic or wind dislodges the seed or mulch due to delays in the continuous operation, reseed and remulch the affected areas.

Areas outside 10 feet of the Shoulder shall be mulched within 24 hours after seeding.

C.1 Temporary Mulching

Perform temporary mulching on contiguous areas of 2.0 acres and greater to protect the site from erosion when left idle for more than one week and during non-seeding periods and when outside the seeding and sodding dates. For areas less than 2 acres, mulch in accordance with 2575.3M “Rapid Stabilization.”

C.2 Type 1, Type 3, Type 7, and Type 8 Mulch

Use blower Equipment to place Type 1, Type 3, Type 7, and Type 8 mulch at a target application rate of 2 tons per acre. Apply the mulch at an actual rate as directed by the Engineer to match varying Material or Project conditions. Apply the mulch to ensure 90 percent coverage of the soil surface.

C.3 Type 4 Mulch

Apply Type 4 mulch as a dual operation with the Type 1 mulch blown on the soil surface at 1 1/2 tons per acre and immediately over-spray with stabilized fiber matrix per 3884, “Hydraulic Erosion Control Products,” at 750 pounds per acre.

C.4 Type 5 Mulch

Apply Type 5 mulch at a rate of 80 cubic yard per acre as specified in the Plans as an erosion control Material.

C.5 Type 6 Mulch

Apply Type 6 mulch at the rate shown on the Plans or Special Provisions.

C.6 Type 9 Mulch

Apply Type 9 mulch at a rate required by the Contract. Before placing mulch, uniformly compact and smooth the foundation, cover the foundation with Type 1 geotextile, per 3733, “Geosynthetic Materials,” and uniformly spread the Aggregate mulch to the thickness shown on the Plans without harming the foundation. Level the finished Aggregate surface flush with adjacent areas.

C.7 Winter Mulching

Perform frozen ground mulching on bare frozen soils. Place 3882,"Mulch Material," Type 5, Type 6 and Type 9 mulch Materials with no modifications to meet the requirements of frozen ground mulching. Place 3882, "Mulch Material," Type 1, Type 3 or Type 8 mulch Materials with the following modifications to meet frozen ground mulching:

At temperatures above 20°F use 3884, "Hydraulic Erosion Control Products," Type Natural or Synthetic Tackifier, in lieu of disc anchoring

At temperatures below 20°F delay mulching until ground is snow covered and perform snow mulching.

Perform snow mulching at any time over the top of snow. No disc anchoring is required. Apply Snow mulching prior to or during a snowfall event.

D Disk Anchoring

Anchor Type 1, Type 3, and Type 8 mulches with a disk anchoring tool as required by the Contract immediately after placement unless otherwise approved by the Engineer.

Punch the mulch into the soil to a depth from 2 inches to 3 inches. Space the blades and disks on the anchoring tool no greater than 8 inches apart. Use hydraulic erosion control products to anchor the mulch in lieu of disk anchoring, in areas inaccessible by disk Equipment.

E Placing Hydraulic Erosion Control Products

Protect public and private investments and properties from overspray by suitable means and methods including appropriate shields, covers, and avoidance measures. Accidental overspray must be cleaned up at the time of installation (occurrence). Perform after and separate from hydro-seeding. Provide an Applicator's Certification from the manufacturer before applying the polyacrylamide tackifier, organic fiber matrix, bonded fiber matrix, and reinforced fiber matrix.

E.1 Tackifiers

Use natural tackifiers alone, as an additive to other soil stabilizers, or as an overspray on mulched areas.

E.1.a Type Natural Tackifier

Use the manufacturer's recommended rate of application and mix ratios based on use, site conditions, and time of year. Allow from 9 to 12 hours of dry time before subject to rain. Uniformly distribute the tackifier over the target area.

E.1.b Type Synthetic Tackifier

Dilute synthetic tackifier at a rate of 10 parts water to 1 part polymer and apply to the soil at a rate of 1,200 gallon per acre.

E.1.c Type Polyacrylamide (PAM)

Do not use polyacrylamide (PAM) on pure sand or Gravel without fine Silts or clays. Do not apply PAM over snow cover or to slopes that flow directly into a wetland or State waters. Apply PAM as recommended by the manufacturer.

Provide certification of the following:

(1) Percent of pure PAM present by weight
(2) Percent Activity
(3) Average molecular weight
(4) Charge density of the PAM

Provide a Material Safety Data Sheet for prepackaged PAM. The Contractor may include PAM as a part of a polymer stabilized fiber matrix. Apply PAM in its pure form on slopes and channels at a rate no greater than 200 pounds per acre and no later than 4 hours prior to rain.

E.2 Matrices

E.2.a Type Organic Fiber Matrix (OFM)

Apply organic fiber matrix with hydraulic spray Equipment in a water-slurry mixture. The tank must have jet or mechanical agitation for mixing. The dry Material targeted application rate is 3,500 pounds per acre. Use the water to bale ratio as recommended by the manufacturer.

E.2.b Type Mulch

Apply hydraulic mulch with hydraulic spray Equipment in a water-slurry mixture. The dry Material targeted application rate is 2500 pounds per acre. Use the water to bale ratio as recommended by the manufacturer. Increase the application rate and percent tackifier to roughened soils for complete coverage. The Engineer may inspect the tank loading and spray application, to verify that the applied Materials meet the manufacturer’s recommendations and the soil is 100 percent covered.

E.2.c Type Stabilized Fiber Matrix

Do not field mix additives or components for stabilized fiber matrix, as this mulch is a pre-manufactured matrix. Apply stabilized fiber matrix at the targeted dry weight rate of 3000 pounds per acre. Adjustments made in the field based on site characteristics, soil conditions, and manufacturer’s recommendations.

E.2.d Type Bonded Fiber Matrix (BFM)

Apply BFM with hydraulic spray Equipment by a manufacturer's certified applicator. The Contractor may apply seed and BFM in a single operation in small or inaccessible areas as approved by the Engineer. Apply BFM at the targeted dry weight rate of 3500 pounds per acre. Adjustments are made in the field based on site characteristics, soil conditions, and manufacturer’s recommendations. Use the water to bale ratio recommended by the manufacturer. Apply the BFM from at least 2 opposing directions and obtain continuous ground coverage. Apply the BFM in 2 stages using 1/2 of the Material in each stage. Allow the first stage application to dewater before applying the second stage. Do not use BFM in water bearing soils or by itself in ditch bottoms carrying concentrated flows.

E.2.e Type Reinforced Fiber Matrix (RFM)

Apply FRM with hydraulic spray Equipment by a manufacturer's certified applicator. Apply RFM at the targeted dry weight rate of 3900 pounds per acre. Adjustments made in the field based on site characteristics, soil conditions, and manufacturer’s recommendations. Use the water to bale ratio recommended by the manufacturer.

F Placing Sod

Before delivering sod to the Work site, prepare the soil per 2574.3A, “Soil Preparation, General,” to avoid delays in placing the sod. Before placing the sod pre-wet the soil to a damp condition. Provide proper notching into existing surfaces. Hand tamp or roll sod to get complete ground contact.

Use straw or hydro mulch to stabilize exposed areas until installation of sod is within the specified sodding dates. Incorporate any straw mulch into soil prior to sod installation.

Reseed or remulch damaged areas adjacent to the sod within 5 Working Days after completing the sod placement and rolling or tamping operations.

F.1 Slopes

Place sod strips starting at the bottom of the slope and progressing upward with long edges parallel to the contour. Stagger joints alternately without space between. Secure the sod to the slope with 12 inch tapered wooden stakes cut from 1 inch by 2 inch lumber or 8 inch (minimum) staples made of 11 gauge steel wire or another anchor system approved by the Engineer. Spaced no greater than 2 feet apart. At the tops of slopes steeper than 1:4 (Vertical:Horizontal), trench the sod 3 inches into the topsoil.

Shingle sod on slopes 1:2 (Vertical:Horizontal) and steeper and at Culvert ends, overlap the upper piece by at least 3 inches. Use wire staples to secure sod on the slope at 16 inch intervals. Trench 3 inches of sod into the topsoil on the uppermost strip of sod.

F.2 Ditches

In ditch bottoms and other areas with expected concentrated water flow (i.e. flumes), place the sod parallel to the direction of water flow in the main channel. Shingle sod overlapping the ends by at least 4 inches and the edges by at least 3 inches. Trench 3 inches of sod into the topsoil on the uppermost strip of sod on side-slopes steeper than 1:4 (Vertical:Horizontal).

In ditch bottoms with high flow velocities, overlay shingled sod with jute, a biodegradable netting, or chain link fence. Use stakes or staples to secure the jute, netting, or fence to the sod. The jute, biodegradable netting, or the chain link fence will not require removal after maintenance period.

F.3 Dormant Sodding

Dormant sod on slopes, in ditches, and at least 10 feet from the Shoulder after the fall sodding date and soil freeze-up meeting the following conditions:

(1) The Engineer authorizes Dormant Sodding
(2) Provide soil preparation for sod
(3) Stake or staple the sod on slopes and in ditches
(4) Water the sod to saturation immediately after placement
(5) Water the sod a second time from 7 to 10 Calendar Days after placement. The second watering is not needed when the sod receives 1 inch of rain or snow cover

Do not dormant sod in areas shown with salt tolerant sod (3878, “Sod,”) or within 10 feet from the Shoulder, including areas next to boulevards and areas receiving salt encrusted snow and ice from winter deicing operations. Temporary stabilize these areas with mulch or rolled erosion prevention product.

G Placing Rolled Erosion Prevention Products

For products without a Plan defined detail sheet, submit manufacturer’s recommendations of installation prior to any changes proposed by the Contractor.

G.1 Temporary Rolled Erosion Prevention Products

G.1.a Straw and Wood Fiber Based Products

Prepare the soil according to 2574, “Soil Preparation.” Place the rolled erosion prevention products within 24 hours after sowing the seed on that area. Products with netting on 2 sides, place the side with the majority of thread stitching on the bottom. Roll out rolled erosion prevention product flat and parallel or perpendicular to the direction of water flow. Evenly spread the rolled erosion prevention product without stretching, allowing the fibers to come in direct contact with the soil over the entire area. Shingle and overlap the edges parallel to water flow by at least 4 inches. Shingle and overlap the edges perpendicular to water flow by at least 7 inches. Anchor overlaps on slopes at 1 1/2 foot intervals and elsewhere using types and depths defined in Table 3885.2-1 and Table 3885.2-2.

At the tops of slopes and at the beginning of each rolled erosion prevention product in ditch bottoms, bury the upgrade end of the blanket in a check slot 6 inches wide by 6 inches deep. Insert the product end to the full depth of the check slot. Backfill and compact the check slot. For slopes longer than 100 feet, dig a second check slot perpendicular to the slope gradient 1/3 of the slope length measured from the bottom of the slope. Place the rolled erosion prevention product to the full depth of the check slot. Backfill, and compact the check slot. Anchor rolled erosion prevention product using types and depths defined in Table 3885.2-1 and Table 3885.2-2 with the number of staples according to Table 2575.3-2 or manufacturer's recommendations.

Table 2575.3-2
Stapling of Blankets

Slope (Vertical:Horizontal)	Minimum Number of Staples per 100 square yard
Flatter than 1:2	120
1:2 – 1:1	170
Channel or ditch applications	350

G.1.b Extended Duration Open Weave Textile Products

Place the 3885, "Rolled Erosion Prevention Products," concurrent with sowing of specified seed on that area. Provide overlap and anchor systems for open weave textile products as shown in the Plans, or according to manufacturer's recommendations.

G.1.c Winter Installation

Place 3885, "Rolled Erosion Prevention Products," over frozen ground and use anchors as shown in Table 3885.2-1 or Table 3885.2-2 for winter utilization.

G.2 Permanent Rolled Erosion Prevention Products

Shape and prepare the site according to 2574, "Soil Preparation." Provide Permanent rolled erosion prevention products meeting the requirements of the categories as shown on the Plans.

G.2.a Surface Applied Products

Seed as per 2575.3G.1, "Temporary Rolled Erosion Prevention Products," but with overlaps, shingling, and trenching according to manufacturer's recommendations. Provide anchor type and depth shown in Table 3885.2-4. Fill voids in product and cover product surface using 3884, "Hydraulic Erosion Control Products," reinforced fiber matrix at the rate defined by the manufacturer.

For steep slopes, 2:1 or greater, hydraulically fill the cells of the product with a blend of seed, fertilizer, and reinforced fiber matrix at a rate of 3900 pounds per acre or to complete fill the product surface and void spaces below.

G.2.b Soil Filled Products

Place the seed at the full seeding rate, half of the fertilizer, and soil/organic amendments. Place the rolled erosion prevention product immediately afterward. Roll out or lay the product parallel to the direction of water flow. Evenly spread the product without stretching, allowing the synthetic fibers to come in direct contact with the soil over the entire area. Do not allow any voids to remain between the product and the soil surface. Bury and anchor the beginning edge of each product in a check slot 6 inches wide by 6 inches deep. Overlap adjacent strip edges by at least 4 inches. Provide anchor type and depth shown in Table 3885.2-5 to provide 3.5 anchors per square yard or to manufacturer's recommendations, whichever is greater.

Fill the surface of the installed product using one of the following methods:

(1) Soil-filled: Spread sandy clay loam topsoil (3877 "Topsoil Material") on top of the installed product at a targeted rate of 135 cubic yard per acre. Apply additional seed at the full seeding rate and the other 1/2 of the fertilizer on top of the soil.
(2) Compost-filled: spread Grade 2 compost (3890 "Compost") on top of the installed product at a targeted rate of 135 cubic yard per acre. Apply additional seed at the full seeding rate and the other 1/2 of the fertilizer on top of the compost.
(3) Organic fiber matrix-filled: Blend additional seed at the full seeding rate and the other 1/2 of the fertilizer with 3884.2B.1, "Organic Fiber Matrix," in the hydroseeder. Do not allow the seed to remain in the hydroseeder tank mixture for more than 1 hour. Hydraulically apply the mixture on top of the installed product at a targeted dry weight rate of 4000 pounds organic fiber matrix per acre.

Adjust actual application rate of soil, compost, or organic fiber matrix as needed to achieve a 1/2 inch to 1 inch Layer and ensure all voids on the product surface are covered and the high points of the product surface are barely visible. Use only rubber tired Equipment if Equipment must operate on the product. Do not allow tracked Equipment or sharp turns on the product.

Place temporary rolled erosion prevention category 35 per 2575.3G.1, "Temporary Rolled Erosion Prevention Products," on top of the seeded topsoil, compost, or organic fiber matrix.

G.3 Placing Permanent Ultra High Performance Products

G.3.a Category 80

Shape and prepare the site according to 2574, "Soil Preparation" or as shown in the Plan. Prepare, shape, and smooth the Subgrade and ensure soils are free of all rocks, stones, sticks, roots, other protrusions, or debris of any kind. The prepared smooth surface shall provide a firm unyielding foundation for the product with no sharp or abrupt changes or breaks in the grade, and contain the water flow profile. For category 80A only, apply seed directly to the prepared soil prior to installation of the product. Furnish and install products at the locations and to the line and grade specified on the Plans. Follow the Standard Specifications, Table 3885.2-6, and manufacturer's directions for installation, including head and side trenching, shingle overlap, and anchor spacing.

G.3.b Category 90

Provide product at the thickness shown in the Plans. Shape and prepare soil appropriate to the intended use. Unless otherwise specified, bury the upgrade end and sides of the product in a check slot 6 inches wide by 6 inches deep. Place anchoring and fastening pins following the manufacturer's recommendations. Overlap all edges by at least 4 inches and secure with anchoring or fastening pins. Apply a bonding seal agent to the seams for a water tight seal. Apply sufficient water to allow proper saturation and hydration and setting of mat and cover as per manufacture's recommendations. Apply additional water 1 hour later on fabrics thicker than 0.5 inches, ditch grades greater than 2 percent, slopes greater than 1:3, and temperatures greater than 80 degrees Fahrenheit to complete the hydration process. Product has a working time of 1-2 hours after hydration.

H Shoulder Mulch Overspray

Perform Shoulder mulch overspray by spraying 3884, "Hydraulic Erosion Control Products," tackifier over seeded and mulched areas on a strip 3 feet wide immediately abutting a Gravel or paved Shoulder as shown on the Plans. During placement, perform the following:

(1) Seed
(2) Cultipack the seedbed
(3) Place Type 1 mulch
(4) Immediately disk anchor the mulch as required by the Contract
(5) Uniformly overspray with Type natural tackifier as a continuous operation

Use a distributer spray bar to spray the 3884.2A, "Hydraulic Tackifiers," at an application rate of 200 pounds per acre that provides 90 percent ground coverage.

I Compost Blanket

Uniformly apply a 2-inch deep layer of Grade 2 compost per 3890, "Compost," as a compost blanket over the soil after preparing the soil per 2574, "Soil Preparation." Distribute the compost by hand with a shovel, spreader unit, or pneumatic blower. Incorporate seed into the compost or broadcast the seed over the top after uniformly spreading the compost. When placing compost blanket adjacent other erosion control products or existing vegetation provide an overlap of at least 2 feet. When placing compost blanket on a 1:2 (Vertical:Horizontal) slope, place and anchor open weave textile netting over the top.

J Weed Control

Control and prevent the spreading of State listed Noxious Weed (NW) and/ or invasive weeds as per Contract or as directed by the Engineer. The current State listed NW species is determined by the Minnesota Department of Agriculture. Identify, mark, map, and monitor weed infestation areas and apply treatments at the appropriate time in order to prevent seed production and spreading.

Obtain a permit from the County Agricultural Inspector or Minnesota Department of Agriculture to transport Material or Equipment containing propagating parts of NW. Follow the permit requirements. Submit to Engineer a copy of the permit.

Submit a Plan at the pre-construction meeting for reducing the spread of NW. The Plan must include methods and sequence of Work. Plans including the use of herbicide(s), submit a copy of the commercial applicator license with categories for CORE and Right-of-way, and list of herbicides to be used. The Inspector must approve herbicides used on Department Right-of-way prior to use.

Movement and reuse of topsoil from infested areas shall be limited to the confines of identified infested areas.

Delineate weed infested areas indicated on the Plan on the Project and when appropriate, fence off from any Work, vehicles, or Equipment.

Minimize the spread of weed seed and other propagules from designated infested areas by minimizing disturbance and by cleaning vehicles and Equipment. Cleaning shall remove soil and vegetation debris from vehicles and Equipment before moving out of infested areas or moving into Project limits. Stockpile of NW infested soils shall be separate from non-infested stockpiles.

K Maintenance

K.1 Sod

Sod maintenance period is 30 Calendar Days. The maintenance period is suspended when soil temperature falls below 32°F and resumes after snow melt and soil temperature is above 40°F. Water within 1/2 hour after sod is laid on soil and provide 1 inch of water. Water sod as needed to maintain soil moisture for the first 10 Calendar Days. For the remainder of the 30 Calendar Days, water sod to supplement rainfall to provide 1 inch per week. Apply all water at a rate that prevents runoff to occur.

During the maintenance period, replace sod dried, dead, damaged, displaced, or weakened or sod infested with over 50 percent weeds. Maintain areas replaced with new sod for at least 20 Calendar Days after replacement.

After maintenance period has ended and as directed by the Engineer apply additional water to supplement rainfall not to exceed 1 inch per 7 Calendar Days until soil temperature falls below 32 degrees.

K.2 Rolled Erosion Prevention Products

Maintain the product installation for 45 Calendar Days if required by the Contract or if substituting product and seed for sod, as approved by the Engineer. Water the blankets and mat systems immediately after placement at a metered application rate of at least 3000 gallons per acre and thereafter as needed to furnish appropriate vegetation. Control erosion and establish a permanent vegetative cover as approved by the Engineer until Contract acceptance. Restore areas with seeding failure or erosion during the maintenance period at no additional cost to the Department.

K.3 Seed

Repair damage within the area caused by Contractor operations and within the Contractor’s control at no expense to the Department. Reseed areas where the original seed has failed to grow, as directed by the Engineer.

K.4 Mulch

Re-mulch areas where the original mulch has eroded, washed away, or blown off, and reseed areas where the original seed has failed to grow, as directed by the Engineer. Use the seed mixture shown on the Plans or other seed mixture approved by the Engineer to perform reseeding.

K.5 Mowing and Weed Spraying

Perform the Work required to control the Department of Agriculture State listed Prohibited Noxious Weeds, either on the areas seeded or sodded under the Contract. The weed spray mixture to be furnished and used shall be as required for that weed control. The Engineer shall approve all Work and weed control Material prior to the start of Work. The Equipment used shall not be so heavy that it causes soil slips or ruts on the slopes or in the ditches. Perform the Work at such time and in such a manner that will avoid spray drift outside the areas designated for spraying.

L Turf Establishment

Turf establishment by a lump sum is for establishing permanent vegetation on small areas of 2 1/2 acres or less per Contract. Such Work shall include soil bed preparation, fertilizer, sod or mulch, rolled erosion prevention products, seed and repair of erosion rills of 3 inches or greater in width or depth.

Unless otherwise shown on the Plans, establish vegetative cover by sodding or by seeding and mulching. Fertilize the areas with a Type 3, slow release fertilizer in accordance with 3881.2B.3, “Type 3 – Slow Release Fertilizer,” at a rate derived from a topsoil fertility test. If seeding, provide and place seed mixture 25-141 as specified in 3876, “Seed,” and provide 3882, “Mulch Material,” Type 3 mulch with disk anchoring or rolled erosion prevention product 25 on slopes 1:3 and steeper, and ditch bottoms.

The Engineer will accept the area after the perennial seed germinates, vegetation is at least 4 inches in height, and cover is uniform. If the seeding fails to germinate, correct and reseed failed areas to establish turf. If using sod, place and maintain sod in accordance with 2575.3F, “Placing Sod,” and 2575.3K, Maintenance.” The Engineer will accept sod in accordance with 2575.3N, “Acceptance of Work.”

L.1 Subsurface Drain Outlets

As per 2502,”Subsurface Drains,” place seed mixture 25-141 in accordance with 3876, “Seed,” or the seed mixture as shown in the Plans. Place rolled erosion prevention category 25 or as shown in the Plans, for that area. Center the headwall along the width of the temporary product. Extend the temporary product 3 feet above the headwall, and 6 1/2 feet below the headwall or to the toe of slope, whichever is the shorter distance. Place product anchors at intervals no greater than 1 1/2 feet apart of the type and depth defined in 3885.2, “Rolled Erosion Prevention Products, Requirements.” If placing a headwall at a location that will be sodded as required by the Contract, delete the seed and rolled erosion prevention product.

M Rapid Stabilization

Perform rapid stabilization at any time when Work is stopped temporarily and there is a risk that sediment will enter the resource waters due to stormwater runoff. Provide the Materials for the methods of rapid stabilization in accordance with Table 2575.3-3:

Table 2575.3-3
Rapid Stabilization

Method	Materials
1	Type 1 mulch placed at a rate of 2 tons per acre with disk anchoring
2	Type 3 mulch placed at a rate of 1.5 tons per acre 3884.2B.3, “Stabilized Fiber Matrix (SFM),” placed at a rate of 750 pounds per acre
3	3884.2B.3, “Stabilized Fiber Matrix (SFM),’ placed at 330 pounds per 1000 gallons of slurry mix Seed mixture 22-111 placed at a rate of 10 pounds per 1000 gallons of slurry mix Type 3 slow release fertilizer 10-10-10 placed at a rate of 50 pounds per 1000 gallons of slurry mix Water placed at a rate of 875 gallons per 1000 gallons of slurry mix Apply mixture at a rate of 6000 gallons per acre
4	Rolled erosion prevention category 25. (natural net) Seed mixture 22-111 placed at a rate of 2 pounds per 100 square yard Type 3 slow release fertilizer 10-10-10 placed at a rate of 8 pounds per 100 square yard
5	Rip rap class II Geotextile type 3

M.1 Placement

M.1.a Method 1

Use method 1 to place mulch on a coverage area from 1/2 acre to 2 acre. Loosen the soil surface before placement to allow anchoring the mulch. Place the mulch to obtain 90 percent ground coverage. Use blower Equipment to place mulch. In areas inaccessible to a blower, place mulch by hand. Immediately after placement, use a disk anchoring tool to anchor the mulch.

M.1.b Method 2

Use method 2 to place mulch on a coverage area from 1/2 acre to 2 acre. Loosen the soil surface before placing the mulch. Place mulch to obtain 75 percent ground coverage. Use blower Equipment to place mulch. In areas inaccessible to a blower, place mulch by hand. Immediately after placement, overspray the mulch with type hydraulic mulch at a rate of 750 pounds per acre.

M.1.c Method 3

Use method 3 to place slurry on a coverage area from 1/2 acre to 1.5 acres. Apply Material in quantities to obtain 100 percent soil surface coverage. In inaccessible areas, pump the mix through a hose. Do not place on snow covered areas. Do not use when Material is left in the tank overnight.

M.1.d Method 4

Use method 4 to place fertilizer, seed, and rolled erosion prevention product on a coverage area from 100 square yards to 1000 square yards. Bury the upgrade end of each blanket strip at least 6 inches in a vertical check slot. Place anchors at seams and throughout the blanket spaced no greater than 2 feet apart, following type and depth defined in Table 3885.2-2.

M.1.e Method 5

Use Method 5 to place class II riprap and geotextile to cover areas.

N Acceptance of Work

Notify the Engineer at least 24 hours before beginning or changing turf establishment operations.

N.1 Seeding

The Engineer will accept permanent seeding in area increments after the placement of seed in accordance with the specifications 2575.3B, “Placing Seed.” For hydro-seeding acceptance will be based on uniform soil coverage.

N.2 Mulching

Mulching will be accepted 2 Calendar Days after initial placement. Remulch areas where the mulch has blown off or washed away during the 2 Calendar Day period at no additional cost to the Department.

N.3 Sod

After expiration of the sod maintenance period, the Engineer will inspect the Work and will accept living sod that is placed in accordance with 2575.3F, “Placing Sod,” and when pulled does not lift from soil.

N.4 Rolled Erosion Prevention Products

For Contracts not requiring maintenance, the Engineer will accept products when installed in accordance to 2575.3, “Establishing Vegetation and Controlling Erosion, Construction Requirements” and 3885, “Rolled Erosion Prevention Products.”

N.5 Hydraulic Erosion Control Products

The Engineer will accept hydraulic erosion control products providing 90 percent exposed soil coverage. The Engineer will accept areas covered by BFM and Type RFM at 100 percent exposed soil coverage.

O Restoration

After the Engineer accepts the turf establishment in an area, restore areas damaged by erosion and sedimentation beyond the Contractor's control as directed by the Engineer. Scarify, grade, shape, excavate, and till to restore eroded areas and clean up sedimentation as directed by the Engineer. Shape, fill, and compact depressions and washouts resulting from erosion with suitable topsoil borrow meeting 3877, "Topsoil Material," as approved by the Engineer. Remove deposited sedimentation as directed by the Engineer. Spread or dispose of sediment removed as approved by the Engineer. Use seed, mulch, rolled erosion prevention products, and sod in the restoration as approved by the Engineer.

P Temporary Poly or Geotextile Coverings

Cover exposed soils with poly sheeting, or Type 5 geotextile fabric and secure tightly in place using an anchoring system of sand bags or other methods accepted by the Engineer. Trench at the top of slope and secure adequately to maintain cover during reasonably expected conditions in the area. Provide a water diversion above to direct water away from areas and prevent undermining. Provide toe protection to control drainage from areas covered so that the discharge does not cause erosion.

Q Workmanship and Quality

To qualify for payment, perform corrective actions when the quality and workmanship fails to meet the Material, installation, or maintenance requirements in the Contract.

2575.4 METHOD OF MEASUREMENT

A Seeding

Measure seeding by the area seeded, regardless of the seed mixture or quantity of seed used, and regardless of whether the seed was furnished by the Contractor or the Department. Areas reseeded by order of the Engineer, after the original seeding of the area was accepted, will be measured and added to the area originally seeded.

B Seed

Measure seed by the weight of Pure Live Seed (PLS) by PLS mass of each mixture or species placed.

C Mulch

Measure mulch in accordance with the following:

(1) Type 1, Type 3, and Type 8 mulch by weight of each type provided and applied in accordance with 2575.3C, "Applying Mulch"
(2) Type 4 mulch by area covered with Material provided and installed in accordance with 2575.3C, "Applying Mulch"
(3) Type 5 and Type 6 mulch Material by loose volume of the Material provided and installed in accordance with 2575.3C, "Applying Mulch"
(4) Type 9 (aggregate) mulch by volume, based on the area of Aggregate provided and a placed in accordance with 2575.3C, "Applying Mulch" to the thickness shown on the Plans
(5) Additional mulch Materials ordered and accepted by the Engineer in remulched areas

D Water

Measure water used by volume for turf establishment of seeded or sodded areas.

E Disk Anchoring

Measure disk anchoring for Type 1, Type 3, and Type 8 mulch by the area of mulch disked in accordance with 2575.3D, "Disk Anchoring."

F Sod

Measure sod by the surface area based at the time of installation. Include the overlapped portion of shingled sod in the measurement.

G Hydraulic Erosion Control Products

Measure tackifiers by the area covered in accordance with 2575.3E, "Placing Hydraulic Erosion Control Products." Measure all other hydraulic erosion control products by dry weight of each type.

H Turf Establishment

Measure turf establishment by lump sum, no measurement will be made of any individual turf establishment item. Included are all Materials and labor as necessary to accomplish the Work regardless of quantities involved.

I Rolled Erosion Prevention Products

The Engineer will measure each Rolled Erosion Prevention Category separately by the square yard of area covered. The Engineer will measure Category 90 by the square yard of surface area covered and cured in place. The Engineer will measure the seed and fertilizer separately. The Engineer will measure any soil or soil amendments installed before placement of rolled erosion prevention products separately.

J Seams and Trenches

The Engineer will not measure those portions of rolled erosion prevention products buried in trenches or check slots or covered by overlaps along seams.

K Blanket Checks

For blanket checks placed according to *Standard Plan 5-297.404*, the Engineer will add an additional 4 feet of length, multiply by the width, and convert to square yards of blanket for each blanket check placed.

L Soil Filled Products

The Engineer will not measure any soil, compost, or organic fiber matrix applied on top of soil filled products.

M Rolled Erosion Prevention Products

Measure each category separately by the area covered. Do not include those portions buried in trenches or covered by required overlaps along seams. For blanket checks installed according to *Standard Plan 5-297.404*, add an additional 4 feet of length, multiply by the width, and convert to square yards of blanket for each blanket check installed.

Measure the seed and fertilizer separately. Measure any soil or soil amendments installed before placement of rolled erosion prevention products separately. Any soil, compost, or organic fiber matrix applied on top of soil filled products is included in the Pay Item rolled erosion prevention.

Measure category 90 by the surface area covered and cured in-place.

N Rapid Stabilization

Measure method 1 and method 2 rapid stabilization by the acre acceptably installed. Minimum measure is 1/2 acre and in 1/6 acre increments per area measured.

Measure method 3 rapid stabilization by the 1000 gallons (M gallon) of slurry furnished and acceptably placed. Minimum measure is 3 M gallon and in 1 M gallon increments (1/6 acre equivalent).

Measure method 4 rapid stabilization by the square yard of rolled erosion prevention product acceptably installed. Minimum measure is 100 square yard and in 25 square yard increments per area measured.

Measure method 5 rapid stabilization will be measured by the ton of rock provided and acceptably installed.

O Temporary Poly or Geotextile Coverings

Measure temporary coverings by the square yard for each areas covered, include all Materials and labor necessary to provide proper slope protection for the life of the Contract of that area covered.

2575.5 BASIS OF PAYMENT

The Contract Pay Items for establishing turf and controlling erosion will include all labor, Materials, Equipment and other Incidentals to compete the Work. The Contract Pay Item will include maintenance, replacement, and repair when required by Contract.

For items of Work not included in the schedule of Contract Pay Items, the Department will pay Unit Prices for the relevant items of Work.

A Erosion Control Items

When the Contract requires maintenance, the Department will pay for installation in a partial payment no greater than 50 percent of the Contract Unit Price. The Department will pay the remaining partial payment after proper maintenance and final acceptance by the Engineer.

B Seed

The Department will pay for seed by the PLS weight of each mixture or species measured.

C Hydroseeding

The Department will not pay for seed mixture or seed/fertilizer mixture that is unused and left in the hydroseeder for longer than 1 hour.

D Mulch

The Contract Unit Price for mulch Material, Type 9 includes the cost of the geotextile fabric for the area covered. The Contract Unit Price for mulch Material type 4 includes hydraulic stabilized fiber matrix.

E Rapid Stabilization

The Contract Unit Prices for rapid stabilization will include the cost of mobilization.

The Contract acre price of rapid stabilization, method 1 or method 2 includes the cost of disk anchoring or hydraulic erosion control products.

The contract M gallon price for rapid stabilization, method 3 includes the cost of seed, fertilizer, and hydraulic erosion control products.

The Contract square yard price for rapid stabilization, method 4 includes the cost of seed and fertilizer.

The Contract ton price for rapid stabilization, method 5 includes the cost of geotextile.

F Rolled Erosion Prevention Products

The Department will pay for rolled erosion prevention product by the square yard. Portions of rolled erosion prevention product covered by overlap along the seams or buried in trenches or check slots are included in the Contract Unit Price. Portions of rolled erosion prevention product folded over as blanket checks are paid for by the square yard of Rolled erosion prevention, Category ___. Soil, compost, or organic fiber matrix applied on top of Soil filled products are included in the Contract Unit Price.

G Shoulder Mulch Overspray

The Department will pay for hydraulic erosion control products, type tackifier separately from Type 1 mulch and disk anchoring for shoulder mulch overspray

H Compost Blanket

The Contract Unit Price for compost blanket will include compost and all Work to perform the task.

I Turf Establishment

The Contract Unit Item includes all costs incurred to complete the Work. The cost of restoring disturbed areas includes tilling, fertilizing, mulching, and establishment of vegetative cover. The Department will provide partial payment of 50 percent of the Contract Unit Item. The Department will pay the remaining partial payment after proper maintenance and acceptance of the vegetative cover.

J Mowing and Weed Control

Payment for mowing and weed spraying at the Contract prices per unit of measure will be compensation in full for all labor and Equipment employed in the Work, and for all Materials used, except that separate payment will be made for the weed spray mixture furnished and applied in conjunction with the item of weed spraying.

K Schedule

The Department will pay for establishing and maintaining turf and controlling erosion on the basis of the following schedule:

Item No.	Item	Unit
2575.501	Turf Establishment	lump sum
2575.504	Compost Blanket	square yard
2575.504	Rolled Erosion Prevention Category ____*	square yard
2575.504	Hydraulic ____ Tackifier	square yard
2575.504	Mulch Material Type 4	square yard
2575.504	Rapid Stabilization Method 4	square yard
2575.504	Sodding Type ____	square yard
2575.504	Temporary ____‖ Covering	square yard
2575.505	Disk Anchoring	acre
2575.505	Mowing	acre
2575.505	Rapid Stabilization Method ____	acre
2575.505	Seeding	acre
2575.505	Weed Spraying	acre
2575.506	Weed Spray Mixture	gallon
2575.507	Mulch Material, Type ____	cubic yard
2575.508	Hydraulic ____ Tackifier	pound
2575.508	Hydraulic ___ _Matrix	pound
2575.508	Shoulder Mulch Overspray	pound
2575.508	Seed, Mixture ____	pound
2575.509	Mulch Material Type ____	ton
2575.509	Rapid Stabilization Method 5	ton
2575.523	Water	M gallon
2575.523	Rapid Stabilization Method 3	M gallon

* If maintenance applies, the Department will place the sub note, "Includes Maintenance" on the Pay Item shown in the summary of quantities on the Plans.
‖ Specify Poly or Geotextile.

2577 SOIL BIOENGINEERED SYSTEMS

2577.1 DESCRIPTION

This Work consists of installing vegetation with geosynthetic or natural Materials to stabilize areas susceptible to erosion. The Contractor may use soil bioengineering as a permanent soil stabilization system in ditches, along stream banks, on shorelines, or on slopes. This Work also consists of providing and installing a composite system on the Project.

2577.2 MATERIALS

A Seed, mix as specified................ 3876

B Mulch, Type as specified................ 3882

C Rolled Erosion Prevention Products................ 3885

D Nursery plant stock................ 3861

E Sediment Control Logs................ 3897

F Riprap................ 3601

2577.3 CONSTRUCTION REQUIREMENTS

A General

The installation locations and layouts shown on the Plans are approximate. The Engineer will determine the exact locations and layouts of bioengineered systems.

Provide a qualified nurseryman, landscape specialist, or experienced crews working under the direct supervision of a qualified nurseryman or landscape specialist to harvest and install plant Material.

Do not begin planting operations or deliver planting stock to the Project until the Engineer determines that weather and soil conditions are suitable for planting and preparations for planting are complete.

During placement, install components until complete. Prevent overnight drying out of plant stock by storing in water. On slopes, begin installing Material at the bottom of slope and proceed in horizontal layers upward. On shorelines and banks, begin installing Material below the water line and proceed up the bank.

During the Work, prevent siltation and turbidity of flowing or impounded waters of the State. If working in water, protect the Work site with curtains, barriers, or other containment devices to prevent sediment and debris from entering the receiving water body.

B Harvesting Plant Stock

Obtain plant stock and cuttings from the regions, zones, or both shown on the Plans.

At least three Working Days before harvesting planting stock for the Project, notify the Engineer of the harvest date to allow for inspection.

C Season of Placement

Refer to Table 2577.3-1 for the dates for seasonal placement. The Engineer may adjust a date specified in Table 2577.3-1 by no more than 20 Calendar Days, based on the prevailing weather conditions.

Provide plant Material in a dormant stage; before buds burst open in the spring or after leaves change color and drop in the fall.

Table 2577.3-1
Approximate Season of Placement

System	Spring	Fall
Wattling	Before April 15	After Nov 1
Brush Layering	Before April 15	After Nov 1
Live Stake	Before April 15	After Nov 1
Root-Rap	April 15 – June 10	July 20 – Sept 20

D Wattling

Dig trenches along the contours of the slope, place bundles of dormant plant cuttings into the trenches, and tamp loose soil over the bundles. Before trenching, drive wooden stakes 16 inches on center along each trench location. Provide stakes with a diameter of 2 inches and a length of 2 feet. Drive the stakes to a firm hold with the tops 6 inches above grade.

Dig trenches no more than 1 hour before installing plant Materials to minimize drying of soils. Leave the overall soil surface in a rough condition with clods, and ridges for maximum resistance to erosion. Immediately following trenching, place bundles of dormant plant cuttings into the trench. Lay cuttings in bundles together with the butt ends located at alternate ends of the bundle and tightly tied with binder twine at least 3 points along the bundle. Provide bundles consisting of dormant woody cuttings from 3/8 inch to 2 inches in diameter and from 3 feet to 8 feet long. Provide bundles from 6 inches to 8 inches in diameter. Overlap wattle ends in the trench. Drive additional stakes through bundles at a spacing no greater than 2 feet on center. During placement of the bundles, cover the bundles with loose soil, working it into the wattles leaving a uniform fringe of plant Material, exposed to a height from 2 inches to 3 inches.

E Brush Layering

Make trenches along the contour of the slope and embed dormant green plant cuttings into the slots and tamp loose soil over the cuttings. Make trenches 2 feet deep, angled downward into the slope. Provide plant cuttings consisting of stems 3 feet long, and from 1/2 inch to 2 inches in diameter. Transport cuttings in containers of water and keep cuttings in the containers until installation. As soon as possible after making the trenches, place the plant cuttings into the trenches with the butt end placed into the trench and at least 6 inches of the cuttings protruding out of the trench. Place the stems randomly with some crisscrossing. While placing plant cuttings, immediately backfill the trench cuttings with soil and firm the backfill to meet the Engineer's approval.

F Live Stakes

Insert dormant live cuttings into the soil and tamp soil lightly around the cutting. Provide cuttings consisting of stems at least 3 feet long and from 1 inch to 2 inches in diameter. Transport cut Material in containers of water and keep Material in water until installation. Insert the bottom end of the cuttings so the bottom-end is at right angles to the slope face for at least 2/3 to 3/4 of the cutting length and tamp. Do not split the ends or damage the bark of the cuttings. Place cuttings 2 feet on center, using a triangular spacing. Place cuttings at a density of 2 to 4 stakes per square yard.

If riprap is less than 2 feet thick, stake the riprap (joint planting). Make a pilot hole by driving a tool, such as a pry bar or rebar, through the riprap and filter Layer, to reach the ground soil. Use a dead blow hammer to tamp the cuttings and avoid damaging the bark. Place the cuttings in a random configuration 2 feet on center.

G Placing Coir log

Place sediment control log type coir for stabilizing shorelines. Before installing the coir log, drive wooden stakes with a diameter of 2 inches and a length of 3 feet, 1 foot on center along the planned alignment of the coir log. Ensure the stakes extend from 8 inches to 10 inches above the elevation of the water surface shown on the Plans. After placing the stakes, install the coir log so the upper surface of the coir log is parallel to the water surface and 2 inches protrude above the normal water level. Lace coir logs together end to end with woven nylon twine, 1/8 inch in diameter to create a continuous length. Bury both ends of the coir rolls 5 feet laterally into the bank.

H Root-Rap

Place a soil filled riprap liner, and overseed or plant vegetation in accordance with the details, typical sections, and elevation controls as shown on the Plans. The Engineer will stake the actual alignment. During the Work, continuously place the granular channel lining or riprap and shape the channel. Begin seeding or planting within 48 hours of shaping the channel or as required by Contract.

I Root Wad

Place a large tree trunk with root attached for stabilizing higher velocity river and stream banks. Tree trunk shall be a minimum diameter of 12 inches and length of 14 to 20 feet with attached roots. Provide footer boulders between 350 to 450 pounds and 24 to 30 inches diameter in accordance to Specifications 3601, "Riprap Material."

Support root wad with footer log, bury footer boulder to support root wad, and bury tree trunk into stream bed, root end facing stream. Top of root wad shall be at bank full elevation and tree trunk should be angled down at a slope of 1:6 (Vertical:Horizontal) into the bank.

J Acceptance of Work

Upon satisfactory installation of the bioengineered systems, the Engineer will authorize partial payment not to exceed 80 percent of the Contract Unit Prices. The remaining percentage shall not become due and payable until after the 30-day maintenance period.

K Workmanship and Quality

To qualify for payment, perform corrective actions when the quality and workmanship fails to meet the Material, installation, or maintenance requirements in the Contract.

2577.4 METHOD OF MEASUREMENT

A Wattling

The Engineer will measure Wattling by the linear foot of each trench made and planted. If several trenches are made and planted, the Engineer will add each length of trench planted and accepted to the total.

B Brush layering

The Engineer will measure Brush layering by the linear foot of each horizontal trench made and planted. If several trenches are made and planted, the Engineer will add each length of trench planted and accepted to the total.

C Coir log

The Engineer will measure coir log by the linear foot provided and installed including buried portions.

D Root Wad

The Engineer will measure Root wad by the each installed including the footer log and footer boulder.

E Root rap

The Engineer will measure Root rap by the cubic yard and includes the riprap and topsoil Material. Seeding and stabilization will be measured separately.

2577.5 BASIS OF PAYMENT

The Contract Pay Item for Bioengineering systems will include all labor, Materials, Equipment, and other Incidentals to compete the Work. For items of Work not included in the schedule of Contract Pay Items, the Department will pay Unit Prices for the relevant items of Work.

If the Contract does not include Pay Items for bioengineered systems, the Department will pay for bioengineered system items as Extra Work in accordance with 1402, “Contract Revisions.”

A Wattles

The costs of plant cuttings, bundles, and stakes and rope to fasten logs are included in the Contract Unit Price for Wattling.

B Brush Layering

The costs of plant cuttings and stakes and rope to fasten logs are included in the Contract Unit Price for Brush layering.

C Coir Logs

The costs of stakes and rope to fasten logs are included in the Contract Unit Price for coir logs.

D Schedule

The Department will pay for bioengineered system items on the basis of the following schedule:

Item No	Item	Unit
2577.502	Live Stakes	each
2577.502	Root Wad	each
2577.503	Brush Layering	linear feet
2577.503	Wattling	linear feet
2577.507	Root Rap	Cubic yard

2580 INTERIM PAVEMENT MARKING

2580.1 DESCRIPTION

This Work consists of placing interim pavement markings on those pavements, prior to opening them to traffic, where the in-place surface is to be covered by a subsequent paving course or the permanent lane markings are to be placed at a future date.

2580.2 MATERIALS

A Removable Preformed Plastic Pavement Marking Tape 3355

B Multi-Component Liquid Pavement Markings .... 3590 and 3592

C Water-Based Traffic Paint .... 3591 and 3592

D Temporary Raised Pavement Markers (TRPMs)................Temporary Raised Pavement Markers *Approved/Qualified Products List*.

2580.3 CONSTRUCTION REQUIREMENTS

A Application

When centerline or lane markings (excluding edgelines) are removed, apply the interim pavement markings prior to opening the Roadway to traffic. Apply edgelines within 14 Calendar Days of opening Roadway to traffic. Apply the interim pavement marking on a clean, dry pavement surface, free of dirt and foreign matter as recommended by the Material manufacturer and as required by Contract. Follow the manufacturer's specifications for installation procedures and Materials.

When final markings are to be multi-component liquid and paint is used for interim solid lines, a 10 mil thick Layer application of a water-based traffic marking paint shall be used. With a 10 mil Layer of paint applied, beads should be applied at a rate of 6 pounds per gallon. Removal of the 10 mil Layer of paint is not required prior to placing the multi-component liquid. If the Layer of paint is greater than 10 mils, removal is necessary prior to placing the multi-component liquid.

Interim markings shall consist of centerline markings including no passing zone markings, painted islands, and lane lines (excluding edgelines, crosshatching, and pavement messages) in accordance with the *Minnesota Manual on Uniform Traffic Control Devices* (*MN MUTCD*). Provide interim markings with a width equal to the corresponding permanent pavement marking and with a cycle length as indicated in the Plan. Lateral placement of the markings from centerline shall be as directed by the Engineer.

B Tolerance

Conform with the following interim striping tolerances:

A tolerance of plus 1/4 inch and minus 0 inch from the specified width will be allowed for striping provided the variation is gradual and does not detract from the general appearance. Lengths for the broken line segments may vary no more than ±3 inches. Place longitudinal markings 2 inches ± 1 inch from the edge of pavement or longitudinal (centerline) joint. Also, pertaining to the cycle length, the total allowance for the line segment and gap shall be no more than ± 3 inches. Establishment of application tolerances shall not relieve the Contractor of their responsibility to comply as closely as practicable with the planned dimensions. Interim markings on the final pavement surface shall match the location of the final markings.

In the event the Engineer determines the interim striping is out of tolerance, take corrective action. Remove pavement markings utilizing Equipment that is not detrimental to the final surface, as required by the Engineer. Costs associated with removing and restriping the interim markings will be at the Contractor's expense. This would include any costs associated with repairing damage caused to the wearing course after pavement marking removal.

C Temporary Raised Pavement Markers (TRPMs)

When TRPMs are used as interim markings, install per the Plan. Removal of TRPMs shall be included in the 2580, "Interim Pavement Marking, " Pay Item.

D Maintenance and Removal

Maintain and replace the interim markings without additional compensation until they are covered by the next paving course, are replaced with permanent pavement markings, or final acceptance of the Project is made. Remove TRPMs and pavement marking tape between pavement courses, except for TRPMs used with seal coats. Remove TRPMs used as Interim pavement markings. Remove any solid line delineations on the final pavement surface marked with pavement marking tape prior to placing the permanent pavement markings. The Engineer may require the removal of any Interim pavement markings that will interfere with the placement of the permanent markings or could cause confusion to the traveling public if left in place. Removal of Interim pavement markings, if required, shall be included in the Pay Item, and shall be in accordance with 2102, "Pavement Marking Removal." Waste from installation, removed marking Material and removal media shall become property of the Contractor. Dispose of all waste generated by Interim pavement marking removal process in accordance with 1701, "Laws to be Observed," and 1717, "Air, Land, and Water Pollution."

2580.4 METHOD OF MEASUREMENT

A Length

Interim pavement markings will be measured by the actual length in linear feet of each line marked as indicated in the Plan and will not include the gap between line segments. No additional quantity will be included for repair or renewal Work. Measurement for TRPMs will be made according to the length of line being simulated.

B Lump Sum

The Engineer will not measure Interim pavement markings placed, maintained, and removed if the Contract specifies Interim pavement markings as a lump sum.

2580.5 BASIS OF PAYMENT

Payment for Interim pavement marking at the Contract price per unit of measure shall be compensation in full for costs of furnishing and placing the marking, removal if required, and necessary maintenance and renewal Work.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for Interim pavement marking. The amounts of these adjustments are deemed reasonable.

If the Contractor is negligent in adhering to the provisions set forth in 2580.3B, "Tolerance," the Department will assess an hourly charge at a rate of $250.00 per hour for each hour or any portion thereof which the Engineer determines that the Contractor has not complied.

B **Schedule**

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

Item No.	Item	Unit
2580.501	Interim Pavement Marking	lump sum
2580.503	Interim Pavement Marking	linear foot

2581 REMOVABLE PREFORMED PAVEMENT MARKING AND MESSAGE TAPE

2581.1 DESCRIPTION

This Work consists of providing, placing, maintaining, and removing Removable preformed pavement marking and message tape as shown on the Plan or directed by the Engineer. Removable preformed pavement marking tape is used for longitudinal markings and Removable preformed pavement message tape is used for messages and crosswalks.

2581.2 MATERIALS

A **Removable Preformed Pavement Marking Tape 3355**

2581.3 CONSTRUCTION REQUIREMENTS

Place, maintain, and remove Removable preformed pavement marking and message tape as shown on the Plans or as directed by the Engineer before modifying traffic flow. Place the removable tape on a clean and dry surface in accordance with the manufacturer's recommendations. Do not use narrow line Material to piece together wider linear pavement markings.

For Removable preformed pavement message tape, utilize precut messages, symbols, and blocks meeting the requirements of the *Minnesota Manual on Uniform Traffic Control Devices* and the *MnDOT Standards Signs and Markings Manual*. Kits provided by the manufacturer are acceptable. Do not use line Material to piece together individual letters, symbols, or crosswalk blocks. An exception is that 3 strips of 12" line Material may be used to form crosswalk blocks of 36" width.

Waste generated from installation, removed marking Material, and removal waste shall become property of the Contractor. Dispose of waste generated by Removable preformed pavement marking and message tape process in accordance with 1701, "Laws to be Observed," and 1717, "Air, Land, and Water Pollution."

The Department will base acceptance of Removable preformed pavement marking and message tape on the certification and Quality Control testing verified by the Materials Laboratory testing of verification samples and spot checks on samples obtained from Contractor stock or from the Project Site in accordance with the Pavement Marking Qualification and Acceptance Program.

2581.4 METHOD OF MEASUREMENT

A **Length**

The Engineer will measure Removable preformed pavement marking tape lines by the length in feet of each type constructed in-place as required by the Contract. The Engineer will not include the gaps between broken and dotted line segments in the measurement.

B **Area**

The Engineer will measure Removable preformed pavement message tape by the area in square feet of Material constructed in-place as required by the Contract.

2581.5 BASIS OF PAYMENT

The Contract linear foot price for Removable preformed pavement marking tape includes the cost of providing, placing, maintaining, replacing, removing, and disposing of the marking tape.

The Contract square foot price for Removable preformed pavement message tape includes the cost of providing, placing, maintaining, replacing, removing, and disposing of the marking tape.

The Department will pay for Removable preformed pavement marking tape on the basis of the following schedule:

Item No.	Item	Unit
2581.503	__ " Removable Preformed Pavement Marking Tape *‖	linear foot
2581.518	Removable Preformed Pavement Message Tape *‖	square foot
* Specify if markings are Contrast		
‖ Specify if markings are WR		

2582 PAVEMENT MARKINGS

2582.1 DESCRIPTION

This Work consists of providing permanent and temporary pavement markings for Roadways, including pavement messages, linear pavement markings, and crosswalks.

A Definitions

For the purpose of the Work specified in section 2582, "Pavement Markings," the Department defines:

Pavement Messages
Word and symbol pavement markings installed in the Roadway that are not line segments or Crosswalks.

Linear Pavement Markings
Line segments of various widths installed in the Roadway, including lane lines, centerlines, no passing zone lines, edgelines, airplane markings, crosshatching of flush medians/gores, and stop lines. The Department does not consider Crosswalks or Pavement Messages as Linear Pavement Markings.

Crosswalks
Blocks installed in the Roadway parallel to the direction of travel in a pattern that is transverse to the direction of travel.

2582.2 MATERIALS

A Preformed Pavement Marking Tape (Pref Tape).. 3354

B Preformed Thermoplastic (Pref Thermo)... 3356

C Multi-Component Liquid Pavement Markings (Multi Comp) 3590

D Water-Based Traffic Paint (Paint) 3591

E Drop-On Glass Beads 3592

Provide and use pavement marking Materials listed on the *Approved/Qualified Products List*. For wet reflective (WR) Materials, use the wet reflective marking Materials *Approved/Qualified Products List*.

Do not change any of the following unless approved by the Department:

(1) Product identification
(2) Chemical composition as indicated by infrared spectrophotometry or chemical analysis
(3) Application requirements

Submit proposed changes to the Materials Laboratory for further evaluation.

2582.3 CONSTRUCTION REQUIREMENTS

A Certification of Materials

The Department will base acceptance of pavement marking Materials under the Pavement Marking Qualification and Acceptance Program on the product certification and Quality Control testing verified by Materials Laboratory testing of verification samples and spot checks on samples obtained from Contractor stock or from Project Sites.

B Application

Apply on a clean, dry pavement surface, free of dirt and foreign matter, and as required by the Contract. Apply surface treatments prior to pavement marking installation.

Notify Engineer one Business Day prior to installation of pavement markings.

B.1 Manufacturer's Specifications

Apply the pavement marking as recommended by the Material manufacturer in regards to pavement type, pavement composition, environmental conditions, placement within a rumble, and other relevant factors in order to meet the requirements detailed in 2582.3C "Acceptance."

B.2 Concrete Surface Preparation

Before applying Multi Comp or Paint markings on new Portland cement concrete surfaces, remove surface treatments or laitance unless the marking is recessed per 2582.3B.7, "Recessing."

B.3 Bituminous Surface Cure

Before applying non-recessed permanent pavement markings, allow bituminous pavement to cure a minimum of 10 Calendar Days (or follow manufacturer's specifications for pavement cure time, whichever is greater), unless otherwise directed by the Engineer.

B.4 Thickness Requirements

For Multi Comp markings, apply the multi-component liquid marking with a wet-film thickness of at least 20 mil. Apply at a greater wet-film thickness as recommended by the Material manufacturer based on pavement type, pavement composition, environmental conditions, placement within a rumble, and other relevant factors.

B.5 Manufacturer Installation Certification

For Pref Tape or Pref Thermo, obtain manufacturer certification for installation. Certification is typically achieved by attending an application training seminar. The training shall address surface preparation and application requirements and techniques necessary for successful marking tape applications. Upon completion of the seminar for these personnel, the manufacturer of the Pref Tape or Pref Thermo shall provide written certification of approval to each person approved. Present a valid training certification card upon request of the Engineer or other State Project personnel.

B.6 Assembly of Preformed Markings

For Pref Tape or Pref Thermo Pavement Messages and Crosswalks, utilize precut messages, symbols, and blocks meeting the requirements of the *Minnesota Manual on Uniform Traffic Control Devices* and the *MnDOT Standards Signs and Markings Manual*. Kits provided by the manufacturer are acceptable. Do not use line Material to piece together individual letters, symbols, or crosswalk blocks. An exception is that 2 strips of 18-inch line Material may be used to form Crosswalk blocks of 36-inch width. For Pref Thermo it is also acceptable to use 3 strips of 12-inch line Material to form Crosswalk blocks of 36-inch width.

Do not use narrower line Material to piece together wider Linear Pavement Markings.

For Pref Thermo, taper the external edge of the marking to minimize risk of plow damage.

For Perf Tape over cracks or joints, lay over crack or joint then cut 1 inch on each side of crack or joint.

B.7 Recessing

For ground in (Gr In) pavement markings, recess the pavement marking utilizing the following Equipment and details:

B.7.a Recessing Equipment

For any pavement markings on concrete surface, Pref Tape on bituminous surfaces, or Pref Thermo on bituminous surfaces, the recessing shall be performed by a self-propelled machine equipped with gang stacked diamond cutting blades mounted on a floating head with controls capable of providing uniform depth and alignment. The cutting heads shall consist of stacked 1/8 inch to 3/8 inch wide diamond tipped cutting blades. The spacers between each blade must be such that the raise in the bottom of the finished recess between the blades is less than 25 percent of the recessed depth. The resulting bottom of the recess shall have a fine corduroy finish. If a coarse tooth pattern is present, increase the number of blades and/or decrease the thickness of the spacers on the cutting head.

For liquid pavement markings on bituminous surfaces, the recessing shall be performed by either:

(1) A self-propelled machine equipped with gang stacked diamond cutting blades mounted on a floating head with controls capable of providing uniform depth and alignment. The cutting heads shall consist of stacked 1/8 inch to 3/8 inch wide diamond tipped cutting blades. The spacers between each blade must be such that the raise in the bottom of the finished recess between the blades is less than 25 percent of the recessed depth. The resulting bottom of the recess shall have a fine corduroy finish. If a coarse tooth pattern is present, increase the number of blades and/or decrease the thickness of the spacers on the cutting head.

(2) A self-propelled machine equipped with carbide cutting blades with controls capable of providing uniform depth and alignment.

The Equipment shall be capable of recessing the total width of the recess in 1 pass or recessing uniform depths with multiple passes. The maximum number of passes is detailed below in Table 2582.3-1. If multiple passes are used, the ridge between passes shall be mechanically removed prior to recess cleaning and pavement marking application.

The Equipment shall be capable of recessing double lines simultaneously or parallel lines to a uniform depth with 2 passes.

The Equipment shall be self-vacuuming and leave the cut recess ready for pavement marking installation. Dry cut recessing without a vacuum will only be allowed if markings run perpendicular to the Roadway, such as stop bars. Use the Equipment and method approved by the pavement marking manufacturer.

Waste generated from the recessing process shall become property of the Contractor. Dispose of waste generated by the recessing process in accordance with 1701, “Laws to be Observed,” and 1717, “Air, Land, and Water Pollution.”

B.7.b Recessing Details

The recessing shall be performed within the following tolerances. Failure to meet these tolerances will result in the suspension of Work until the Contractor can demonstrate that these tolerances can be met to the satisfaction of the Engineer. The pavement marking system shall be applied so that it is centered within the recess.

Table 2582.3-1
Recess Width and Maximum Number of Passes

Marking Material Width	Recess Width	Max Number of Passes
4 inches	5 inches ± 1/8 inch	1
6 inches	7 inches ± 1/8 inch	1
8 inches	9 inches ± 1/8 inch	1
12 inches	13 inches ± 1/8 inch	2
24 inches	25 inches ± 1/8 inch	3
Note: The recess width for other marking Material widths must be 1 inches ± 1/8 inch greater than the marking Material width.		

Place the recesses for double or parallel lines 4 inches ± 3 inches apart perpendicularly.

Place the recess for broken or dotted lines the length of the marking ± 3 inches.

For Pref Tape Gr In or Pref Thermo Gr In, provide a recess depth of 110 mil ± 10 mil.

For Multi Comp Gr In or Paint Gr In pavement markings, provide a recess depth of 40 mil ± 10 mil.

For Multi Comp Gr In (WR) or Paint Gr In (WR), provide a recess depth of 70 mil ± 10 mil.

Since pavements are irregular, the depth of recess across the width may vary. To compensate for this, the depth of the recess shall be measured from the bottom of the recess to a straight edge placed on the recess edges extended over the recess.

Place the recess 2 inches ± 1 inch from the edge of joints or seams along edge or centerline, unless otherwise indicated in the Plan.

Recess alignment deviations from the control guide or existing lines specified by the Engineer shall not exceed 2 inches.

Clean the recess completely prior to pavement marking application, using an air compressor with at least 185 CFM air flow and 120 psi air pressure. The compressor must be equipped with a moisture and oil trap, and cannot have more than 50 feet of 3/4 inch inside diameter hose between the compressor and the air nozzle. The air nozzle must have an inside diameter of 1/2 inch or greater.

Place pavement markings to be recessed in accordance with pavement marking and retroreflective media manufacturer's instructions, except for recess depth. Do not construct a recess in new bituminous pavement unless the pavement is cured enough to handle the weight of the Equipment.

If the pavement markings are to be installed in the same location where there are existing pavement markings, including interim or temporary, the removal of the existing pavement markings shall be included in the 2582, "Pavement Marking," Pay Item. The Contractor may cut the recess and remove the existing marking in a simultaneous operation.

B.8 Retroreflective Media

For Paint linear markings that are not WR, apply glass beads specified in 3592 "Drop-On Glass Beads" immediately after applying a Paint line at a rate of at least 8 pounds per gal. Apply beads at a greater rate if recommended by the manufacturer to achieve the minimum levels of retroreflectivity in accordance with Table 2582.3-2.

For Multi Comp linear markings that are not WR, apply glass beads specified in 3592 "Drop-On Glass Beads" at a rate of at least 25 pounds per gal. Apply beads at a greater rate if recommended by the Material manufacturer to meet the required minimum levels of retroreflectivity in accordance with Table 2582.3-2.

For WR markings, apply wet reflective media per manufacturer's specifications.

Evenly distribute retroreflective media on pavement markings.

C Acceptance

C.1 Alignment

Provide Linear Pavement Marking in the width specified in the Contract, varying by no greater than +1/4 inch per 10 feet. Provide broken line segments with lengths varying by no greater than 3 inches. Provide alignment deviating from the control guide or existing lines specified by the Engineer by no greater than 2 inches. Ensure the transverse position of linear markings varies by no greater than 1 inch per 10 feet. Do not apply pavement marking Material over a longitudinal joint.

C.2 Color

Provide pavement markings in the color specified in 2582.2, "Pavement Markings, Materials," for the respective Material.

C.3 Retroreflectivity

Initial pavement marking retroreflectivity is defined as the pavement marking retroreflectivity as measured between 14 Calendar Days and 44 Calendar Days after pavement marking installation, prior to snow and ice maintenance operations. Provide pavement markings meeting the following minimum initial pavement marking retroreflectivity when tested using 30 meter geometry in accordance with *ASTM E1710, Standard Test Method for Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer*. Measurement of message retroreflectivity is done via *ASTM D7585/D7585M*

6.4.4, Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments.

Table 2582.3-2
Minimum Initial Pavement Marking Retroreflectivity

	White	**Yellow**
Pref Tape	600 millicandela/square meter/lux	500 millicandela/square meter/lux
Pref Thermo	300 millicandela/square meter/lux	200 millicandela/square meter/lux
Pref Thermo, ESR (Enhanced Skid Resistance)	250 millicandela/square meter/lux	150 millicandela/square meter/lux
Multi Comp	300 millicandela/square meter/lux	200 millicandela/square meter/lux
Paint	275 millicandela/square meter/lux	180 millicandela/square meter/lux

Remove and replace, pavement markings not meeting the minimum initial pavement marking retroreflectivity values in accordance with Table 2582.3-2 at no additional cost to the Department.

C.4 Mobile Reflectometer Measurements (MRM)

Provide dry retroreflectivity measurements of longitudinal markings utilizing an independent Contractor using a vehicle-mounted mobile retroreflectometer utilizing 30 meter CEN geometry in accordance with *ASTM E1710, Standard Test Method for Measurement of Retroreflective Pavement Markings Materials with CEN-Prescribed Geometry Using a Portable Reflectometer*. The retroreflectometer shall be calibrated in accordance with the operating manual and calibration guide for the particular machine and vehicle. Measurement shall consist of the average retroreflective readings and standard deviations, as well as contrast ratios, over 0.1 mile intervals (or over the length of the line if shorter than 0.1 mile) for each type of pavement marking placed.

Provide a measurement report that includes:

(1) State Project Number
(2) Data collection software version
(3) Date and time of data collection
(4) The Highway number with the beginning and ending reference points of data collection rounded to the nearest hundredths of a mile and the beginning and ending coordinates determined by a Global Positioning System receiver with 3 meter accuracy, including the direction of travel in terms of increasing or decreasing reference points
(5) Which line is being read (LEL – Left Edgeline, REL – Right Edgeline, CL, Centerline, LL – Lane Line Skip, 1LL – left most LL in multilane, 2LL – second to left most LL in multilane (Auxiliary Lane markings are included and will be read separate from edgelines), etc.)
(6) The 0.1 mile interval retroreflective reading averages and standard deviations
(7) The 0.1 mile interval contrast ratio average
(8) An explanation for any intervals that are marked invalid
(9) A summary of the average retroreflective readings for each individual run file
(10) A summary of the average retroreflective readings in one mile intervals

(11) A summary of average retroreflective readings based on 0.1 mile intervals. Base the summary on Table 2582.3-3

Table 2582.3-3
Summary of Average Retroreflective Readings

Product	White	Yellow
Pref Tape	Percent of Intervals < 300	Percent of Intervals < 250
	300 ≥ Percent Intervals ≤ 419	250 ≥ Percent Intervals ≤ 349
	420 ≥ Percent Intervals ≤ 479	350 ≥ Percent Intervals ≤ 399
	480 ≥ Percent Intervals ≤ 539	400 ≥ Percent Intervals ≤ 449
	540 ≥ Percent Intervals ≤ 599	450 ≥ Percent Intervals ≤ 499
	600 ≥ Percent Intervals	500 ≥ Percent Intervals
Multi Comp	Percent Intervals < 150	Percent Intervals < 100
	150 ≥ Percent Intervals ≤ 209	100 ≥ Percent Intervals ≤ 139
	210 ≥ Percent Intervals ≤ 239	140 ≥ Percent Intervals ≤ 159
	240 ≥ Percent Intervals ≤ 269	160 ≥ Percent Intervals ≤ 179
	270 ≥ Percent Intervals ≤ 299	180 ≥ Percent Intervals ≤ 199
	300 ≥ Percent Intervals	200 ≥ Percent Intervals
Paint	Percent Intervals < 150	Percent Intervals < 100
	150 ≥ Percent Intervals ≤ 191	100 ≥ Percent Intervals ≤ 125
	192 ≥ Percent Intervals ≤ 219	126 ≥ Percent Intervals ≤ 144
	220 ≥ Percent Intervals ≤ 246	145 ≥ Percent Intervals ≤ 162
	247 ≥ Percent Intervals ≤ 274	163 ≥ Percent Intervals ≤ 179
	275 ≥ Percent Intervals	180 ≥ Percent Intervals

Provide the measurement report in the form of an electronic database file, or delimited text file, containing all raw data collected. Submit the data to the email address: PMdata.dot@state.mn.us and copy the Engineer. Provide a printed summary to the Engineer. The formats of the required data file and summary can be found at the MnDOT Traffic Engineering Pavement Marking Management website.

Conduct the evaluation of retroreflectivity between 14 Calendar Days and 44 Calendar Days after pavement marking installation, prior to snow and ice maintenance operations. If readings are not taken prior to snow and ice maintenance operations, readings will not be taken and no compensation will be given. Excess beads or reflective elements must not be visible before the retroreflectivity testing is conducted. Collect the data when pavement and markings are dry, clean and no visible moisture is on the road surface. Note in the report any areas where the pavement markings are obscured. Measure centerline markings in both directions. Measure other longitudinal markings in the direction of intended vehicular travel. Notify the Engineer at least 1 Business Day prior to collecting data.

Evaluate any replaced or repaired markings per this Specification at no additional cost to the Department.

D Preformed Pavement Marking Warranty

For Permanent Pavement Markings, transfer manufacturer’s warranties to the Department after placement.

E Correction of Defects

Remove and replace pavement markings not meeting the Contract requirements as directed by the Engineer at no additional cost to the Department.

F Pavement Marking Installation Record

For Permanent Pavement Markings, provide a record of the pavement marking installation.

F.1 Striper Computerized Data Logging System for Liquid Markings (DLS)

For liquid pavement marking Material (such as Paint or Multi Comp) on Projects with at least 1 centerline mile in length, provide Striper Computerized Data Logging System files as described below. The pavement marking device shall have an onboard monitoring system for the purpose of managing the amount of striping Materials being applied to the pavement surface. Collect data for any pavement marking application of 300 feet (drive length) or greater.

For preformed Materials (Pref Tape and Pref Thermo) and liquid pavement markings on Projects with less than 1 centerline mile of length provide the Construction Striper Operations Daily Logs as described in 2582.3F.2, “Construction Striper Operations Daily Log.” The Contractor may provide the Striper Computerized Data Logging System files in lieu of the Construction Striper Operations Daily Log.

The following data shall be included in the documentation from the DLS:

(1) State Project Number
(2) For every Highway marked

  (a) the route system abbreviation – I, US, or MN
  (b) the Highway number
  (c) the beginning and ending reference points rounded to the nearest hundredths of a mile and the beginning and ending coordinates determined by a Global Positioning System receiver with 3 meter accuracy, including the direction of travel in terms of increasing or decreasing reference points

(3) Date and beginning and ending time of application
(4) Product (binder and reflective Material)
(5) Lot number(s) of product (binder and reflective Material) used
(6) Striping Contractor (striper code)
(7) Designation of the marking being applied (LEL – Left Edgeline, REL – Right Edgeline, CL - Centerline, LL – Lane Line Broken or Dotted, 1LL – left most LL in multilane, 2LL – second to left most LL in multilane, etc.)
(8) Width of marking being applied
(9) Presence of recess rumble strip, or contrast marking (report if majority of line is installed with each characteristic within that segment)

The following data shall be reported as an average for each drive mile (or other Engineer approved segment) installed:

(10) Application vehicle speed to the nearest 0.1 mph
(11) Weight (pounds) and/or volume (gallon) as measured through a positive displacement pump (mechanism or flow meter) of liquid Material(s) used by color
(12) Weight (pounds) of reflective Material used
(13) Ratio of reflective Material used (weight) per liquid Material used (volume) reported as pounds/gallon
(14) Ambient air temperature (in degrees Fahrenheit)
(15) Road surface temperature (in degrees Fahrenheit)
(16) Humidity (percent)
(17) Dew Point (in degrees Fahrenheit)

(18) The system shall record the average Material application rates and film thickness calculated over the section striped

Provide the measurement report in the form of an electronic database file, or delimited text file, containing raw data collected. Submit the data to the email address: PMdata.dot@state.mn.us and copy the Engineer. Provide a printed summary to the Engineer. The formats of the required data file and summary can be found at the MnDOT Traffic Engineering Pavement Marking Management website.

The DLS Equipment shall be operational, calibrated, and in use during pavement marking operations. Pavement marking installation without the use of a DLS shall constitute unauthorized Work under 1512, “Unacceptable and Unauthorized Work.”

Upon request, provide to the Engineer the DLS manufacturer’s recommendations for Equipment calibration frequency and provide certification that the Equipment meets manufacturer’s recommended calibration.

Verify that the physical and electronic measurement of distance travelled is consistent by travelling a 100 foot distance prior to the start of pavement marking operations.

F.2 Construction Striper Operations Daily Log

For Projects with a liquid pavement marking Material (such as Paint or Multi Comp) and less than 1 centerline mile in length, utilize either a DLS from 2582.3F.1 “Striper Computerized Data Logging System for Liquid Markings (DLS)” or complete the *Construction Striper Operations Daily Log* form after applying the pavement markings. This form can be found at the MnDOT Traffic Engineering Pavement Marking Management website.

For non-liquid Linear pavement markings (such as Pref Tape), Pavement Messages of any Material, and Crosswalks of any Material, complete the *Construction Striper Operations Daily Log* form after applying the pavement markings. This form can be found at the MnDOT Traffic Engineering Pavement Marking Management website.

2582.4 METHOD OF MEASUREMENT

A Pavement Messages

The Engineer will measure Pavement Messages by the area in square foot of Material installed as required by the Contract.

B Lines

The Engineer will measure pavement marking lines by the length in feet of each type constructed in-place as required by the Contract. The Engineer will measure broken and dotted lines by the actual length of line marked. The Engineer will not include the gaps between the broken and dotted lines in the measurement.

C Crosswalks

The Engineer will measure Crosswalk blocks by type and by the area in square feet of Material installed as required by the Contract.

D Mobile Retroreflectometer

The Mobile retroreflectometer measurements will be measured by the length in feet. The linear foot will be measured for the distance travelled by the mobile retroreflectometer as it measures the retroreflectivity of the pavement marking. This assumes 1 laser instrument on 1 van that will read 1 line with each pass. For a 1 mile section of 2-lane, 2-way Roadway this would need 4 passes – First Direction: REL and CL, Second Direction: REL and CL - equating to 21120 linear feet.

2582.5 BASIS OF PAYMENT

The Contract Unit Price for pavement markings includes the costs of Materials, collection of survey data, marking of spot locations, initial pavement marking retroreflectivity, installation, pavement marking installation records, traffic control, surface preparation, and primers as required by the Contract. Twenty-five percent of the payment for pavement markings will be retained until the pavement parking installation records are submitted per 2582.3F, “Pavement Marking Installation Record.”

The Contract Unit Price for the Mobile retroreflectometer measurements (MRM) includes all costs incurred in Materials, Equipment, labor, traffic control, and time as required by the Contract. When MRM is required per the Contract, 50 percent of the payment for pavement markings will be retained until the evaluation of retroreflectivity is complete and the Work is accepted by the Engineer.

A Monetary Adjustments

The Department must apply Incentives and Disincentives and may apply monetary deductions for pavement markings. The amounts of these adjustments are deemed reasonable.

A.1 Retroreflectivity

The Department may apply a monetary deduction if the pavement marking retroreflectivity deficiency compared to Table 2582.3-2 is no greater than 20 percent per tenth mile segment. The Engineer will reduce the Contract Unit Price by the percent of retroreflectivity deficiency.

B Schedule

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

Item No.	Item	Unit
2582.503	___” * ‖† (‡) # §	linear foot
2582.503	Mobile Retroreflectometer Measurements	linear foot
2582.518	Pavement Message ‖ † (‡) # §	square foot
2582.518	Crosswalk ‖ † (‡) # §	square foot

* Specified type of line
‖ Specified Material
† Specified if markings are Ground In
‡ Specified if markings are WR
# Specified if markings are contrast
§ Specified if markings are Enhanced Skid Resistant (ESR)

END OF VOLUME 2