2451 STRUCTURE EXCAVATIONS AND BACKFILLS

2451.1 DESCRIPTION

This work consists of excavating, preparing foundations, and placing backfill for bridges and miscellaneous structures, either cast-in-place or prefabricated. This work also consists of constructing and removing cofferdams, making soil bearing tests, and the disposing of surplus excavated materials.

The Department considers cast-in-place structures as bridge substructures, concrete box culverts, concrete retaining walls, and structural plate arch footings. The Department considers prefabricated structures as precast concrete or prefabricated metal structures including pipe culverts and sewers, cattle passes, and subsurface drains.

2451.2 MATERIALS

A Granular Materials..... 3149

Provide granular materials for special backfill, bedding, drain, or filter purposes as shown on the plans and in accordance with the following:

2451.3 CONSTRUCTION REQUIREMENTS

A General Requirements

Prepare foundations to the elevations and grades shown on the plans. Use temporary construction to place structures or substructures in open excavations under dry conditions.

A.1 Site Preparations

Clear and grub in accordance with 2101, “Clearing and Grubbing.” Clear and grub the entire area bounded by straight lines between the structure extremities. If constructing bridges, extend clearing and grubbing operations to the right-of-way between the bridge extremities. Remove tree branches that overhang the structure and inhibit its function.

Perform preliminary embankment construction in accordance with 2105, “Excavation and Embankment.”

A.2 Elevations and Dimensions

The Engineer may make adjustments, in writing, to the approximate elevations and dimensions of footings as shown on the plans.

The Engineer may make adjustments to the approximate location and orientation of box culverts and pipe structures as shown on the plans.

A.3 Temporary Construction

Perform temporary construction work to avoid unnecessary hazard or disruption to the permanent work at no additional cost to the Department. Temporary construction may include sheeting, shoring, bulkheads, dikes, channels, drainage pipes, sluiceways, cofferdams, warning signs, and fencing as necessary.

Obtain the Engineer's approval of detailed construction plans and methods before starting temporary construction work as required by the contract.

A.3.a Cofferdams

Construct cofferdams of sufficient size to allow pumping, and provide waterways outside of the forms. Include provisions to allow lowering the foundation elevation to 3 ft [1 m] below the level as shown on the plans.

Do not place cofferdam bracing against the concrete forms or the structure. The Contractor may extend steel bracing through poured concrete located below the final ground elevation. Do not box out braces or struts unless otherwise approved by the Engineer in writing.

Remove cofferdams located within roadbed embankments when no longer needed, to at least 4 ft [1.2 m] below the subgrade elevation. Remove cofferdams located in streams or lakes to the bottom of the stream or lakebed. Remove cofferdams located in established navigation channels to an elevation at least 2 ft [0.6 m] below the established bottom of the channel. Remove all other cofferdams to an elevation at least 2 ft [0.6 m] below grade.

A.3.b Concrete Foundation Seal

If the plans do not show a concrete seal, the Contractor may install a concrete seal within a cofferdam, if reviewed and accepted for general compliance by the Engineer. Perform the concrete seal construction, including necessary excavation, at no additional cost to the Department. Submit written notice to the Engineer indicating the planned seal thickness, sources of materials, and method of concrete placement. If the Engineer accepts the proposed seal, the Engineer will provide a mix design for the concrete.

Place the entire seal below the foundation elevation for that particular substructure shown on the plans in accordance with 2401.3.C, "Placement of Concrete."

A.3.c Pumping

While pumping from within foundation enclosures, keep the foundation materials intact and do not draw water through or over the fresh concrete. The Contractor may pump during concrete placement and within 24 h after concrete placement, if using a pump separated from the work by a watertight wall or other means that prevent damage to the foundation.

Do not begin pumping to dewater a cofferdam sealed with concrete until the seal has cured in accordance with the following minimum requirements:

(1) Three days when the temperature of the water within the cofferdam has been maintained at 70 °F [20 °C] or greater,
(2) Four days when the temperature of water has been maintained from 45 °F [7 °C] to 70 °F [20 °C], or
(3) Five days when the temperature of the water within the cofferdam has been no greater than 45 °F [7 °C] during the curing period.

A.4 Restoration Work

Restore portions of the surface and general features of the excavation site after completion of the work to allow use and function as before excavation, as approved by the Engineer.

A.5 Cold Weather Protection

Place permanent or temporary backfill, or other insulating material approved by the Engineer, to protect foundation soils against freezing and related heaving actions after casting footings or driving foundation piles. The Department will waive this requirement if the Contractor has only driven the test pile within the foundation at the time of freezing conditions. If frost heaving is evident, drive the test pile further when installing the rest of the foundation piles, as directed by the Engineer.

B Excavating

B.1 General

Perform structure excavation to allow the erection of forms, temporary construction, and compaction of backfill materials, unless the contract requires or the Engineer directs otherwise.

B.2 Types

The Department will classify excavation types in accordance with the following:

(1) Class U: Material within the excavation unclassified by the material encountered or the conditions of removal.

(2) Class E: Material within the excavation except for Class R material.
(3) Class R: Ledge rock, boulders, detached rock, or concrete pieces, with a volume of at least ½ cu. yd [0.4 cu. m].
(4) Class W: The upper limit of excavation designated by the elevation of low water as shown on the plans for waterway bridges.

The Department will consider the volume of removed structures as a separate contract pay item and will not include the volume of structure removals within the excavation limits as part of the excavation volume. The Department will include the cost of structure removals with other relevant pay items, unless otherwise required by the contract.

B.3 Cast-In-Place Structures

The Engineer may reject the work if water accumulates within the excavation and detrimentally affects the structure or the stability of the backfill.

Confine excavation in streams or lake beds within caissons or cofferdams. Repair disturbances to streams or lake beds using materials approved by the Engineer.

Complete necessary areas of excavation within sealed cofferdams before placing items, such as walers, struts, and other framework items, that may restrict the access to the excavation equipment.

B.3.a Earth Excavations

If placing concrete on natural soil foundation without piling, as shown on the plans, shape the bottom of the excavation to the dimensions and elevations shown on the plans. Use vibratory methods to compact the foundation soils as directed by the Engineer. Replace unsuitable foundation soils with firmly compacted acceptable material as shown on the plans and as directed by the Engineer. Replace materials unnecessarily removed below the foundation elevation at no additional cost to the Department.

Complete excavation before beginning pile driving operations for each unit. After driving the piles, shape the bottom of the excavation to the elevation shown on the plans. Use sand, gravel, or concrete to backfill excavations below the established elevation of the foundation at no additional cost to the Department.

B.3.b Rock Excavation

Do not remove Class R and Class WR materials encountered in the excavation, unless the Department classifies the excavation as Class U, until the Engineer measures the pay quantities for Class R and Class WR materials.

For footing foundations located in solid rock, remove the rock to the elevation as shown on the plans for the entire area bounded by vertical planes through the neat lines of the footing. If the plans do not show a footing elevation, remove the rock to an elevation no higher than the established elevation for the bottom of the footing or as directed by the Engineer.

Remove rock without affecting the quality of the foundation.

B.4 Prefabricated Structures

B.4.a Earth Excavations

If the contract does not contain provisions for foundation preparation, excavate to provide uniform support under the entire structure, to allow the placement of the structure to the staked grade and line, and to allow for the installation of backfill materials.

If the contract contains provisions for foundation preparation, excavate to provide the foundation thickness shown on the plans and uniform structure support.

B.4.b Rock Excavations

Expose, but do not remove Class R and Class WR materials encountered during Class E or Class WE excavation, until the Engineer measures the pay quantities for Class R and Class WR materials.

Remove and replace unyielding materials such as bedrock, boulders, or concrete located within 1 ft [300 mm] from the sides or the bottom of the structure in accordance with 2451.3.D, “Backfilling Excavations,” and 2451.3.C, “Foundation Preparations.”

C Foundation Preparations

Prepare the structure foundations in accordance with the following, except as modified by structure specifications and as shown on the plans.

Provide temporary construction, pumping, or other means to construct the structure in a dry excavation at no additional cost to the Department.

C.1 Cast-In-Place Structures

Remove disintegrated material, loose material, and thin strata rock from rock foundations. Clean and fill rock seams with concrete, cement mortar, or grout as directed by the Engineer.

If the character of the natural foundation soil is unsuitable, provide additional excavation below the planned footing elevation as directed by the Engineer. The Engineer will direct the limits of the excavation and the placement of special backfill.

C.2 Prefabricated Structures

For structure foundations in new embankment, construct the embankment to an elevation 1 ft [300 mm] above the low point of the structure in accordance with 2105, "Excavation and Embankment." Remove natural topsoil beneath the structure site when the height of embankment to the bottom of the structure is no greater than 3 ft [1 m].

Remove and replace unsuitable foundation materials encountered at or below the foundation elevation using suitable replacement materials as directed by the Engineer. Excavate the sub-foundation with near vertical sides and a bottom width equal to the structure width plus twice the depth of excavation. Unless the contract requires otherwise, provide replacement material in accordance with 2451.3.D, "Backfilling Excavations." Install the replacement material in layers 6 in [150 mm] thick. Compact each layer to uniform density.

Before installing the structure, shape the foundation to fit the bottom of the structure and provide uniform support. For lines of pipe, prepare the foundation with Class C bedding, unless the contract requires otherwise.

Provide Class C bedding consisting of the foundation material shaped to fit the lower part of the pipe to the following depths:

(1) At least 15 percent of the outside diameter for circular pipes, and
(2) At least 50 percent of the height at the point of maximum span above the bottom of the arch for pipe-arch structures.

Provide Class B bedding as shown on the plans consisting granular bedding material at least 6 in [150 mm] thick. Shape the bedding material using a template to fit the lower part of the pipe exterior to at least 60 percent of the pipe width for round pipe and at least 80 percent for pipe-arches. After excavating the trench to an elevation 15 percent of the outside diameter or rise of the pipe above the grade for the bottom of the pipe shown on the plans, complete excavation to the depth and shape of the bedding shown on the plans to prepare the foundation.

Compact granular materials used for Class B bedding and foundation backfill at pipe installations in accordance with 2105, "Embankment Materials," except consolidate the material within the 6 in [150 mm] layer immediately below and parallel to the bottom surface of the pipe sufficient to produce uniform pipe support. After compaction of the bedding layer, scarify a layer of uniform and minimal thickness for template shaping.

D Backfilling Excavations

Backfill excavations for structure construction to the required extent shown on the plans and at the appropriate time. Uniformly distribute suitable backfill materials in layers no thicker than 8 in [200 mm] loose measurement. Compact the backfill to the required density before placing successive layers.

Compact backfill in accordance with 2105, "Excavation and Embankment," to the specified density for adjacent and overlying embankment construction as shown the plans. If the plans do not show a specified density, compact each backfill layer until the density of the backfill and the adjacent material at the same elevation become equivalent, as approved by the Engineer.

If the contract does not specify special backfill materials, use selected material in accordance with 2105, "Excavation and Embankment," placed within 18 in [450 mm] of the sides and 12 in [300 mm] above the top of the structure. For the remainder of the backfill, use embankment material in accordance with 2105, "Excavation and Embankment." If outside the roadbed construction, use suitable material found in the excavation.

Do not place backfill material on a foundation frozen deeper than 3 in [75 mm] or when the material may freeze during the placement or compaction work.

Step the sides of the excavation if steeper than 4:1 and if potential wedging action of the backfill may be detrimental to the structure. If the contract does not require specific maximum dimensions for the excavation, the Contractor may enlarge the excavation and flatten the side slopes for convenience of backfill and compaction operations, at no additional cost to the Department.

Backfill uniformly in horizontal layers throughout the excavation area. Maintain the sides of the excavation and prevent voids in the backfill when removing shoring or bracing from the excavation.

E Surplus Materials

Excavated materials not necessary for backfill are the property of the Contractor. Dispose of surplus materials in accordance with the disposal form submitted to and approved by the Engineer.

2451.4 METHOD OF MEASUREMENT

The Engineer will determine quantities of excavation and embankment in accordance with 1901, "Measurement of Quantities," except as modified by this section. Provide sufficient time for the Engineer to determine quantities.

A Structure Excavation

The Engineer will not adjust (P) designated quantities unless otherwise specified in 1901, "Measurement of Quantities," or for excavation materials reclassified by the Engineer.

The Contractor may dispute an excavation quantity. If the Engineer considers the dispute, the Engineer will recalculate the excavation quantity for the entire structure. If the Contractor completes the excavation before the Engineer directs a change, the Engineer will not make deductions or additions for resulting changes in the excavation volume if no enlargement of the excavation is required.

The Engineer will consider additional quantities determined by recalculation as separate from the contract pay item quantities for structure excavation for bridges.

The Engineer will measure rock within the structure excavation and recalculate the volume for each excavation pay item classification considering the quantity of exposed rock measured. The Engineer will proportionately increase or decrease excavation pay item quantities based on the measured volume of rock to maintain the planned total excavation quantity.

The Engineer will not adjust low water elevations as shown on the plans or for safety concerns, working clearances, or stability of soils, regardless of existing conditions.

The Engineer will calculate the volume of structure excavation in accordance with the following limits except as modified for the type of structure and unless otherwise required by the contract:

(1) Vertical planes that encompass the structure, located 1½ ft [450 mm] beyond the outermost limits of the structure or its projections within the excavation,
(2) A top elevation that is either the natural ground surface or the designated elevation, in embankment or excavation, establishing the beginning of structure excavation, and
(3) The bottom of the structure and its projections.

If the plans include a separate contract pay item for the removal of an existing structure from the excavation limits of the new structure, the Engineer will reduce the structural excavation quantity by the measured volume of the existing structure.

If the Contractor excavates material to expedite the work and the contract includes the material removal in a different contract item or indicates removal by others, the Engineer will not include this material in the structure excavation quantities.

A.1 Cast-in-Place Structures

For the horizontal limits of excavation for footings for cast-in-place structures in ledge rock, the Engineer will use the footing limits as shown on the plans.

The Engineer will measure excavation for timber pile abutments and timber bents using the limits as shown on the plans.

A.2 Prefabricated Structures

For foundation construction requiring a greater surface dimension than provided in 2451.4.A, "Structure Excavation," the Engineer will measure the excavation using the greater dimension.

A.2.a Induced Trench

For excavation by the induced trench method performed in accordance with 2501.3.E, "Induced Trench Installation," the Engineer will measure additional excavation required for loose backfill over the structure in accordance with the following:

(1) Within the planned grading section,
(2) Between vertical planes separated by a distance equal to the outside width of the structure, and
(3) To a depth equal to the outside height of the structure.

B Granular Materials

The Engineer will measure granular materials for special backfill, bedding, or filter purposes by loose volume or compacted volume in accordance with 1901, "Measurement of Quantities," and as required by the contract.

2451.5 BASIS OF PAYMENT

If the contract does not contain a contract item for clearing or grubbing, the Department will consider clearing and grubbing to be extra work in accordance with 1402, "Contract Revisions."

The Department will pay for preliminary embankment construction in accordance with 2105, "Excavation and Embankment."

The contract unit price for *Foundation Preparation Pier___* includes the cost of excavation for seal construction.

If the contract does not include a contract item for the restoration work on the surface of the excavation site, the Department will include this cost with other relevant contract pay items.

The Department will pay for cleaning and filling seams in rock foundations as extra work in accordance with 1402, “Contract Revisions,” unless otherwise required by the contract.

The contract unit price for the relevant structure excavation and backfill contract items include the cost of disposing of surplus excavated materials.

For cast-in-place structures, if the plans do not include limits for the excavation of timber pile abutments and timber bents, the Department will include this cost with other relevant contract items.

If the plans do not include a contract pay item for Class R and Class WR excavation, the Department will pay for these materials if encountered during Class E or Class WE excavation in accordance with the following:

(1) Class R at 5 times the contract unit price of Class E and
(2) Class WR at 3 times the contract unit price of Class WE.

Unless otherwise modified in the contract, the Department will pay for the excavation for cast-in-place structures in accordance with the following:

(1) For additional required excavation depth, the Department will increase the contract unit price by 25 percent for additional excavation to 3 ft [1 m] below excavation as shown on the plans. For excavation required to a depth greater than 3 ft [1 m] below the planned elevation, the Department will pay for this portion of the additional excavation as extra work in accordance with 1402, “Contract Revisions,” unless the Department and Contractor agree on a unit price increase not exceeding 25 percent.
(2) For additional excavation required by changes in the structure dimensions, and the Contractor objects to the contract unit price, the Department will pay for the additional excavation as extra work in accordance with 1402, “Contract Revisions.”
(3) For disputed plan quantities, if the Contractor requests a recalculation of structure excavation for bridge structure, and the recalculation shows an additional quantity, the Department will separately pay for additional structure excavation for bridge construction at 50 percent of the contract unit price.

The contract cubic yard [cubic meter] price for *Granular Backfill* and *Granular Bedding* will include the cost of placing and compacting the materials.

If the plans do not include a separate contract pay item for structure excavation, the Department will include this cost with the contract cubic yard [cubic meter] price for *Granular Backfill* and *Granular Bedding*.

If the plans do not include specific contract pay items, the Department will pay for granular materials used for bedding, backfill, or filter purposes as shown on the plans, in accordance with this section, and as directed by the Engineer as extra work in accordance with 1402, “Contract Revisions.”

The Department will pay for structure excavation and backfill in accordance with the following schedule:

Item No.:	Item:	Unit:
2451.501	Structure Excavation, Class ___	cubic yard [cubic meter]
2451.503	Granular Backfill ___*	cubic yard [cubic meter]
2451.505	Aggregate Backfill ___*	cubic yard [cubic meter]
2451.507	Granular Bedding ___*	cubic yard [cubic meter]
2451.509	Aggregate Bedding ___*	cubic yard [cubic meter]
2451.511	Coarse Filter Aggregate ___*	cubic yard [cubic meter]
2451.513	Fine Filter Aggregate ___*	cubic yard [cubic meter]

* For all granular material items, specify the basis of measure (loose volume or compacted volume) after the item name in accordance with 2451.4.B, “Granular Material.”

2452 PILING

2452.1 DESCRIPTION

This work consists of providing and driving piling as required by the contract.

2452.2 MATERIALS

A Timber Piling 3471

B Preservative Treatment 3491

C Steel H-Piles 3372

D Cast-in-place (CIP) Concrete Piles

D.1 CIP Steel Pile Shells 3371

D.2 Concrete Pile Fill, Mix No. 1C62 2461

E Reinforcement Bars 3301

2452.3 CONSTRUCTION REQUIREMENTS

A Delivery and Inspection of Piling

If the contract requires test piles, provide the number and lengths of piles as shown in the contract, unless otherwise directed by the Engineer. The Engineer may designate that piles authorized for one unit of a structure be driven in another unit of the same structure or any unit of another structure constructed under the same contract.

If test piles are not specified in the contract, provide the number and lengths of piles as shown in the contract.

Before delivery, establish the quality of the material in steel H-piles and in steel shells for cast-in-place concrete piles. Submit the mill test reports and mill shipping papers in accordance with 3371, “Steel Shells for Concrete Piling,” and 3372, “Steel Piling,” to the Engineer.

The Contractor may request the Engineer’s written approval to use small quantities (less than 5 percent in a substructure unit) of piling from the Contractor’s surplus of cut-offs and overruns. Certify the small quantities of piling as remaining quantities of materials previously submitted with accompanying mill test reports and approved for use on other projects. The Department will not pay for pile splices used to make up approved piles for the Contractor’s convenience. Splices made for the Contractor’s convenience are not eligible for extra compensation in accordance with 2452.5.B, “Piling Delivered.”

Do not drive piling before the Engineer accepts the material on the basis of mill test reports.

The Engineer will visually inspect piling at the site before driving to verify the quality of welds and to determine the piles contain no physical defects that would cause the pile to fail during driving and are capable of performing as intended.

B Handling, Transportation and Storage

Handle, transport, and store piling without damaging piles intended for use in the completed structure.

C Equipment for Driving

C.1 Requirements for Pile Hammers

Use pile driving equipment approved by the Engineer. The Engineer will use the wave equation analysis as the basis for approval of equipment.

Submit the following to the Engineer at least 30 calendar days before beginning pile driving operations:

(1) A completed pile and driving equipment data form, obtained from the Engineer, for each hammer proposed for the project,
(2) A wave equation analysis in accordance with GRL WEAP or similar program for each pile type and hammer, and
(3) A hard copy of the results of the wave equation analysis, including a WEAP bearing graph.

The Engineer will only accept pile driving equipment, as determined by the wave equation analysis, capable of operating from 30 blows per ft to 180 blows per ft [10 blows per 0.1 m to 60 blows per 0.1 m] at 155 percent of the pile factored design load as shown on the plans.

Review the pile stresses indicated by the wave equation to determine the capability of the piles driven in accordance with 2452.3.D, “Pile Driving.” If stress levels indicate possible damage to the piling as determined by the wave equation analysis, adjust the pile driving system or the strength of the pile to reduce risk of pile failure.

Include the weight of the driving cap with the pile weight when it receives the hammer blow. Do not include the weight of the driving cap with the pile weight if the ram delivers the blow directly to the pile.

Use the same pile hammer, or another hammer developing similar energy, to drive the test piles and to drive the piles authorized by the Engineer based on the results of the test pile driving, except as otherwise required by pile driving conditions or different pile sizes or capacities.

Do not use gravity hammers for piles, unless otherwise required by the contract.

Refer to Table 2452-1 for minimum ram weight and allowed developed energy.

Table 2452-1
Minimum Requirements of Pile Hammers

Pile Type	Power Driven Hammers	
	Required Ram Weight, *lb [kg]*	**Energy, *ft lb [J]***
Timber and steel H-pile		
< 50 ft [15 m] long	1,500 [680]	7,000 [9,490]
≥ 50 ft [15 m] long	1,800 [815]	12,500 [16,950]
Steel shells for cast-in-place pile		
All lengths	1,800 [815]	12,500 [16,950]

C.2 Pile Driving Caps

Equip the top of the pile with a driving cap in the size and type, as approved by the Engineer, to protect the pile against damage during driving. Use a shock block of the type and size as approved by the Engineer on the upper side of the driving cap, when driving conditions warrant. Provide drive caps and shock blocks as recommended by the pile hammer manufacturer.

C.3 Pile Driver Leads

Provide pile driver leads meeting the following requirements and characteristics:

(1) Capable of holding the pile and the pile hammer in alignment during driving operations,
(2) Long enough to preclude the use of punches or chasers, and
(3) Meeting the requirements of the pile hammer manufacturer.

C.4 Water Jets

Provide jets capable of delivering water in the volume and pressure required to freely erode the material adjacent to the pile. Provide a water source capable of maintaining at least 100 psi [690 kPa] of pressure at two jet nozzles, ¾ in [19 mm] in diameter.

D Pile Driving

Notify the Engineer at least 24 h before beginning pile driving operations. The Engineer will reestablish the working points for each substructure unit after the Contractor completes the excavation for that unit. Stake the pile locations.

Excavate to the bottom of footing elevation as shown on the plans before driving foundation piles or test piles in any substructure. During pile driving operations, keep

the water level in the excavation below the top of the pile. Do not perform underwater pile driving unless a concrete foundation seal is required to dewater cofferdam.

For each foundation pile, perform continuous pile driving operations unless otherwise directed by the Engineer.

Sharpen timber piles to a square point with dimensions at least 5 in [127 mm] at the tip. Provide timber piles with blunt ends for soils with SPT below counts less than 20 as shown in plan borings or for piles having point bearing on hard stratum.

Do not use punches or chasers for pile driving if the contract requires a concrete foundation seal in a cofferdam. If driving piles in a cofferdam, provide the extra length of piling to drive the piles to the cutoff elevation, at no additional cost to the Department. Accurately locate and space the piling as shown in the bridge plans with tolerances per 2452.3.D.4, "Foundation Piles," 2452.3.D.5, "Pile Bents," and 2452.3.F.2, "Pile Bents."

Provide pile material and appurtenances capable of withstanding driving to substantial refusal defined in accordance with 2452.3.E.1, "General." The Department considers failure of piles during pile driving operations to include buckling, bending, kinking, splitting, or rupturing that will impair the strength of the pile or reduce the effectiveness of the energy delivered by the pile hammer, as determined by the Engineer.

If the Engineer determines that the piling material and appurtenances cannot withstand driving to substantial refusal, discontinue pile driving and correct or change the pile driving operations, equipment, or material as approved by the Engineer.

If failure of the pile occurs after the Engineer directs the Contractor to continue driving after obtaining substantial refusal, the Department will pay for the cost of the failure.

D.1 Jetting and Preboring

The Contractor may perform water jetting if needed, or as required by the contract, to aid in driving displacement type piles. Do not perform jetting in embankments or in areas where the jetting may damage the existing soils. Before reaching 5 ft [2 m] of the final tip elevation, withdraw the jets and drive the piles with the hammer to secure the final penetration. Control and dispose of jet water, as approved by the Engineer.

Perform preboring for displacement type piles driven through embankments if the embankment depth, measured below the bottom of the footing, is greater than 8 ft [2.4 m]. Perform preboring through the depth of the embankment. Continue

preboring through shallow, dense crust at the surface of the original ground as directed by the Engineer.

Perform preboring through embankments less than 8 ft [2.4 m] if the material may damage the piles during driving, as directed by the Engineer. Perform preboring for displacement type piles if the material below the bottom of a footing precludes driving to a penetration of 10 ft [3.0 m] below the bottom of the footing without damaging the piles, as directed by the Engineer. If the pile does not penetrate greater than 0.03 in [0.75 mm] per blow for each 1000 foot pounds [1,356 J] of rated energy, the Engineer will consider this, the weight of the ram, and the type and size of the piles to determine the probability of damage.

Make prebored holes of a diameter that will admit the largest section 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 for bearing for the full length of the pile driving. Redrive the test piles as required by the Engineer and in accordance with 2452.3.D.8, “Pile Redriving.”

If the Engineer determines that steel test piles have not developed adequate bearing capacity per 2452.3.E.1, “Penetration and Bearing, General,” provide additional lengths and splice as directed by the Engineer.

D.3 Pile Load Tests

D.3.a General

Perform pile load tests at the locations required by the contract or as directed by the Engineer. Cast concrete for cast-in-place concrete piles at least 7 calendar days before beginning the load test. If using high-early strength concrete, the Contractor may cast the concrete at least 5 calendar days before beginning the load test. Unless driving piles to end bearing on rock or other very dense layer, do not begin load testing until at least 5 calendar days after completion of driving.

Drive piles for pile load tests at locations, as directed by the Engineer, and perform one of the following:

(1) Perform a load test on the test pile, or
(2) Drive another pile at a location near the test pile as shown on the plans to the penetration and bearing required by the Engineer.

Submit details of the method and equipment proposed for use for the load test to the Engineer at least 10 days before the scheduled test.

Complete pile load tests to allow analysis before continuing with pile driving. The Contractor may include piles used as reaction piles as foundation piles if driven at proper locations and capacity as shown on the plans. Do not drive reaction piles within 7 ft [2.1 m] of the pile to be load tested, unless otherwise approved by the Engineer. The Engineer will make the final determination regarding the use of reaction piles as permanent piles. Redrive reaction piles to be used as permanent piles with evidence of uplift, as directed by the Engineer.

If using a hydraulic jack to apply the load on the pile in increments in accordance with 2452.3.D.3.b, “Pile Load Tests, Type 1,” or 2452.3.D.3.c, “Pile Load Tests, Type 2,” provide a hydraulic jack meeting the following characteristics and requirements:

(1) Equipped with a pressure gauge,
(2) Capable of maintaining a specified load within 5 percent for loads no greater than 50 ton [45 tonne], and
(3) Capable of maintaining a specified load within 3 percent for loads greater than 50 tons [45 tonne].

Calibrate the jack and the gauge as a unit as approved by the Engineer. Provide a certified calibration chart to the Engineer for each jack and gauge combination to be used.

The Engineer will provide, place, and read Ames dials for measurement of settlement. Provide and install posts and cross frames as required for proper support of the Ames dials, as directed by the Engineer. Provide a support system for the Ames dials independent of the other loading apparatus, containing support beams perpendicular to the reaction beam.

Provide a temporary shelter at the location of each load test to protect the workers, inspectors, and equipment during load testing. Provide heat and lights as directed by the Engineer.

D.3.b Pile Load Tests, Type 1

Apply test loads in increments totaling at least 200 percent of the minimum pile bearing as shown on the plans for the unit requiring the Pile Load Test, unless failure

occurs at a lesser load. The Department will consider a load tested pile with a total settlement greater than 2 in [50 mm] as a failed pile load test. Apply the load increments, defined as a percent of the total load in accordance with Table 2452-2, "Pile Load Test Increments."

Take readings every 15 min to determine cessation of measurable settlement. The Department will consider the cessation of measurable settlement to occur when the average of at least two dials indicates a settlement of less than 0.01 in [250 µm] during a 15 min period. After determining the cessation of measurable settlement, take readings every hour until the holding time specified in Table 2452-2 has elapsed for that increment, unless otherwise directed by the Engineer.

Remove the load test increments in reverse order as applied, except limit that the time interval for each increment to one 15 min period. Take the final reading 2 h after removing the load.

Table 2452-2
Pile Load Test Increments

Percent of Total Load	Holding Time after Measurable Settlement, *h*
40	1
50	2
60	3
70	4
80	5
90	6
100	12

D.3.c Pile Load Tests, Type 2

For each Type 2 pile load test, apply a total load of 400 percent of the minimum pile bearing as shown on the plans for the unit requiring the pile load test, unless failure occurs at a lesser load. The Department will consider the pile load test as a failure if the Contractor continuously pumps the hydraulic jack to maintain load or if the settlement becomes disproportionate to the load applied.

Provide a hydraulic jack meeting the following requirements and characteristics:

(1) In accordance with 2452.3.D.3.a, "Hydraulic Jacks,"
(2) Provide continuous communication between the person reading the pile deflection gauges and the person applying the jacking pressure, and
(3) Capable of ram travel of at least 6 in [150 mm].

Apply the load in 5 ton [4.5 tonne] increments at 2.5 min intervals. Remove loading after failure or reaching 400 percent of minimum pile bearing.

D.4 Foundation Piles

Guide piles during driving. Complete pile driving with piles having the required batter or plumbness within ½ in per ft [40 mm per m], and having a final position within 6 in [150 mm] of plan location within the footing area. The Engineer may reject or reduce payment for improperly positioned piles, as determined by the Engineer.

If the Engineer determines that some piles in a unit have heaved during the driving of other piles in the unit, redrive the piles as directed by the Engineer to complete the pile driving.

D.5 Pile Bents

The Department defines pile bents as piles meeting the following characteristics and requirements:

(1) Driven in single rows,
(2) Capped with timber, steel, or concrete caps, and
(3) Driven to closer tolerances than for general pile driving, as described below.

Guide piles during driving. Complete pile driving with piles having the required batter or plumbness within ¼ in per ft [20 mm per m], and having a final position within 3 in [75 mm] of plan location within the bent. The Contractor is responsible for any increase in pile cap dimensions or reinforcing caused by inaccurately placed piles. The Engineer may reject or reduce payment for improperly positioned piles, as determined by the Engineer. For timber pile bents, select piles having a uniform diameter.

D.6 Cast-in-Place Concrete Piles

Equip the bottom of each pile with a driving shoe meeting the following requirements:

(1) Welded watertight, and
(2) Dimensions no greater than ¼ in [6 mm] larger than the dimensions of the periphery of the pile shell.

Provide pile points, if required by the contract, at specified locations or as directed by the Engineer. Provide the pile points for cast-in-place concrete piles in lieu of flat driving shoes. Equip the bottom of each shell with a commercially manufactured conical pile point of cast steel welded watertight, as approved by the Engineer. Attach the conical pile point to the pile as recommend by the manufacturer.

Inspect each pile with the Engineer after driving, for depth to the driving shoe and for condition of the shell. Notify the Engineer upon observation of impairment or

damage. The Engineer, considering the bearing requirements and driving conditions, will determine the acceptability of the pile. Provide a light for a visual inspection of the full length of pile.

The Department will not require the Contractor to provide reinforcement bars unless otherwise shown on the plans.

Vibrate concrete in the portion of pile shells containing reinforcement cages.

Do not perform pile driving and other operations that will cause noticeable vibrations near concrete-filled piles until the concrete has been in place for at least 3 calendar days. Refer to 2401.3.G, "Concrete Curing and Protection," for vibration limits on newly placed concrete.

Do not place concrete for footings and caps until the day after concrete placement for the piles.

Protect concrete in the piles against freezing temperatures for at least 3 calendar days after placement. If placing concrete in piles during freezing temperatures, provide 30 percent additional cement to the concrete mix for concrete above 10 ft [3 m] below the groundline 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 listed on the Approved/Qualified Products List. Attach the cast steel points to the piles as recommended by the manufacturer.

The Contractor may provide thick wall pipe on a performance basis and meeting the following requirements and characteristics in lieu of steel H piling as approved by the Engineer:

(1) Meeting the requirements of ASTM A252 Grade 3,
(2) Wall thickness of at least ½ in [13 mm],
(3) Tensile properties of at least 110,000 psi [760 MPa],
(4) Cross-sectional area at least equal to H piling,
(5) Section modulus at least equal to the weakest axis of the H piling,
(6) Diameter at least equal to the H pile depth less 3 in [75 mm],
(7) Driven open ended and filled with granular material or 1C62 concrete mix.

The Engineer will consult with the Regional Bridge Construction Engineer or Metals Quality Engineer for special welding requirements.

D.8 Pile Redriving

Redrive of test or foundation piles determines the capacity that can be obtained by including pile "set up." "Set up" is the time-dependent increase in pile shaft resistance.

If the contract includes a pay item for "Pile Redrive," drive the test piles to foundation length or at least 70 percent of Pile Bearing Resistance as shown on the plans. Perform pile redrive at the direction of the Engineer a minimum of 24 h after initial driving unless otherwise required by the contract. If driving conditions allow, continue to drive test pile to the length shown on the plans and in accordance with 2452.3.E.1, "Penetration and Bearing, General." Redrive additional foundation piles to verify the bearing capacity as determined and directed by the Engineer.

Do not drive other piles in the same substructures 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. When redriving, do not strike each pile with greater than 20 blows. 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 nominal pile bearing resistances indicate the factored loads that the piles are required to support. The Department will use the nominal pile bearing resistance as determined by 2452.3.E.2, "Determination of Nominal Bearing Resistance," to establish the minimum criteria for pile acceptance in which the driving resistance is not less than the 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 2452.4.A, "Test Piles." Perform pile redriving as shown on the plans with the penetration and time delays in accordance with 2452.3.D.8, "Pile Redriving."

The Engineer will consider that substantial refusal is attained, in accordance with 2452.3.D, "Pile Driving," when the penetration rate equals 0.05 in [1.3 mm] per blow.

E.2 Determination of Nominal Bearing Resistance

The Department bases the required nominal resistance as shown on the plans for each field control method. Determine the driven pile nominal resistance in accordance with the following using the appropriate corresponding field control method as shown on the plans. Unless the contract requires otherwise, if more than one field control method is shown on the plans, determine the method used in accordance with the following:

(1) If the contract includes a "Pile Analysis" contract item for a substructure, provide the Pile Driving Analyzer (PDA) for the field control, or
(2) If the contract does not include a "Pile Analysis" for a substructure, the Contractor may choose the field control method. The Department will include the cost of the PDA with the relevant contract item for piling driven.

E.3 Mn/DOT LRFD Nominal Resistance Pile Driving Formula Used as Field Control Method

Determine the nominal pile bearing resistance using the following dynamic formula for all types of piling driven with power-driven hammers:

$$R_n(english) = \frac{10.5E}{S+0.2} x \frac{W+(CxM)}{W+M}$$

$$R_n(metric) = \frac{867E}{S+5} x \frac{W+(CxM)}{W+M}$$

Where:

R_n = Nominal Pile Bearing Resistance in lb [N]
W = Weight of the striking part of the hammer in lb [kg]
H = Height of fall in ft [mm]
S = Average penetration in in [mm] per blow for the last 10 blows or 20 blows, except if the pile may be damaged by this number of blows
M = Total weight of pile plus weight of the driving cap in lb [kg]
C = 0.1 for timber, concrete and CIP shell type piles, and 0.2 for steel H piling
E = WH for single acting power-driven hammers. E equals the foot pounds of energy per blow for each full stroke of either single acting or double acting

hammers as described by the manufacturer's rating for the speed of hammer operation.

For the requirements of this section, double-acting hammers include hammers utilizing a power source for acceleration of the down-stroke of the ram. Apply the dynamic formula only if:

(1) The hammer has a free fall,
(2) The head of the pile is free of broomed or crushed fibre,
(3) The penetration of the pile is at a uniform rate, and
(4) There is no bounce after the blow. If a bounce occurs, deduct twice the bounce height from H to determine the value of H in the formula.

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 2452.3.K, "Dynamic Monitoring of Pile Driving." Use the WEAP bearing graph as required in 2452.3.K.3, "Wave Equation Analysis," to determine the bearing resistances recorded on the pile driving report. Attach a copy of the bearing graph to the pile driving report. Calculate and record the bearing resistances for informational and comparison purposes on the report in accordance with 2452.3.E.3, "Mn/DOT LRFD Nominal Resistance Pile Driving Formula 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 in [25 mm] to ½ in [13 mm]. After cutting off the timber pile, leave the head of the pile with sound, undamaged wood.

Cut off steel piles using an approved method that preserves the shape of the pile at the elevation shown on the plans. For piles driven to within ±1 in [25 mm] of the cut-off elevation without damage to the pile head, the Engineer will not require the pile to be cut off.

F.2 Pile Bents

After aligning and bracing the pile bent, cut off the tops of timber piles at the elevation shown on the plans to provide uniform bearing for the cap without using shims or fills.

Cut off steel piles using an approved method that preserves the shape of the pile at the elevation shown on the plans to allow concrete forming or framing in brace members.

G Disposal of Pile Cut-Offs

Use pile cut-offs belonging to the Department in substructure units for piling lengths not authorized for the same structure or for other foundations within the same contract, as required by the Engineer.

Stockpile remaining steel H-pile, steel shell pile cut-offs, and timber cut-offs designated for salvage by the Engineer on skids at a location convenient for truck loading. Dispose of cut-offs not designated for salvage as approved by the Engineer.

H Extensions, Splices, and Studs

Make splices for steel H-piles and CIP steel shell piles as shown on the plans, except make splices for cold rolled fluted steel shells as recommended by the manufacturer and as approved by the Engineer.

Provide pile welders meeting the qualifications of AWS D1.1 or with a Mn/DOT welding certification and with continuity records proving performance in the last 6 months.

Make splices on piles driven in pile bents at points not exposed to view, unless otherwise approved by the Engineer. If making splices in pile bents exposed to view as approved by the Engineer, finish the splices by grinding in such a way that the ground area blends in smoothly with the contour of the CIP pipe. Verify the complete removal of the defect by visual inspection and the wall thickness shall not be adversely affected. If shear studs are required on the piles, perform the welding in accordance with AWS D1.5, clauses 7.5.1-7.5.4.

The Contractor may provide commercial drive-fit splices for CIP piles on a performance basis as approved by the Engineer. Do not use splices in the following conditions:

(1) In pile bent-type piers or abutments,
(2) Where foundation soils are soft or unstable,
(3) In foundations where uplift is anticipated (concrete seals, etc.),
(4) Within 10 ft [3 m] of the pile cut-off, or
(5) Where down drag is indicated in the pile load table.

I (Blank)

J Painting Steel H-Piles and Steel Pile Shells

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 extending above ground surface or water surface with epoxy zinc-rich primer for the entire length, except for sections below splices at least 2 ft [600 mm] below the final ground surface or low water elevation. Apply the primer preferably before shipping or at least 2 days before driving the piles.

After driving, paint the piles with intermediate and finish coats on exposed portions above the water level, existing at the time of paint application or above an elevation 6 in [150 mm] below the final ground surface. Paint the finish coat for piles in bridges with concrete superstructures in a color matching the Federal Standard 595C No. 37200 (lusterless aluminum) and paint the finish coat for piles in bridges with painted steel superstructures with the topcoat color of the superstructure. Paint the finish coat for piles in bridges with unpainted 3309, "High-Strength Low-Alloy Structural Steel," steel or timber superstructures in a color matching the Federal Standard 595C No. 10075 (brown) with a semi gloss finish.

K Dynamic Monitoring of Pile Driving

K.1 Description of Work

Provide and use a Pile Driving Analyzer (PDA) to perform dynamic pile testing of driven piles meeting the requirements of ASTM 4945. Perform the dynamic pile testing on the initial driving and redriving of the test piles as directed by the Engineer. Test additional piles as directed by the Engineer.

K.2 Pile Preparation and Wave Matching

Attach instrumentation to the piles prepared for testing, except if testing on initial driving of CIP steel shell piles, attach the instrumentation after placing the pile in the leads. Employ an engineer experienced in dynamic testing and CAPWAP analysis to perform wave matching of the PDA data using the Case Pile Wave Analysis Program (CAPWAP). Run the program on all piles dynamically tested or as directed by the Engineer.

K.3 Wave Equation Analysis

After the wave matching, use the GRLWEAP program and CAPWAP data to produce a refined Wave Equation Analysis Program (WEAP) bearing a graph and inspector's chart for the basis for pile acceptance. Use the bearing graph to determine the foundation pile's nominal bearing resistance to be recorded on the pile driving report. Perform the wave matching analysis and wave equation analysis before any further pile driving.

K.4 Deliverables

Provide the results from each dynamic test performed with the PDA and checked with the CAPWAP program meeting the following requirements to the Engineer within the time specified:

(1) Hard copy form;
(2) Data presented in columns produced by the PDAPLOT program; and
(3) Data consisting of blow counts, stresses in the pile, pile capacities, hammer energies, and hammer strokes for each 1 ft [0.25 m] depth increment.

Provide expert advice regarding the analysis of the PDA and CAPWAP data.

Provide a WEAP bearing graph and inspection chart showing blow count-versus-pile resistance and stroke-versus-blow count to be used to determine the nominal bearing resistance of the foundation piles. Develop the graphs and charts based on the PDA and CAPWAP data. Ensure that the maximum force and maximum transferred energy calculated by WEAP matches the CAPWAP analysis within 10 percent. Deliver the bearing graphs to the Engineer within 2 working days after completion of driving the test piles at any single substructure unit.

Provide a brief report for the piles at each substructure tested including a summary of the PDA and CAPWAP results to the Engineer within 3 working days after completion of dynamic pile tests at any given substructure unit.

Provide a PDA summary report summarizing the findings from the PDA and the associated CAPWAP computer program and the developed GRLWEAP bearing graphs to the Engineer within 5 working days after completion of the dynamic pile tests, addressed separately.

2452.4 METHOD OF MEASUREMENT

A Test Piles

If the plans show specific contract pay items for test piles, the Engineer will measure the number of test piles provided as required by the contract and driven as directed by the Engineer. The Engineer will not eliminate test piles from the contract, unless all piles for the unit are eliminated or unless mutually agreed upon by the Contractor and the Engineer.

If the plans do not show a specific contract pay item for test piles, the Engineer will include the measurement of test piles with the measurement for piling delivered and piling driven.

If the Engineer determines that steel H-test piles or steel shells for cast-in-place concrete test piles provided in the lengths required by the contract do not develop

sufficient nominal pile bearing resistance or do not provide information per 2452.3.D.2, “Test Piles,” for ordering foundation piles, splice extensions onto test piles or deliver longer piles as required by the Engineer.

The Engineer will measure splice extensions onto test piles or longer piles as required by the Engineer in accordance with the relevant contract pay items for piling delivered and piling driven.

B Piling Delivered

If test piles are not required, the Engineer will measure piling delivered as shown on the plans for acceptable piling provided and delivered in the lengths and sizes of the relevant contract pay items. If the contract requires test piles, the Engineer will measure the lengths approved by the Engineer.

C Piling Driven

The Engineer will measure piling driven by the length of acceptable piling below cut-off.

D Pile Load Tests

The Engineer will measure pile load tests by the number of piles load tested as required by the contract and as directed by the Engineer.

E Reinforcement Bars

The Engineer will measure reinforcement bars used in cast-in-place concrete piles by weight in accordance with 2472, “Metal Reinforcement.”

F Pile Redriving

The Engineer will measure pile redriving by the number of piles redriven as required by the contract and as directed by the Engineer. The Engineer will recalculate the estimated plan quantity to agree with the actual number of piles redriven at the project site, estimated not to exceed 25% of the total number of planned piles. The Engineer will consider any pile redriving completed without the direction of Engineer as unauthorized work and the Department will not compensate the Contractor for that work.

G Dynamic Monitoring of Pile Driving

The Engineer will measure Pile Driving Analyzer field control by the number of piles that required the pile driving analysis as required by the contract. The Engineer will consider initial analysis and redrive analysis on an individual pile as one pile analysis. The Engineer may increase or decrease the number of piles to be dynamically monitored.

If the contract does not require the Pile Driving Analyzer field control method, the Contractor may perform the Pile Driving Analyzer field control method at the Contractor's option and at no additional cost to the Department.

2452.5 BASIS OF PAYMENT

The contract unit prices for *Test Pile* include the fixed costs of piling delivered and piling driven. If the plans do not include a contract pay item for test piles, the Department will include the fixed costs of piling delivered and piling driven with the relevant contract unit price for mobilization.

A Test Piles

The contract unit price for the test pile contract item of each kind and length include the cost of providing and driving test piles, providing and placing driving caps, concrete for cast-in-place concrete piles, painting steel H-piles and CIP steel shell piles, and performing the wave equation analysis and the relevant submittals.

The Department will pay for splice extensions onto test piles or longer piles as required by the Engineer with the contract pay items piling delivered and piling driven.

B Piling Delivered

The Department will not pay full contract unit prices, but may make partial payments based on actual cost, for stock lengths of steel H-piles and steel shells for cast-in-place concrete piles delivered before the Engineer authorizes final lengths based on test pile driving. The Department will only pay contract unit prices for *Piling Delivered* in the lengths authorizes by the Engineer. Remove delivered unauthorized piles at no additional cost to the Department.

The Department will not pay for piles or portions of piles damaged during handling. The Department will pay for piles damaged during driving if the Engineer determines that the damage was not caused by the Contractor's carelessness or negligence. The Department will not pay for piles rejected by the Engineer due to the use of an excessively heavy hammer.

The Department will pay for splicing of steel H-piles and CIP steel shell piles meeting the following requirements and characteristics at six times [two times] the relevant contract unit price for piling delivered, if the splice is actually made and:

(1) The Engineer directed the change after the Contractor cut the piles to lengths previously approved;
(2) Only for any extra splices required for a particular unit, if Engineer approved lengths longer than the length of the longest test pile of a specific kind as shown on the plans; and

(3) The Engineer ordered cut-offs, belonging to the Department, to be spliced together or onto other sections, except if made solely for the Contractor's convenience.

For a CIP steel shell pile made entirely from Department-owned cut-offs as required by the Engineer, the Department will consider providing and attaching the end plate as an additional splice and will pay for the additional splice with the relevant contract unit price.

C Piling Driven

The relevant contract unit prices for *Piling Driven* include the cost of preparing the piles for driving, preboring, jetting, providing and placing the driving shoes, concrete for cast-in-place piles, cutting and trimming, and painting steel H-piles and steel shell piles.

In the event foundation conditions are found to exist at the site of a structure, or a portion thereof, that are quite different from those upon which the foundation design was based, resulting in changes in foundation design or resulting in requirements for foundation pile lengths substantially different from those upon which the contract unit prices were established, the Engineer will, upon presentation of documentary evidence by the Contractor, enter into a Supplemental Agreement to reimburse the Contractor for any additional pile driving expense incurred as a result of those changes.

The Department will pay for driving pile cut-offs, from previously driven piles in the same contract that are the property of the Department, at the following percentages of the contract unit price for piling driven:

(1) Timber and Steel H-Piles, 150 percent, and
(2) Cast-in-Place Concrete Piles, 200 percent

The Department will include the cost of splices per 2452.5.B, “Piling Delivered,” in the relevant contract unit prices for piling delivered.

D Pile Load Tests

The contract each price for *Pile Load Test* includes the cost of providing and driving reaction piles at locations that preclude their use in the structure as foundation piles.

E Pile Redriving

The contract unit price for *Pile Redriving* includes the cost of redriving test piles and foundation piles, and providing and driving additional pile lengths as directed by the Engineer.

F Dynamic Monitoring of Pile Driving

The contract each price for *Pile Analysis* includes the cost of dynamic testing of a pile during initial driving and redriving, additional time needed in driving operations, labor, consultants, and equipment.

The Department will include the cost of the actual redrive with the contract each price for *Pile Redriving.*

The Department will not adjust the contract each price for increased or decreased contract quantities for *Pile Analysis.*

G Pile Points

The contract each price for *Pile Points* includes the cost of providing and attaching the points to the piles.

H Pile Tip Protection

The contract each price for *Pile Tip Protection* includes the cost of providing and attaching the tips to the piles.

I Pay Items

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

Item No.:	Item:	Unit:
2452.501	Untreated Timber Piling Delivered	linear foot [meter]
2452.502	Untreated Timber Piling Driven	linear foot [meter]
2452.503	Treated Timber Piling Delivered	linear foot [meter]
2452.504	Treated Timber Piling Driven	linear foot [meter]
2452.507	Cast-in-Place Concrete Piling Delivered ___*	linear foot [meter]
2452.508	Cast-in-Place Concrete Piling Driven ___*	linear foot [meter]
2452.510	Steel H-Piling Driven ___*	linear foot [meter]
2452.511	Steeel H-Piling Delivered ___*	linear foot [meter]
2452.516	Untreated Timber Test Pile, ___ ft [m] long	each
2452.517	Treated Timber Test Pile, ___ ft [m] long	each
2452.519	Cast-in-Place Concrete Test Pile, ___ ft [m] long ___*	each
2452.520	Steel H-Test Pile, ___ ft [m] long ___*	each
2452.525	Reinforcement Bars	pound [kilogram]
2452.526	Pile Load Test, Type ___	each
2452.527	Pile Redriving	each
2452.528	Pile Analysis	each
2452.529	Pile Points ___ in [mm]	each
2452.530	Pile Tip Protection ___ in [mm]	each

* Nominal size in in [mm]

2461 STRUCTURAL CONCRETE

2461.1 DESCRIPTION

This work consists of producing, providing, placing, curing, and protecting portland cement concrete for placement in structures, pavements and incidental construction.

2461.2 MATERIALS

A Cementitious Materials

Provide cementitious materials from certified sources listed on the Approved/Qualified Products list.

Use Type I or Type I/II portland cement to produce Type 1 non-air-entrained concrete.

Use Type I or Type I/II portland 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 Ground Granulated Blast Furnace Slag. 3102

A.3 Blended Hydraulic Cement 3103

A.4 Fly Ash 3115

A.5 Cementitious Content

Provide concrete with the minimum cementitious content for the grades and slumps of concrete in accordance with Table 2461-1:

Table 2461-1
Minimum Cementitious Content,
lb per cu. yd [kg per cu. m]

Specified Slump Limit, ***in [mm]***	**Grades**							
	U	**V**	**W**	**X**	**Y**	**A**	**B**	**C**
1 [25]	800 [475]	730 [435]	—	—	—	—	—	—
2 [50]	830	765	660	630	570	530	490	420

Table 2461-1
Minimum Cementitious Content,
lb per cu. yd [kg per cu. m]

Specified Slump Limit, ***in [mm]***	**Grades**							
	U	**V**	**W**	**X**	**Y**	**A**	**B**	**C**
	[490]	[455]	[390]	[375]	[340]	[315]	[290]	[250]
3 [75]	850 [505]	730 [475]	695 [410]	665 [395]	605 [360]	560 [335]	515 [305]	445 [265]
> 3 [75]	—	—	730 [475]	700 [415]	640 [380]	590 [350]	540 [320]	470 [280]

Except for grout mixtures, limit the maximum cementitious content for a cubic yard [cubic meter] of concrete to 850 lb [505 kg].

A.6 Cementitious Substitutions

The Contractor may replace Type I or Type I/II portland cement with other cementitious materials in accordance with the following restrictions:

(1) Maximum of 15 percent substitution of Class C or Class F Fly Ash, on a one for one basis, by weight of the designed portland cement;
(2) For Department designed mixes, the Department will adjust the batch weight of coarse aggregates to compensate for volume changes due to cementitious substitutions;
(3) Maximum of 30 percent substitution of Class C or Class F Fly Ash for concrete pavement, on a one for one basis, by weight of the designed portland cement;
(4) Maximum of 35 percent substitution of slag, on a one for one basis, by weight of the designed portland cement; and
(5) Ternary mixes (portland cement and two other supplementary cementitious materials) are allowed when approved by the Engineer, in conjunction with the Concrete Engineer, or required by or allowed in the contract.

B Fine Aggregate 3126

C Coarse Aggregate 3137

Unless otherwise required by the contract, the Contractor may select the class of coarse aggregate as defined in 3137.2.B, “Classification.”

D Water 3906

E Concrete Admixtures..... 3113

The Contractor may use the following admixtures listed on the Approved/Qualified Products List:

(1) Type A, "Water Reducing Admixtures,"
(2) Type B, "Admixtures Identified as Hydration Stabilizers," or
(3) Type S, "Viscosity Modifying Admixtures."

Do not use admixtures other than cementitious materials, aggregates, water, air-entraining admixtures, and other admixtures referenced in items (1), (2), and (3) above in the concrete, unless otherwise required by or allowed in the contract.

Use admixture dosage rates recommended by the manufacturer.

The Contractor may use calcium chloride in concrete as approved by the Engineer, in conjunction with the Concrete Engineer. Do not use calcium chloride in units containing prestressing steel or in bridge superstructure concrete.

E.1 Use of Additional Admixtures

On a case by case basis, the Engineer will consider the use of additional admixtures provided the Contractor meets the following requirements:

(1) Provides a QC Plan for using additional admixtures.
(2) Performs trial batches of the concrete including plastic and hardened concrete testing as directed by the Engineer.
(3) Uses the same equipment, batch size, and materials proposed for the work for the trial batches as proposed for the work. Incorporate the trial batches into the work with the approval of the Engineer.
(4) The Contractor must demonstrate to the Engineer the ability to properly mix, control, and place the concrete.

The Concrete Engineer, in coordination with the Engineer, will review the trial batch results and all related concrete testing for compliance with the QC Plan and the contract.

Upon approval of the QC Plan, design the mix in accordance with 2461.2.F.2, "Contractor Designed."

F Concrete Mix Designs

F.1 Department Designed

The Department will provide the estimated composition of concrete mixes unless otherwise required by the contract.

The Department may adjust the mix composition of the concrete without adjusting the contract unit price for any contract items.

F.1.a 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.

F.1.b High-Early Strength Concrete

When the Engineer requires high-early strength concrete, the concrete is designed in accordance with the following:

(1) Increasing the cement content of the concrete up to 30 percent; using an approved accelerator as allowed by the Engineer, in conjunction with the Concrete Engineer; or both.
(2) Using 100 percent portland cement, unless allowed by the contract or the Engineer.
(3) A maximum cement content for a cubic yard [cubic meter] of concrete not to exceed 900 lb [535 kg].
(4) A water/cement ratio not to exceed 0.38 unless otherwise required by the contract.

F.2 Contractor Designed

Design the concrete mix based on an absolute volume of 27.00 cu. ft ± 0.10 cu. ft [1.000 cu. m ± 0.003 cu. m] for the following:

(1) Concrete paving mixes in accordance with 2301, “Concrete Pavement;”
(2) Concrete mixes with an anticipated or required 28-day compressive strength of at least 5,000 psi [34 MPa];
(3) Precast concrete in accordance with 2405, “Prestressed Concrete Beams,” 2412, “Precast Concrete Box Culverts,” 3236, “Reinforced Concrete Pipe,” 3238, “Precast Concrete Box Culverts,” 3621, “Concrete Masonry Units,” 3622, “Sectional Concrete Manhole and Catch Basin Units,” and 3630, “Precast Concrete Median Barriers;”
(4) Colored concrete;
(5) Stamped concrete;
(6) Cellular Concrete Grout – Controlled Low Strength Material (CLSM); and
(7) Concrete as otherwise required by the contract.

Submit the concrete mixes using the Mn/DOT Contractor Mix Design Submittal Package available on the Department’s website at least 21 calendar days before initial

placement of the concrete mix. The Engineer, in conjunction with the Concrete Engineer, will provide specific gravity and absorption data for mix design calculations.

The Concrete Engineer, in coordination with the Engineer, will review the mix design submittal and will approve the materials and mix design for compliance with the contract.

The Contractor assumes full responsibility for the mix design and performance of the concrete.

The Engineer determines final acceptance of the concrete for payment based on satisfactory field placement and performance.

F.3 Classification of Concrete

The Department will classify concrete by type, grade, consistency, and aggregate size. Refer to the mix number and Table 2461-2 to determine the mix requirements for each item of work.

Table 2461-2
Mix Number Identification

First Digit	Second Digit	Third Digit	Fourth Digit	Additional Digits
Type	Grade	Slump range	Coarse aggregate gradation range	Class A coarse aggregate when required, modified mix designation, or both

Refer to individual contract items in the Standard Specification for Mix Numbers. Deviations from the specified Mix Numbers require coordination with the Concrete Engineer.

If the contract does not show a concrete mix number, provide Type 3, Grade Y concrete with a slump and aggregate gradation determined by the Engineer.

The Department will designate grout by type and grade followed by the word "GROUT." Do not provide grout containing coarse aggregate. If the plans do not show a type or grade for grout, provide 3A GROUT.

F.3.a Type Designation

Provide Type 1 or Type 3 concrete in accordance with Table 2461-3:

Table 2461-3 Concrete Type Designation		
Concrete Type	**Target Air Content*, %**	**Maximum Water/Cement Ratio‖**
1	2.0	≤ 0.53 for 1A43 ≤ 0.68 for 1C62 ≤ 0.64 for 1C Grout
3	6.5 †	≤ 0.45†

* For concrete mix design purposes only.
‖ The water/cement ratio is defined as the ratio of the total water weight to the total cementitious weight.
† Unless otherwise required by 2301 or elsewhere in the contract.

F.3.b Grade Designation

The Department will designate concrete grade using a letter to represent the anticipated compressive strength and the minimum cementitious content in accordance with 2461.2.A.5, "Cementitious Content," and Table 2461-4:

Table 2461-4 Concrete Grade Designation		
Concrete Grade	**Type 1 Anticipated Compressive Strength, *psi [MPa]* ***	**Type 3 Anticipated Compressive Strength, *psi [MPa]* ***
U	6,300 [43]	5,600 [39]
V	6,000 [41]	5,300 [37]
W	5,700 [39]	5,000 [34]
X	5,400 [37]	4,700 [32]
Y	5,000 [34]	4,300 [30]
A	4,500 [31]	3,900 [27]
B	4,100 [28]	3,400 [23]
C	3,200 [22]	2,700 [19]

* Anticipated minimum strength produced in accordance with the Department specifications and cured for 28 days under laboratory conditions.

The Concrete Engineer, in coordination with the Engineer, may increase the cement content for concrete with test cylinder results less than the anticipated compressive strength in accordance with Table 2461-4, "Concrete Grade Designation." The Contractor may request an increase in the cement content as approved by the Engineer, in conjunction with the Concrete Engineer.

F.3.c Slump Designation

Refer to the slump designation for the upper limit of the slump range without a water reducer in accordance with Table 2461-5:

Table 2461-5
Slump Designation

Slump Designation	Slump Range without Water Reducer, *in [mm]*
1	½ – 1 [12 – 25]
2	1 – 2 [25 – 50]
3	1 – 3 [25 – 75]
4	2 – 4 [50 – 100]
5	2 – 5 [50 – 125]
6	3 – 6 [75 – 150]

F.3.d Coarse Aggregate (CA) Designation

Refer to the coarse aggregate designation for the range of optional coarse aggregates gradations allowed in the mix in accordance with Table 3137-4, “Coarse Aggregate Designation for Concrete,” and Table 2461-6:

Table 2461-6
Coarse Aggregate Designation for Concrete

Range	Optional Coarse Aggregate Designation
0	CA-00 only
1	CA-15 to CA-50, inclusive
2	CA-15 to CA-60, inclusive
3	CA-35 to CA-60, inclusive
4	CA-35 to CA-60, inclusive
5	CA-45 to CA-60, inclusive
6	CA-50 to CA-70, inclusive
7	CA-70 only
8	CA-80 only

F.3.e Additional Designations

For mix designs that require a specified class of coarse aggregate as defined in 3137.2.B, “Classification,” an additional letter will follow the fourth digit of the Mix Number such as “A” (Class A Aggregate Requirement).

The Engineer may identify special concrete mix designations with additional letters following the last digit such as “HE” (High Early), “WC” (Water/Cement Ratio), “HPC” (High Performance Concrete), “MS” (Microsilica), or others.

2461.3 CONSTRUCTION REQUIREMENTS

A Batching Equipment

A.1 Mixer Requirements

Provide stationary mixers or truck mixers.

A.2 General Condition

Maintain mixers as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examine to detect wear of blades.

Replace or recondition pickup and throwover blades in mixers with a rated capacity less than 14 cu. ft [0.40 cu. m] showing a blade wear loss of greater than ½ in [13 mm], and pickup and throwover blades in mixers of greater capacity, showing a blade wear loss of no greater than ¾ in [19 mm] from the original factory dimensions.

A.3 Manufacturer's Rating Plate

Provide mixers that include the manufacturer’s rating plate, showing the following information:

(1) Serial number of the unit,
(2) Mixing speed of the drum or paddles, and
(3) Maximum capacity in terms of volume of mixed concrete.

A.4 Drum Speed for Stationary Mixers

Operate the drum speed in the mixer as specified by the manufacturer or as directed by the Engineer.

A.5 Auxiliary Equipment Requirements

Provide mixers equipped with the following:

(1) Timing device,
(2) Discharge locking device,
(3) Water measuring device that operates mechanically and automatically during each batching cycle, and
(4) A graduated adjustable indicator device to represent the volume of discharge in increments no greater than ¼ gal [1 L] in full view.

A.6 Mixer Capacity

Do not exceed the manufacturer's rated capacity of the mixer when mixing a single batch of concrete.

Batch concrete in volumes the mixer can accommodate without spilling, leaking, or segregating during the charging, mixing, or discharging operations. Provide mixers with a capacity of at least 1 sack [0.25 cu. m].

A.7 Mixing Time

The Department defines the mixing time as the time period beginning when the cement and aggregates enter the mixer drum and ending when the discharge begins.

Refer to the manufacturer's recommended minimum mixing time for single drum and dual drum mixers. In the absence of manufacturer's recommendation, the Engineer will designate the minimum mixing time. The minimum mixing time for any concrete batch is 60 s. The Contractor may reduce the manufacturer's recommended minimum mixing time or the Engineer designated mixing time if the Contractor obtains uniform mixing in accordance with 2461.3.E, "Mixing Requirements," and as approved by the Engineer, in conjunction with the Concrete Engineer.

If there is evidence of inadequately mixed concrete (unmixed or partially mixed materials) during concrete placement, the Engineer may direct an increase in the mixing time.

A.8 Turbine Type Mixers

Provide turbine type mixers meeting the applicable requirements for conventional type mixers (2461.3.A.1 through 2461.3.A.7) and in accordance with this subsection (2461.3.A.8). Maintain the mixer drum in a cylindrical shape within ¾ in [19 mm] from the original factory dimensions at any point. Maintain the mixer discharge gate in a mortar tight condition in the closed position. Replace or recondition mixer paddles showing a wear loss greater than ½ in [13 mm] from the original factory dimensions.

Add the mixing water to the batch materials in a manner that distributes the water to the inner or central areas of the drum. Start the flow of water before introducing the solid batch materials into the mixer drum.

During mixing, operate the paddles at a speed between 20 revolutions and 30 revolutions per minute. After adding the batch materials to the drum, mix the concrete for an additional 60 s.

A.9 Horizontal Axial-Revolving Blade Type Mixers

Provide horizontal axial-revolving blade type mixers in accordance with the applicable requirements for conventional type mixers (2461.3.A.1 through 2461.3.A.7) and in accordance with this subsection (2461.3.A.9).

Charge the water, aggregates, and cement in the sequence approved by the Engineer. Test the concrete uniformity as directed by the Engineer. The Engineer will use concrete uniformity tests to determine the minimum mixing time.

B Transportation Units

B.1 General Requirements

Equip transportation units intended for both mixing and agitating with watertight revolving drums mounted and powered and fitted with properly designed mixing blades in accordance with 2461.3.A.1 through 2461.3.A.7. Provide units capable of combining all the ingredients into a homogeneous mixture and designed to provide two drum speeds, one for mixing and the other for agitating. Provide units capable of delivering the concrete without segregation or loss of any of the batch materials.

Equip the mixer drum with a working counting device to record the number of revolutions.

Equip dump trucks and agitator trucks with vibrators to aid in discharge.

B.2 Capacity of Transportation Units

Refer to the truck mixer manufacturer’s certification plate attached to the unit for the maximum capacity of the unit. If the unit will not satisfactorily mix the maximum volume shown, reduce the batch volume to allow proper mixing or discontinue use of the mixing unit as directed by the Engineer until the problem is corrected.

C Handling and Storing Materials

C.1 Batch Material Requirements

Do not change the source, kind or gradation of batch materials after the start of concrete production for the work unless otherwise approved by the Engineer. If the Engineer approves use of different material, completely exhaust the supply on hand before changing to the different material.

If delivering freshly washed aggregates to the batching plant, drain the aggregates for at least 12 h before using in the batching operation. If draining freshly washed aggregates at the site of the batching plant, completely separate the drained material from the undrained materials, and provide for the disposal of water that accumulates from the drainage of materials.

Provide smooth, firm, and well-drained stockpile sites cleared of vegetable and extraneous matter. Where the natural foundation is unsatisfactory, as determined by the Engineer, construct the stockpiles on suitable platforms. Construct suitable bulkheads or partitions to separate different kinds of aggregate, gradation, or water content.

Construct stockpiles by methods that hold segregation and degradation to a minimum. If the Engineer sees segregation or degradation, the Engineer may designate that pile as unacceptable for use.

Do not use aggregates used to construct runways for loading or hauling equipment in concrete batches.

Use of aggregates from the bottom 1 ft [0.3 m] of a stockpile placed on an unprepared surface in concrete batches is allowed only under the Engineer's direct supervision and if the material meets all requirements of 3126, "Fine Aggregate for Portland Cement Concrete," and 3137, "Coarse Aggregate for Portland Cement Concrete."

Provide aggregates in accordance with the specified gradation requirements.

The Engineer will consider aggregates unacceptable if the variation in moisture content carried by any of the aggregates causes a marked variation in the consistency of successive batches of the mixed concrete, and will suspend operations until corrected.

C.2 Concrete Temperature Control

Produce concrete at temperatures from 50 °F to 90 °F [10 °C to 30 °C] and maintain temperatures until deposited in the work.

If necessary to maintain placement temperature, uniformly heat or cool the water, aggregates, or both, before introduction into the mixer. Control the temperature of the mixing water during heating or cooling.

Use aggregate at temperatures from 32 °F to 130 °F [0 °C to 55 °C]. Do not allow cementitious material to contact other batch material when the aggregate temperature exceeds 130 °F [55 °C].

Do not heat the cement, add salt, or add chemical admixtures to the concrete mix to prevent freezing.

Use a heating system to heat batch materials as approved by the Engineer. Do not use steam jets to spot heat the material as the work progresses.

Do not place mixer heaters intended for heating the batch materials in the mixer drum.

D Batching Requirements

Calibrate weighing equipment in accordance with 1901, “Measurement of Quantities.” Inspect and test the scales meeting the requirements of the Concrete Manual.

D.1 Batching by Weight

D.1.a Proportioning Methods

Proportion concrete batch materials by weight in a central plant or by volume as directed by the Engineer, in conjunction with the Concrete Engineer.

D.1.b Weighing Equipment and Tolerances

Weigh or measure concrete mixture ingredients using load cells or meters for ready-mix and paving concrete to within the targeted batch weight in accordance with the following:

(1) Water – 1 percent,
(2) Cement – 1 percent,
(3) Other cementitious materials – 3 percent,
(4) Aggregates – 2 percent, and
(5) Admixtures – 3 percent.

D.1.c Batching of Mixing Water

Measure the mixing water on scales or water metering devices containing the following:

(1) A discharge indicator capable of being set to within 1 gal [5 L] of a predetermined quantity,
(2) A positive automatic shutoff valve, and
(3) An approved inspection seal on the scale or water metering device dating the time of the previous calibration and adjustment

An authorized service agency will calibrate the water meter every 6 months and make adjustments as necessary before use meeting the requirements of the weighing procedure in the Concrete Manual.

Check the water meter for accuracy at least once each month as the work progresses.

D.1.d Batching of Cementitious Materials

Weigh the cementitious material independently of the aggregates in separate compartments or on separate scales.

If the Contractor weighs the cement first and then separately records the weights of each individual cementitious material, the Contractor may weigh the cementitious materials cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.e Batching of Aggregates

If the Contractor records each individual fraction weight of aggregates separately, the Contractor may weigh aggregates cumulatively as approved by the Engineer, in conjunction with the Concrete Engineer.

D.1.f Admixture Proportioning

If using two or more admixtures in a single concrete batch, add each admixture separately to prevent interaction of the different admixtures before mixing with other batch materials. Agitate admixtures to ensure homogeneous concentrations in accordance with the manufacturers recommendations.

Incorporate admixtures to the batch mix in liquid form. Maintain admixture solutions at a uniform concentration at all times. Use the solution concentration and proportions designated by the manufacturer.

If using a mechanical dispenser for proportioning Class I or Class II admixtures, provide a site gauge or meter. Have the admixture manufacturer check admixture dispensers yearly to determine accuracy and ensure unobstructed flow.

D.2 Batching by Volume

Proportion concrete for bridge deck overlays by volume or as required by the contract.

If the Contractor calibrates the mixer for the specific batch materials in use, the Contractor may proportion concrete on other items of work by volume as approved by the Engineer in writing.

The Engineer will approve all methods and equipment used in volumetric proportioning.

Determine all material proportions and calibration settings on the basis of 100 lb [100 kg] of cementitious material.

Provide and use only sacked cement in the original mill containers unless the Contractor calibrates the mixer for the specific materials in use. Do not use fractional sacks.

Increase the cementitious content by 10 percent in the computation of volume proportions unless the Contractor calibrates the mixer for the specific materials in use.

E Mixing Requirements

The Engineer may check the water measuring equipment for accuracy before mixing operations begin and at any other time the Engineer considers necessary.

Mix concrete by one of the following methods:

(1) A central plant (stationary plant),
(2) Entirely or in part in truck mixers, or
(3) At the construction site.

Do not allow the mixing batch to merge or intermix with the subsequent dry batch during mixing.

Discharge water remaining in the drums before batching.

Mix concrete to provide a mixture that is homogeneous and uniform in color. The Engineer will reject concrete batches that show a marked variation in consistency or evidence of improper mixing as unacceptable work in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

After completely mixing the concrete, either in a central plant mixer or truck mixer, continuously agitate while in transit to the point of placement until the concrete is discharged from the unit, unless otherwise allowed by the Engineer, in conjunction with the Concrete Engineer.

If the mixing does not appear uniform, perform slump tests at the 15 percentage point and the 85 percentage points during unloading. If the results show a slump variation greater than 1½ in [38 mm], stop work and correct the mixing unit.

Produce concrete in such quantity and at such a rate as proper placement and finishing will permit. Do not re-temper partially set concrete.

Do not hand mix concrete.

E.1 Mixing In Truck Mixer

Charge the materials into the truck mixer drum by introducing sufficient water before adding solid materials. Perform charging operations without losing materials.

Leave the truck mixer at the plant site for a minimum of 5 min or 50 revolutions during the mixing period. Transport the concrete at agitating speed to the point of placement.

F Certified Ready-Mix Concrete

F.1 Definitions

The Department defines ready-mix concrete as one of the following:

(1) Central-mixed concrete proportioned and mixed in a stationary plant and hauled to the point of placement in revolving drum agitator trucks or a truck mixer, or
(2) Truck-mixed concrete proportioned in a stationary plant and fully mixed in truck mixers.

Table 2461-7 defines commonly used certified ready-mix terms.

Table 2461-7
Certified Ready-Mix Terminology

Term	Definition
Mix design water	The maximum allowable water content for 1 cu. yd [1 cu. m] of concrete in accordance with Mn/DOT Form TP 02406, *Estimated Composition of Concrete Mixes*.
Total moisture factor	Factor used to determine total amount of water carried by a given wet aggregate.
Absorption factor	Factor used to determine the water contained within the pores of the aggregate and is held within the particles by capillary force.
Free moisture	The water that is carried on the surface of the aggregate that becomes part of the total water.
Batch water	Water actually batched into the truck by the batcher.
Total water	Batch water added to free moisture. Total water may also include the water used in diluting admixture solutions.
Temper water	Water added in mixer to adjust slump.
Total actual water	The water in the concrete mixture at the time of placement from any source other than the amount absorbed by the aggregate. It includes all batch water placed in the mixer, free moisture on the aggregate and any water added to the ready mix truck prior to placement.

Ready-Mix Producer or "Producer"	Party that is producing the concrete for the Contract. It is understood that the Ready-Mix Producer is the agent of the Contractor.

F.2 General Requirements

Supply ready-mix concrete in accordance with 2461.3.F.3, "Certified Ready-Mix Plant Program."

The Engineer will reject ready-mix concrete delivered to the work site that does not meet the specified requirements for delivery time, consistency, quality, air content, or other properties as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

Provide batches for a delivered load of concrete in sizes of at least 1 cu. yd [1 cu. m].

F.3 Certified Ready-Mix Plant Program

Provide ready-mix concrete produced by a certified ready-mix plant. Perform quality control of concrete production under a certification program for ready-mix concrete plants.

F.3.a Plant Certification

Before concrete production each season, ensure the producer performs the following:

(1) Performs an on-site inspection at the concrete plant with the Engineer and completes a Mn/DOT Form 2163, *Concrete Plant Contact Report*.
(2) Signs the report certifying compliance with the Certified Ready Mix requirements and continual maintenance of the plant. The Engineer will also sign Mn/DOT Form 2163, *Concrete Plant Contact Report*.
(3) Provides a copy of the current Concrete Manual and retains it on-site.
(4) Equips the Certified Ready-Mix Plant with a working facsimile machine or an email address.
(5) Keeps plant reports, charts ,and supporting documentation on file at the plant site for 5 calendar years.

F.3.b Sampling and Testing

Provide a Mn/DOT Certified Concrete Plant Level 2 Technician to oversee testing and plant operations and to remain on-site during concrete production or have cellular phone availability.

Provide facilities in accordance with 1604, "Plant Inspection – Commercial Facility," for the use of the plant technician in performing tests.

Ensure the producer provides technicians with certification at least meeting Mn/DOT Concrete Plant Level 1 to perform all of the duties in accordance with the Concrete Manual. The Engineer will provide technicians with certification at least meeting Mn/DOT Concrete Plant Level 1 to perform all of the duties in accordance with the Concrete Manual.

Ensure the producer performs testing in accordance with the Concrete Manual and determines testing rates meeting the requirements of the Schedule of Materials Control. The Engineer performs testing in accordance with the Concrete Manual and determines testing rates meeting the requirements of the Schedule of Materials Control.

Take samples randomly using ASTM D 3665, Section 5.

Perform testing at the certified ready-mix plant site. Perform additional testing as directed by the Engineer. The Engineer may oversee the quality control sampling process.

Provide equipment and perform calibrations meeting the requirements of the following:

(1) AASHTO T 27, "Sieve Analysis of Fine and Coarse Aggregates,"
(2) AASHTO T 255, "Total Moisture Content of Aggregate by Drying,"
(3) AASHTO M 92, "Wire-cloth Sieves for Testing Purpose," and
(4) AASHTO M 231, "Weighing Devices Used in the Testing of Materials."

F.3.c Gradations

Determine the gradation of the fine aggregates and the coarse aggregates as required by the contract. Use mechanical shakers for sieve analysis of fine and coarse aggregates.

Identify quality control companion samples with the following information:

(1) Date,
(2) Test number,
(3) Time,
(4) Type of material,
(5) Plant, and
(6) Sampling location.

Document gradation results on Mn/DOT Form 2449, *Weekly Concrete Aggregate Report*.

Chart all producer gradation results and Department verification gradation results of the coarse aggregate and the No. 8 [2.36 mm], No. 30 [600 µm], and No. 50 [300 µm] sieves of the fine aggregate.

The producer may request a reduction in testing rates as approved by the Engineer, in conjunction with the Concrete Engineer.

If the gradation tests on split samples from quality control or verification samples result in a variation between the producer and the Department greater than that set forth in Table 2461-8, the parties shall follow the procedures for test result dispute resolution available from the Mn/DOT Concrete Engineering website.

Table 2461-8
Allowable Variations on Percent Passing Sieves

Sieve Size	Allowed Percentage
2 in – ⅜ in [50 mm – 9.5 mm]	± 6
No. 4 – No. 30 [4.75 mm – 600 µm]	± 4
No. 50 [300 µm]	± 3
No. 100 [150 µm]	± 2
No. 200 [75 µm]	± 0.6

F.3.c.(1) Non-conforming Material

Only place concrete meeting the gradation requirements in the work. If the Contractor places concrete not meeting the gradation requirements into the work, the Engineer will not accept nonconforming concrete at the contract unit price.

For concrete not meeting the required gradation, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the contract unit price for the concrete contract item in accordance with Table 2461-9 and Table 2461-10. When there is not a separate *Structural Concrete* contract unit price for an item of work or the concrete is a minor component of the contract unit price, the Department will reduce payment based on a concrete price of $100.00 per cu. yd [$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-9
General Concrete for Individual Aggregate Fractions
Fine and Coarse Aggregate Specification Sieves other than Fine Aggregate No. 200 [75 µm]

Outside of Specification, %	Adjusted Contract Unit Price
≤ 3	The Department will pay 98 percent of the relevant contract unit price for concrete placed as approved by the Engineer.

Table 2461-9 General Concrete for Individual Aggregate Fractions Fine and Coarse Aggregate Specification Sieves other than Fine Aggregate No. 200 [75 µm]	
Outside of Specification, *%*	**Adjusted Contract Unit Price**
4 – 6	The Department will pay 95 percent of the relevant contract unit price for concrete placed as approved by the Engineer.
7 – 10	The Department will pay 90 percent of the relevant contract unit price for concrete placed as approved by the Engineer.
> 10	The Department will pay 75 percent of the relevant contract unit price for concrete placed as approved by the Engineer.

Table 2461-10 General Concrete for No. 200 [75 µm] Sieve of Fine Aggregate	
Outside of Specification, *%*	**Adjusted Contract Unit Price**
< 0.3	The Department will pay 98 percent of the relevant contract unit price for concrete placed as approved by the Engineer.
0.4 – 0.6	The Department will pay 95 percent of the relevant contract unit price for concrete placed as approved by the Engineer.
0.7 – 1.0	The Department will pay 90 percent of the relevant contract unit price for concrete placed as approved by the Engineer.
> 1.0	The Department will pay for 75 percent of the relevant contract unit price for concrete placed as approved by the Engineer.

If failure occurs on the fine aggregate No. 200 [75 µm] sieve and on other sieves concurrently, the Department will only reduce the price based on the larger percentage deduction.

The Engineer, in conjunction with the Concrete Engineer, will determine adjusted contract unit prices for coarse aggregate quality failures in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work.”

F.3.d Moisture Content

Ensure the producer performs the following:

(1) Determines the moisture content using the oven-dry method in all fractions of the aggregate.
(2) Documents moisture tests on Mn/DOT Form 2152, *Concrete Batching Report*.
(3) Charts the moisture content of each aggregate.

In addition to the oven-dry moisture test, the producer may obtain the moisture content in the fine aggregate using a moisture probe.

To obtain approval for the use of a moisture probe, ensure the producer calibrates the moisture probe before each construction season meeting the requirements of the Concrete Manual. Ensure the producer verifies and charts both the probe moisture content and the oven-dry verification moisture test.

F.3.e Plant Diaries

Provide daily plant diaries in accordance with the Concrete Manual using an approved form from the Mn/DOT's Concrete Engineering website.

F.3.f Batch Weight Verification

The Engineer will observe the batching process to verify weights shown on the Certificate of Compliance.

The Engineer will observe the actual water batched during each collection of verification gradations in accordance with the following:

(1) Watching the ready-mix truck reverse the drum after washing,
(2) Verifying use of the current moisture test,
(3) Verifying that any additional water added to adjust the slump is recorded, and
(4) Validating water weights on the load batched and comparing the total water with the design water.

The Engineer will document the actual water batched on Mn/DOT Form 24143, *Weekly Certified Ready-Mix Plant Report* and submit a copy to the Engineer to provide to the Concrete Engineer.

The Engineer will provide plant diaries in accordance with the Concrete Manual.

F.3.g 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 Mn/DOT 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 from the producer for each item of information, including the following:

(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 (Mn/DOT Mix Designation Number).
(11) Cementitious materials using Mn/DOT Standard Abbreviations.
(12) Admixtures using Mn/DOT Standard Abbreviations.
(13) Aggregate sources using 5 digit State Pit Numbers.
(14) Admixture quantity in fluid ounces per 100 lb [milliliters per kilogram] or ounces per cubic yard [milliliters per cubic meter].
(15) Batch information for materials using Mn/DOT standardized labels to represent each column in Table 2461-11. Present the information in the order listed across the page (a through k) or print the information using two lines provided that the materials are identified in each line of information.

Table 2461-11
Standardized Certificate of Compliance Labels

	Formula Letter	Formula	Standard Label
a	Ingredients (aggregate, cementitious, water, admixtures)	—	Ingredient
b	Product Source (Mn/DOT Standard Abbreviation)b	—	Source
c	Total Moisture Factor (in decimals to 3 places)	—	MCFac
d	Absorption Factor (in decimals to 3 places)	—	AbsFac
e	Mn/DOT mix design oven dry (OD) weights, *lb/cu. yd [kg/cu. m]*	—	OD
f	Absorbed moisture in the aggregates, *lb/cu. yd [kg/cu. m]*	(e × d)	Abs

g	Saturated surface dry (SSD) weights for aggregates, *lb/cu. yd [kg/cu. m]*)	(e + f)	SSD
h	Free moisture, *lb/cu. yd [kg/cu. m]*	(c - d) × e	Free Mst
i	Target weights for one cubic yard [cubic meter] of concrete, *lb/cu. yd [kg/cu. m]*	(g + h)	CY Targ [CM Targ]
j	Target batch weights, *lb [kg]*	(cu. yd × i) [cu. m × i]	Target
k	Actual batch weights, *lb [kg]*	—	Actual
NOTE: Actual cubic yards [cubic meters] batched may vary due to differences in air content, weight tolerances, specific gravities of aggregates, and other variables.			

(16) Total Water (Batch Water + Free Moisture) in pounds [kilograms].

(17) Water available to add [(Mix Design Water) × (Target CY (CM)) – Total water] in gallons [liters].

(18) Space to note the water adjustment information, including:

(18.1) Water in gallons [liters] added to truck at plant (filled in by producer, enter zero if no water is added).

(18.2) Water in gallons [liters] added to truck at the jobsite (filled in by producer or Engineer, enter zero if no water is added), and

(18.3) Total actual water in pounds [kilogram] (Total Water from Certificate of Compliance plus any additions).

(19) The following information printed with enough room beside each item to allow the Engineer to record the test results:

(19.1) Air content,
(19.2) Air temperature,
(19.3) Concrete temperature,
(19.4) Slump,
(19.5) Cylinder number,
(19.6) Location or part of structure,
(19.7) Time discharge, and
(19.8) Signature of Inspector.

(20) Location for the signature of the Mn/DOT Certified Plant 1 Technician representing the producer. The technician will review the first Certificate of Compliance for each mix type, each day, for accuracy and hand sign the Certificate of Compliance at a location designated for signature signifying

agreement to the terms of this policy and to certify that the materials itemized in the shipment comply requirements of the contract.

F.3.h Decertification

If the Contractor provides concrete from a plant that cannot produce concrete, fails to perform testing, fails to report accurate results, or fails to complete the required documentation, the Engineer may reject the concrete as unacceptable in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Concrete Engineer, with coordination from the Engineer, may decertify the plant and halt production of concrete if the producer performs the following:

(1) Procedural changes made after the completion of the Concrete Plant Contact Report and after starting the work that cause non-compliance with the program,
(2) Continually produces concrete in non-compliance with this section,
(3) Completely disregards the requirements of this section, and
(4) Submits fraudulent test reports.

If decertifying the plant, the Concrete Engineer may perform the following:

(1) Revoke plant certification.
(2) Revoke technician certification for individuals involved,
(3) Revoke bidding privileges as determined by the Construction Engineer, and
(4) Criminal prosecution for fraud as determined by the Attorney General.

G Concrete Placement

Do not produce concrete earlier than 60 min before the National Weather Service official sunrise, unless the Engineer approves otherwise.

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.

Assume full responsibility for the acceptable production, placement, finishing, and curing of all concrete under the conditions prevailing, regardless of the restrictions imposed. Provide any artificial lighting, rain or cold weather protection necessary at no additional cost to the Department. The Engineer may subject any defects in concrete or concrete surfaces resulting from weather conditions, inadequate lighting, or other causes to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.1 Notice of Inspection

Notify the Engineer at least 24 h before beginning concrete production to allow the Engineer time to provide inspection forces needed for the work and to approve preparations for concrete placement. If the Contractor fails to provide 24 h notice, the Engineer may delay concrete placement in accordance with 1503, "Conformity with Contract Documents" and 1512, "Unacceptable and Unauthorized Work."

If the producer needs to change plants during placement, notify the Engineer and obtain approval before changing the plant.

G.2 Placement Temperatures

Do not place concrete when the air temperature at the point of placement is below 36 °F [2 °C] or is expected to fall below 36 °F [2 °C] within the following 24 h period unless approved cold-weather provisions are in-place. Discontinue concrete placement if the air temperature falls below 36 °F [2 °C].

Maintain concrete at a temperature from 50 °F to 90 °F [10 °C to 30 °C] until placement.

G.3 Delivery Requirements

Place concrete into the work in accordance with the following:

(1) Type 1 Concrete—within 90 min of batching, and
(2) Type 3 Concrete—within 60 min of batching when adding the air entraining admixture at the plant. If adding the entire dosage of air entraining admixture at the jobsite, place concrete within 90 min of batching. Do not add additional mixing water once the concrete is 60 min old.

The Contractor may transport Type 3 concrete in non-agitating equipment if the concrete is discharged within 45 min of batching.

Batch time starts when the batch plant or the transit mix truck adds the cement to the other batch materials.

G.4 Field Adjustments

The Engineer will test the concrete for compliance with 2461.3.G.6, "Consistency," and 2461.3.G.7, "Air Content," in accordance with the following:

(1) If the first test taken by the Engineer passes, the Engineer will resume verification testing in accordance with the Schedule of Materials Control.
(2) If the first test taken by the Engineer fails, make adjustments and perform any quality control testing before the Engineer performs a final test. Acceptance or rejection of the truck is based on the Engineer's final test result.
(3) The Engineer will test up to two additional trucks in accordance with items (1) and (2) above.
(4) If the concrete does not meet the specification after the first three trucks, the Engineer will reduce their verification testing rate to once per truck for acceptance.
(5) Once the Engineer returns to normal verification testing according to the Schedule of Materials Control and a failing test occurs, the Engineer will repeat items (2), (3), and (4) above.

G.5 Test Methods and Specimens

Use the Department-provided molds for the test specimens in accordance with the following:

(1) Use 4 in × 8 in [100 mm × 200 mm] cylinder molds,
(2) Use 6 in × 12 in [150 in × 300 mm] cylinder molds for maximum aggregate sizes greater than 1¼ in [31.5 mm], and
(3) Use 6 in × 6 in × 20 in [150 in × 150 in × 500 mm] beam molds and use other beam mold sizes as approved by the Engineer.

Provide curing tanks of adequate size and number for curing all of the concrete test specimens in accordance with 2031.3.C, "Special Requirements." Supply the curing tanks with heaters to maintain a water temperature of 73 °F ± 3 °F [23 °C ± 2 °C].

Perform the following as required by the contract:

(1) Determine the required testing rates in accordance with the Schedule of Materials Control,
(2) Take samples after the first ¼ cu yd [cu. m] and before discharging the last ¼ cu. yd [cu. m] of the batch,
(3) Perform concrete sampling and testing meeting the requirements of the Concrete Manual,

(4) Measure slump and air content, and make strength specimens when placing the concrete,
(5) Record field measurements, including strength specimen identifications on Mn/DOT Form 2448, *Weekly Concrete Report*, to provide to the Concrete Engineer.

The Engineer will transport the cylinders to the Department's Laboratory for testing.

G.5.a Standard Strength Cylinders

The Department will perform the following for standard strength cylinders:

(1) Cast cylinders for testing at 28 days,
(2) Mark cylinders for identification of the represented unit or section of concrete,
(3) Cure the cylinders meeting the requirements of the Concrete Manual, and
(4) Submit cylinders and a completed cylinder identification card to the Department's Laboratory.

The producer of precast units is responsible for casting standard strength cylinders.

G.5.b Control Strength Cylinders

The Engineer will use control cylinders to determine when the sequence of construction operations is dependent upon the rate of concrete strength development. Cast enough control cylinders to determine when the concrete attains the required strength for all desired control limitations.

The Department will perform the following for control strength cylinders:

(1) Supply control cylinder molds in sets of three,
(2) Mark control cylinders for identification of the represented unit or section of concrete, and
(3) Submit cylinders and a completed cylinder identification card to the Department's Laboratory.

Perform the following for control strength cylinders:

(1) Cast control cylinders in sets of three, and
(2) Cure the cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of the Concrete Manual.

If the Department is unavailable to test the control cylinders, submit the control cylinders to an independent testing facility for testing or perform the testing on the

control cylinders on a portable mechanical or hydraulic testing machine checked and calibrated with a standard proving ring as approved by the Engineer and in the presence of the Engineer.

The producer of precast units is responsible for casting control strength cylinders.

G.5.c Strength Specimens for Concrete Paving

Use flexural beams to determine strength or provide cylinders as allowed by the contract or approved by the Engineer.

Cast standard beams or cylinders for testing at 28 days.

Cast a sufficient number of control beams or cylinders to determine when the concrete attains the required strength for all desired control limitations.

Cure the standard beams or cylinders meeting the requirements of the Concrete Manual.

Cure the control beams or cylinders in the same location and under the same conditions as the concrete structure or unit involved meeting the requirements of the Concrete Manual.

The Engineer will test the flexural beams and record the results on Mn/DOT 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.6 Consistency

The Engineer will test the concrete for consistency using the slump test during the progress of the work. The Department may reject concrete batches with consistencies outside of the slump range in accordance with Table 2461-10. If any test shows the slump in excess of the upper limit of the slump range, the Engineer will reject the concrete represented by that test unless the Contractor makes adjustments to the concrete before use.

Adjust the slump within the allowable range to optimize both placement and finishing.

If not using a Department approved Type A water reducer at the manufacturer's recommended dosage rates listed on the Approved/Qualified Products List, meet the slump values for the slump range without water reducer in accordance with Table 2461-12.

If using an Department approved Type A water reducer at the manufacturer's recommended dosage rates listed on the Approved/Qualified Products List, meet the

slump values for the slump range with water reducer in accordance with Table 2461-12.

Table 2461-12 Slump Range Designation		
Slump Designation	**Slump Range without Water Reducer, *in [mm]***	**Slump Range with Water Reducer, *in [mm]***
1	½ – 1 [12 – 25]	½ – 1 [12 – 25]
2	1 – 2 [25 – 50]	1 – 3 [25 – 75]
3	1 – 3 [25 – 75]	1 – 4 [25 – 100]
4	2 – 4 [50 – 100]	2 – 5 [50 – 125]
5	2 – 5 [50 – 125]	2 – 6 [50 – 150]
6	3 – 6 [75 – 150]	3 – 7 [75 – 175]

Contact the Engineer if encountering unusual placement conditions that render the specified slump range unsuitable. The Department will provide mix composition modifications for Department designed mixes to provide the desired change in consistency while maintaining the other specified properties of the concrete mix. Do not add water solely to temporarily facilitate the placement of concrete.

G.6.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.

G.6.b Non-Conforming Material

Only place concrete meeting the slump requirements in the work. If the Contractor places concrete not meeting the slump requirements into the work, the Engineer will not accept non-conforming concrete at the contract unit price.

For concrete not meeting the required slump, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the contract unit price for the contract item of the concrete in accordance with Tables 2461-13, 2461-14, 2461-15 and 2461-16. When there is not a separate contract unit price for *Structural Concrete* for an item of work or the concrete is a minor component of the contract unit price, the Department will reduce payment based on a concrete price of $100.00 per cu. yd [$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-13 General Concrete*	
Outside of Slump Range	**Adjusted Contract Unit Price**
Below slump range*	The Department will pay 95 percent of the relevant contract unit price for materials

Table 2461-13 General Concrete*	
Outside of Slump Range	**Adjusted Contract Unit Price**
	placed as approved by the Engineer.
≤ 1½ in [40 mm] above slump range	The Department will pay 75 percent of the relevant contract unit price for materials placed as approved by the Engineer.
1¾ in [45 mm] – 2¼ in [55 mm] above slump range	The Department will pay 50 percent of the relevant contract unit price for materials placed as approved by the Engineer.
> 2¼ in [55 mm] above slump range	The Department will pay 25 percent of the relevant contract unit price for materials placed as approved by the Engineer
* If the Contractor places piling or footing concrete below the slump range, the Department will deduct $100 per cu. yd [$130 per cu. m] or the Contractor-provided invoice amount to the relevant contract unit price of the concrete represented by the slump test, whichever is less. The Department will not reduce contract unit price for low slump concrete placed with the slip-form method as approved by the Engineer.	

Table 2461-14 Bridge Deck Concrete	
Outside of Slump Range	**Adjusted Contract Unit Price**
Below slump range	The Department will pay 95 percent of the relevant contract unit price for materials placed as approved by the Engineer.
≤ 1½ in [40 mm] above slump range	The Department will pay 75 percent of the relevant contract unit price for materials placed as approved by the Engineer.
> 1½ in [40 mm] above slump range	The Department will pay 25 percent of the relevant contract unit price for materials placed as approved by the Engineer.

Table 2461-15 Low Slump Bridge Deck Concrete From ½ in to 1 in [12 mm to 25 mm]	
Outside of Slump Range	**Adjusted Contract Unit Price**
Below slump range	No deduction for materials placed as approved by the Engineer.
≤ ½ in [12 mm] above slump range	The Department will pay 50 percent of the relevant contract unit price for materials

Table 2461-15 Low Slump Bridge Deck Concrete From ½ in to 1 in [12 mm to 25 mm]	
Outside of Slump Range	**Adjusted Contract Unit Price**
	placed as approved by the Engineer.
> ½ in – ¾ in [12 mm – 20 mm] above slump range	The Department will not pay for concrete placed but will allow the concrete to remain in place as approved by the Engineer.
> ¾ in [20 mm] above slump range	The Department will not pay for concrete. Provide additional testing as directed by the Engineer to determine if the concrete can remain in place or is subject to removal and replacement.

Table 2461-16 Low Slump Concrete — Patching From ½ in to 1 in [12 mm to 25 mm]	
Outside of Slump Range	**Adjusted Contract Unit Price**
Below slump range	No deduction for materials placed as approved by the Engineer
≤ ½ in [12 mm] above slump range	The Department will pay 75 percent of the relevant contract unit price for materials placed as approved by the Engineer.
≥ ¾ in [20 mm] above slump range	The Department will pay 25 percent of the relevant contract unit price for materials placed as approved by the Engineer.

G.7 Air Content

Maintain the air content of Type 3 general concrete at the specified target of 6.5 percent ±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.

Measure the air content at the point of placement but before consolidation.

G.7.a Non-Conforming Material

Only place Type 3 concrete meeting the air content requirements in the work. If the Contractor places Type 3 concrete not meeting the air content requirements into the work, the Engineer will not accept non-conforming concrete at the contract unit price.

For concrete not meeting the required air content, the Engineer will make determinations regarding the disposition, payment, or removal. The Department will adjust the contract unit price for the contract item of the concrete in accordance with Table 2461-17. When there is not a separate contract unit price for *Structural Concrete* for an item of work or the concrete is a minor component of the contract unit price, the Department will reduce payment based on a concrete price of $100.00 per cu. yd [$130.00 per cu. m] or the Contractor-provided invoice amount for the concrete in question, whichever is less.

Table 2461-17 General Concrete (Target Air Content 6.5%)	
Air Content, %	**Adjusted Contract Unit Price**
> 10.0	The Department will pay 75 percent of the contract unit price for the concrete represented for material placed as approved by the Engineer.
>8.0 – 10.0	The Department will pay 95 percent of the contract unit price for the concrete represented for material placed as approved by the Engineer.
5.0 – 8.0	The Department will pay 100 percent of the contract unit price for the concrete represented, for material placed as approved by the Engineer.
>4.0 – <5.0	The Department will pay 75 percent of the contract unit price for the concrete represented for material placed as approved by the Engineer.
>3.5 – 4.0	The Department will pay 25 percent of the contract unit price for the concrete represented and placed as approved by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the surface is exposed to freeze-thaw cycling, coat the concrete with an approved epoxy penetrant sealer from the Approved/Qualified Products List.
≤ 3.5	Remove and replace concrete in accordance with 1503, “Conformity with Contract Documents,” and 1512, “Unacceptable and Unauthorized Work,” as directed by the Engineer. If the Engineer, in conjunction with the Concrete Engineer, determines the concrete can remain in place, the Engineer will not pay for the concrete and if the Engineer determines the surface is exposed to salt-brine freeze-thaw cycling, coat with an approved epoxy penetrant sealer from the Approved/Qualified Products List.

G.8 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 2461-18.

Table 2461-18 Allowable Testing Tolerances	
Test	**Allowable Tolerance**
Air content, % volume of concrete	1.0
Average slump:	
≤ 4 in [100 mm]	1.0 in [25 mm]
4 in – 6 in [100 mm – 150 mm]	1.5 in [38 mm]
≥ 6 in [150 mm]	2.0 in [50 mm]
Unit weight, per cu. ft [cu. m], calculated to an air-free basis	1.0 lb/cu. ft [16 kg/cu. m]
Compressive strength 3,000 psi – 8,000 psi [20.6 MPa – 55.2 MPa], average of 3 tests	500 psi [3.4 MPa]

2461.4 METHOD OF MEASUREMENT

The Engineer will measure fresh concrete produced as required by the contract by the theoretical volume. The Engineer will deduct accountable waste from the concrete measurement.

The Engineer will measure concrete mixtures on the basis of the dimensions of the structure shown on the plans. If the plans do not include a contract item for concrete used in miscellaneous items, the Department will include the cost of this concrete with other relevant contract items.

2461.5 BASIS OF PAYMENT

The Department will include the cost of the Certified Ready-Mix Plant Program with other relevant contract items.

The contract cubic yard [cubic meter] price for *Concrete, Mix No.* ___ includes the cost of production, placement, finishing, curing, and protection of concrete.

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

Item No.:	Item:	Unit:
2461.501	Concrete, Mix No.___	cubic yard [cubic meter]

2471 STRUCTURAL METALS

2471.1 DESCRIPTION

This work consists of shop and field work for manufacturing, fabricating, and coating structural metals.

2471.2 MATERIALS

If the contract states that the project is a Federal aid project, provide domestic material. Provide Mill Test Reports (MTRs) for Federal aid projects to document that the material was melted and manufactured in the U.S.A. If the Contractor supplies foreign material, the provisions of 1601, "Source of Supply and Quality," shall apply.

Provide new materials in accordance with the following sections. Unless otherwise required by the contract, use structural steel in bridges in accordance with 3309, "High-Strength Low-Alloy Structural Steel," and use structural steel for all other structures in accordance with 3306, "Low-Carbon Structural Steel."

Provide materials from mills, warehouses, or processors with supporting certified MTRs meeting the requirements of applicable ASTM specifications. If the MTR does not contain sufficient information, provide copies of the test results to the Engineer for review and approval before fabrication.

2471.3 CONSTRUCTION REQUIREMENTS

A General

For the purpose of the work specified in this section these terms have the following meaning:

(1) "Engineer" means the Bridge Engineer, unless otherwise indicated.
(2) "Fabricator" means the manufacturer or supplier of fabricated structural metals. In the event that the Contractor performs this work, the term will mean the Contractor or the Contractor's agent.
(3) "Supplier" means fabricator, galvanizer, and paint shop.

Provide the Engineer with a list of fabricators, galvanizers, and painters, including addresses, and a list of products they will provide.

Do not order materials or direct the fabricator to perform shop work until the Engineer approves of the shop drawings.

If installing fabricated components on an existing structure, measure field dimensions in accordance with 2433, "Structure Renovation."

A.1 Definitions

A.1.a Minor Structural Components

The Department defines minor structural components as materials used in the following applications:

(1) Bridges: Bearing assemblies, sole plates, expansion joint devices, shear connectors, ballast plates, diaphragms for bridges (except curved steel bridges), pile and appurtenances, drainage systems, guardrail connections, railings, fencing, conduit systems, and protection angles;
(2) Electric lighting, traffic signs, and signal systems;
(3) Pedestrian bridges; and
(4) Other system or component designated by the Engineer.

A.1.b Major Structural Components

The Department defines major structural components as all components other than minor structural components as defined in 2471.3.A.1.a.

A.2 Certification Requirements

Provide a certification from a fabricator certified in accordance with AISC Quality Certification Program Category, Simple Steel Bridge Structures (Sbr) for the following types of structures and structure components:

(1) Rolled beam bridges with a pay quantity for structural steel no greater than 300,000 lb [136,000 kg],
(2) Pedestrian bridges,
(3) Steel diaphragms with a linear quantity greater than 5,000 ft [1,500 m],
(4) Diaphragms designated major structural components (curved steel bridges), and
(5) Other items as directed by the Engineer.

Provide a certification from a fabricator certified in accordance with AISC Quality Certification Program Category, Major Steel Bridges (Cbr) for the following types of structures and structure components:

(1) Rolled beam bridges with a pay quantity for structural steel of at least 300,000 lb [136,000 kg],
(2) Welded bridge girders,
(3) Tubs,
(4) Boxes,
(5) Trusses, and
(6) Other items designated by the Engineer.

Provide fracture critical items from a fabricator certified in accordance with AISC Quality Certification Program Category, Major Steel Bridges (Cbr) with Fracture Critical Member endorsement (F).

Provide material coated by a supplier certified in accordance with AISC Sophisticated Paint Endorsement (SPE), the SSPS QP Certification, or a Quality Control Plan (QCP) as approved by the Engineer.

B Shop Detail Drawings

B.1 General Requirements

Submit to the Engineer shop detail drawings from the fabricator that include the following:

(1) Detailed plans showing the dimensions and sizes of materials,
(2) Details and information necessary for fabrication,
(3) Fastener lists for shop and field erection,
(4) Blocking and camber diagrams,
(5) Match marking diagram,

(6) Radiographic diagram showing weld locations and identification in accordance with this section (2471),
(7) Complete field erection plan showing piece marks, and
(8) All dimensions as measured in the field.

Ensure shop detail drawings include welding symbols meeting the requirements of ANSI/AWS A2.4, "Standard Symbols for Welding, Brazing, and Nondestructive Examination." Verify that the fabricator placed Welding Procedure Specification (WPS) numbers in the tail of the arrow(s).

Submit shop detail drawings from the fabricator for the complete fabrication of structural metals as required by the contract. If the Department provides standard detail drawings as required by the contract, submit finished detail drawings from the fabricator with additions and revisions.

If the contract requires a "Standard Plate," the Department will not require re-detailed plates except to indicate fit at connections to other structural members for changes shown on the plans or to complete detailed information to the shop or the material supplier. Provide these detail changes from the fabricator.

B.2 Format

Submit shop detail drawings from the fabricator meeting the following characteristics and requirements:

(1) Prepared in a neat and legible form on media from which clear, sharply defined prints can be made for the Engineer's review and inspection purposes,
(2) 22 in × 34 in [559 mm × 864 mm],
(3) ½ in [13 mm] border on all edges except a 2 in [50 mm] border on the 22 in [559 mm] left edge,
(4) Containing title box in the lower right hand corner with the following information:

    (4.1) Departments structure number,
    (4.2) Project number,
    (4.3) Federal Project number (if applicable),
    (4.4) Fabricator's name,
    (4.5) Fabricator's contract number,
    (4.6) Detailer's and checker's initials,
    (4.7) Date of preparation, and
    (4.8) Brief description of the details shown on each sheet.

(5) Height of letters and numerals on each drawing at least 0.14 in [3.5 mm],

(6) Text, details, lines, and dimensions capable of reducing in size to 11 in × 17 in [280 mm × 432 mm] without affecting readability,
(7) Containing a complete bill of materials listing the individual pieces with piece marks and quantities, including dimensions,
(8) Consecutively numbered sheets, and
(9) First drawing of the shop details containing a schedule of sheet numbers, including a brief description for reference.

The Contractor may also provide standard sheets from the fabricator with fastener lists.

B.3 Submittal for Engineer's Review and Approval

Submit two sets of prints of required shop detail drawings from the fabricator to the Engineer for review and release for fabrication. Notify the Engineer of detail variances shown on the plans in writing. The Engineer will return one set of prints of the shop detail drawings to the Contractor with comments.

Submit only checked drawings, in complete collated sets, from the fabricator for review. The Contractor may submit details such as ice-breakers, anchorages, bearing plates, and castings, separately to facilitate the work.

Submit a schedule showing the submission dates of shop drawings and anticipated dates for shop fabrication from the fabricator, as directed by the Engineer. Arrange the schedule to avoid delay in completing the work. If constructing a structure composed of several units, consider submitting shop detail drawings of the separate units in proper order to expedite the review and release for fabrication of the details.

If the Engineer requests changes to the submitted drawings or if the fabricator makes additional changes not required by the Engineer, provide revised prints from the fabricator with circles, underscores, or other marks to distinguish the changes from unchanged details or dimensions.

The Engineer will release shop detail drawings for fabrication after corrections are completed. Provide six sets of prints of the corrected drawings and additional prints as required by the contract or requested by the Engineer from the fabricator at no additional cost to the Department.

B.4 Submittal for Completed Work

After the fabricator completes the shop work, provide detailed shop drawings to the Engineer in two formats:

(1) One set of drawings on 11 in × 17 in bond paper, and
(2) An electronic file in PDF format containing all sheets.

Ensure that the drawings submitted accurately reflect the actual configuration of all structural members and components, including modifications made during fabrication and after delivery to the project, under the fabricator's direction. If making the electronic files by scanning, use a minimum scan resolution of 400 dpi.

C General Fabrication Practices

Provide structural material fabricated and assembled meeting the requirements of AASHTO/NSBA Steel Bridge Collaboration "Steel Bridge Fabrication Guide Specification" and AWS welding codes, except as modified in this chapter. Provide material structurally welded meeting the requirements of ANSI/AASHTO/AWS D1.5, "Bridge Welding Code," for major structural components and ANSI/AWS D1.1, "Structural Welding Code Steel," for minor structural components. Ensure the Certified Welding Inspector (CWI), or an equivalent, witnesses the welder and welding operator qualification tests unless otherwise specified in this section.

Before the start of work, the fabricator is to supply a Quality Control Plan (QCP) to the Engineer for approval. Ensure the QCP describes the methods, equipment, Non Destructive Testing (NDT), and frequency of testing used. The Engineer will use the AASHTO/NSBA, "Steel Bridge Fabrication QC/QA Guide Specification," as the basis for approving the QCP. The Engineer will audit suppliers with approved QCPs on a biannual or annual basis or as otherwise directed by the Engineer to ensure the implementation of the QCP. The Department will invoke its Corrective Action Process if the audit indicates non-conformance. The Department will require corrective action, including hiring a third party Quality Control Inspector at no additional cost to the Department. The Contractor may obtain a copy of the Department's Corrective Action Process from the Engineer.

If the Engineer determines that fabrication work does not comply with the QCP or that fabrication does not follow approved fabrication procedures, the Engineer will deem the materials as non-conforming in accordance with 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work." If the Engineer finds non-conforming work, direct the Supplier to immediately correct the procedure and conduct additional tests and submit a written non-conformance report, containing data required by the Engineer to ensure compliance with the QCP. Perform additional testing in conjunction with the supplier as required by the Engineer at no additional cost to the Department.

C.1 Prefabrication Conference

Before fabrication, the Engineer may schedule a Prefabrication Conference with the Contractor and the fabricator to discuss pertinent specifications, procedures, and requirements of the job. The Engineer will consult the Contractor and the fabricator to decide the location, date, and agenda items for the conference.

C.2 Notification

Notify the Engineer at least 5 business days before the fabricator begins work so that the Engineer may perform inspections. Do not allow the fabricator to begin work before notifying the Engineer.

C.3 Identification of Materials

Before fabrication begins, the Fabricator will provide a copy of purchase orders, Mill Test Report (MTR), or other documentation required by the Engineer, indicating that the materials meet the physical, chemical, and source (mill) requirements of this section for each heat of steel used in the work. The Fabricator will provide copies of purchase orders when placing the orders. When the materials are received, the fabricator will indicate in writing or by ink stamp that the MTRs have been checked for compliance. Include the name of the individual who checked the MTR and the date of inspection with the purchase order. If the Engineer determines that the documentation is incomplete, direct the fabricator to sample and test materials as directed by the Engineer at no additional cost to the Department. Provide scale weights of individual members or sections as required by the Engineer.

Except for the following, the Fabricator of minor structural components may provide Certificates of Compliance and shipping documents for each contract item to the Engineer instead of submitting purchase orders and MTRs:

(1) Pedestrian bridges,
(2) Post and truss chord materials for traffic signs,
(3) High mast light poles,
(4) Modular expansion devices,
(5) Pot bearings, and
(6) Other items designated by the Engineer.

In conjunction with the fabricator, keep appropriate documentation on file for at least seven years.

During each stage of fabrication of major structural components, ensure the fabricator provides and maintains identification to establish the heat of the material from which the component is fabricated. Provide the Engineer with a list showing heat numbers referenced to the material incorporated into each component. The Engineer will reject material that loses its identity unless the identity can be re-established to the satisfaction of the Engineer.

Provide wide flange beams, flanges, webs, splice plates, welded cover plates, and fracture critical members with identification numbers placed on each individual piece of material that referenced to the corresponding heat number.

Ensure the fabricator uses non-oil-based markers or low stress die stamps for the identification coding of material.

C.4 Weld Identification System

Before implementation, ensure the fabricator uses the Mn/DOT standard weld identification system as described in 2471.3.C.4.a, "Standard Weld Identification System," or an alternate system approved by the Engineer to identify welds subject to radiographic testing, ultrasonic testing, or both. Use a traceability system with a unique identification assigned to all welds being examined. Do not repeat identification numbers. Use identification numbers traceable back to the original member examined and document the identification number on the shop detail drawings.

C.4.a Standard Weld Identification System

C.4.a(1) Piece Mark

Provide material marked with the fabricator's piece identification as shown on the approved shop detail drawings.

C.4.a(2) Splice Plane Number

The Department defines a splice plane as a 3 ft [1 m] wide vertical section of a piece that contains a full penetration welded splice in any component of the piece. The Department considers any other full penetration welded splice in any component of the piece within the 3 ft [1 m] vertical splice plane in the same splice plane.

Provide the number of the splice plane on the piece starting from the left end of the piece as shown on the radiographic diagram.

C.4.a(3) Piece Components Code

Verify that the fabricator placed film identification numbers or location marks, only on film, meeting the requirements of AWS D 1.5. Begin marking from NS edge for flanges and the bottom edge for webs.

(1) Bottom flange
(2) Web – single web or near side (NS) web for two webs
(3) Top Flange – single top flange or NS flange for two top flanges
(4) Web – far side (FS) web for two webs
(5) Top Flange – FS flange for two top flanges

C.4.a(4) General Notes

Ensure the fabricator performs the following:

(1) Performs radiographic and ultrasonic testing of welds meeting the requirements of AWS D1.5, except as modified by this section.
(2) Establishes the center line of the weld on the components of the piece before welding by placing punch marks 1 ft [300 mm] back from the center line of the weld and 1 in [25 mm] from the edge of the plate.
(3) Provides Image Quality Indicators (wire penetrameters) as directed by the Engineer.
(4) For joints radiographically inspected less than100 percent, include the untested areas in the Film Identification Number scheme.

C.5 Storage of Materials

Store material above ground on platforms, skids, or other supports. Protect material from dirt, oil, and other foreign matter. Drain material so that water is never in constant contact with the surface. Replace damaged material with new material or repair using a procedure approved by the Engineer.

C.6 Nonconformances

Provide an established Quality System outlined in the QCP for controlling nonconforming material from the fabricator, including procedures for identification, isolation, and disposition.

Submit Non-conformance Report forms from the supplier to the Engineer documenting deviation from the QCP, approved shop drawings, the plans, or specifications. Include the following in the Non-conformance Report form:

(1) Company name and address,
(2) Report title,
(3) Non-conformance Report number,
(4) Date,
(5) Company job number,
(6) Piece mark,
(7) Owner of bridge/structure,
(8) Contractor,
(9) Owner’s project number,
(10) Location,
(11) Detailed description of the non-conformance,
(12) Photo, sketch, or drawing,
(13) Proposed repair/disposition of the non-conformance, and
(14) Quality Control Manager’s signature and date.

The Engineer will advise the supplier of the resolution to non-conformance in writing.

D Structural Components

D.1 Welded Stud Shear Connectors

In accordance with OSHA Subpart R 1926.754, attach shear stud connectors and other similar devices to the top flange of beams or other steel components after the installation of decking falsework or other walking surfaces.

D.2 End Connection Angles

The Engineer will only require finishing of end connection angles to correct a non-conforming assembly. Produce a finished angle at least ⅜ in [10 mm] thick. Do not reduce the original thickness of the angle by greater than ⅛ in [3 mm]. Grind flush portions of members extending beyond the face of the connection angles. Do not recess the web of a connecting member by greater than ⅜ in [10 mm] from the face of the connection angles.

D.3 Bolts

Provide high strength structural steel bolts in accordance with 3391, "Fasteners," except the Contractor may use common structural steel bolts for connections in expansion and deflection devices and in hand railings. Place structural bolts with a projection from ⅛ in to ⅜ in [3 mm to 10 mm] through the nut.

Provide extra bolts in the amount of 5 bolts plus 5 percent of the actual number of field bolts necessary, at no additional cost to the Department. The Department will not include this number of additional bolts in the plan quantity and will include the cost of these additional bolts in the contract unit prices for the bolts in the contract item.

D.4 Pins and Rollers

Provide pins and rollers with a 75 µin [1.6 µm] finish.

Provide pin threads meeting the requirements of American Standard Coarse Thread Series Class 2 and free fit meeting the requirements of ANSI B1.1. Thread pin ends and nuts with diameters of at least 1⅜ in [35 mm] with 6 threads per 1 in [25 mm]. Provide nuts meeting the following requirements and characteristics:

(1) Made of structural steel in accordance with 3306, "Low-Carbon Structural Steel," 3309, "High-Strength Low-Alloy Structural Steel," and 3310, "High-Strength Low-Alloy Columbium-Vanadium Steel;"
(2) Recessed;
(3) Hexagonal; and
(4) Galvanized in accordance with 3392, "Galvanized Hardware."

Machine the grip face of the nut square to the axis of the pin. Ensure the recessed face of the nuts will bear uniformly against the end face of the pin when turning the nut tight. Place pins with a projection of at least ¼ in [6 mm] through the nut after assembly. If making a recessed cut between the threads and the shoulder of the pin, do not make cuts wider than ¼ in [6 mm] or deeper than the base of the thread.

D.5 Shims

The Department defines shims as metal plates not shown on the plans that bring metal surfaces of members into contact or bring the structure to the grade or alignment shown on the plans.

Make shims ⅛ in [3 mm] or thicker of structural steel. Make shims ⅛ in [3 mm] or thinner from sheet steel or sheet brass.

Provide shims at no additional cost to the Department.

E Structural Fabrication

Ensure the fabricator performs the following:

E.1 Cutting

Cut steel and fabricate steel plates and splice plates for major structural components so the primary direction of rolling is parallel to the direction of the main tensile or compressive stresses.

Cut metals to the size shown on the plans with allowance for necessary or required finishing operations. Cut metals within $^{1}/_{16}$ in [2 mm] from true lines. The Department defines true lines as theoretical lines exactly corresponding to and used to transfer dimensions as shown on the plans to materials for cutting, drilling, and fitting.

Cut flange plates or other members to a true curve. Do not use a series of straight cuts to create the curve.

E.1.a Re-Entrants

Form interior and re-entrant corners with a radius of at least 1 in [25 mm]. Form filleted corners with radii no greater than 1 in [25 mm] by drilling.

E.1.b Shearing

Do not shear nonferrous metals with a thickness greater than ½ in [13 mm].

E.2 Machining

E.2.a General

Perform heat treatment before final machining. The Department defines heat treatment as intentionally and systematically applying heat at a temperature below the melting point of any ferrous castings, weldment, or other components.

E.2.b Machining Tolerances

For members requiring machine finishing, the standard tolerance is ±0.03 in [760 µm]. Apply this tolerance to the following:

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

E.2.c Machine Lubricant

Use machining lubricant on structural material requiring machine work or drilling capable of being completely removed.

E.2.d Edge and Corner Finishing

Bevel corners of painted bridge member edges to at least $^{1}/_{16}$ in [2 mm]. If thermal cutting material to final size, grind or mill edges to remove thermal cutting marks sufficient to achieve and measure the required painting surface profile.

E.2.e Finishing

Machine finish, or straighten by a method approved by the Engineer, warped or deformed plates to provide the proper fit. Machine finish surfaces intended for contact bearing with other structural parts to a flatness no greater than 0.005 × nominal dimension of the part to achieve full contact for all parts.

E.3 Bending

Before bending, round the corners of the plates to a radius of $^{1}/_{16}$ in [2 mm] throughout the portion of the plate at which the bending is to occur as shown on the plans. Bend metals before coating or heat treatment. Bend without causing fractures, kinks, reduced section below minimum, or other defects in the material.

E.4 Cambering and Curving

The Engineer will verify measurements of vertical camber and horizontal curvature for final acceptance after the completion of welding and heating operations and after the flanges cool to uniform ambient temperature. The Engineer will check horizontal curvature with the girder in the vertical position.

The Engineer may reject materials showing over hardening, fractures, or other defects due to improper heating.

E.5 Straightening Material

Straighten material without shearing, fracturing, stressing, or damaging the bolts, welds, or base metal. Use heat straightening methods approved by the Engineer. Replace material damaged during straightening operations with new material at no additional cost to the Department.

If the Engineer determines it is not possible to straighten a member as part of an assembly, remove the bent material from the assembly, straighten, and re-assemble.

E.6 Dimensional Tolerances

Provide fascia beam webs with a flatness tolerance no greater than half the limit in ANSI/AASHTO/AWS D1.5, "Bridge Welding Code."

F Structural Welding

Ensure the fabricator performs the following:

F.1 General

Obtain written approval from the Engineer before performing welding, including weld repair, or deviating from the approved shop drawings or project plan.

Submit Weld Procedure Specifications (WPS) with shop detail drawings. Do not begin fabrication until the Engineer has approved the WPS(s). The Engineer may require testing for particular weld details described in the WPS to assure the Engineer that proper welds can be made. Test welds as required by the Engineer.

Provide information or Procedure Qualification Records (PQRs) demonstrating that the proposed WPSs meet the requirements of the ANSI/AASHTO/AWS D1.5, "Bridge Welding Code" (BWC) as approved by the Engineer. PQRs, once approved, will remain valid indefinitely.

Notify the Engineer to witness welding and testing. If the Engineer cannot witness qualification or certification welding or testing, arrange the witness of an approved third party at no additional cost to the Department.

Conduct testing of qualification welds in a laboratory accredited by the American Association for Laboratory Accreditation (A2LA) or an approved equal at no additional cost to the Department

F.1.a Welded Flange Splices

Place welded flange splices at least 12 in [300 mm] from web splices. For welded girders with radii no greater than 1,900 ft [580 m], the Department will allow additional splices only on individual flanges that are uniform in thickness and greater

than 39 ft [12 m] in length. The Department will allow these splices in addition to the splices shown on the plans. Provide flanges with no more than two additional splices.

Locate additional splices in accordance with the following:

(1) Near the third points of individual flange plates,
(2) Midway between adjacent diaphragm connections,
(3) At least 12 in [300 mm] from transverse stiffeners and welded connection plates,
(4) At least 10 ft [3 m] from field splices, bearing points at piers, and flange groove welds as shown on the plans, and
(5) At locations approved by the Engineer.

F.1.b Web-to-Flange Welds

The Department defines a repair as any area of the welded product not meeting the requirements of AASHTO AWS D1.5, "Bridge Welding Code." Limit each individual web-to-flange weld repairs to 2 percent of the weld length and grinding web-to-flange weld repairs to 5 percent of the weld length. If the Contractor exceeds the repair limits, the Engineer will revoke the Welding Procedure Specification (WPS) used to perform the initial production welding.

F.2 Preparation of Base Metal

For coated metals, remove coatings on either side of the weld area to a distance of at least 2 in [50 mm].

F.3 Conditions for Welding

Preheat without producing visible moisture in the weld joint before welding.

F.4 Backing

Produce "Complete Joint Penetration" (CJP) groove welds using steel backing that is continuous for the full length of the weld. Make joints in the steel backing CJP joints, also.

G Fracture Critical Members

Ensure the fabricator performs the following:

(1) Provide fracture critical members meeting the requirements of ANSI/AASHTO/AWS D1.5, "Bridge Welding Code (BWC), Fracture Control Plan (FCP) for Fracture Critical Bridge Members" and as modified by this section.

(2) Provide fracture critical members as shown on the plans. The Engineer may provide written exemption from these requirements for welds in designated members not subject to tension forces.
(3) Do no weld or drill holes for temporary attachments to rolled beams or girders.

G.1 Fracture Critical Welder Qualifications

Provide fracture critical members welded by welders meeting the certification requirements in accordance with AASHTO/AWS D1.5, "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 AASHTO/AWS D1.5 and show the test plate in accordance with Figure 5.24. Include the WPS in the QCP.

H Hole Forming Operations

H.1 Bolt Holes

Ensure the fabricator drills holes for bolts full size from the solid unless punching is allowed in accordance with this section. Do not sub-punch or sub-drill holes unless otherwise approved by the Engineer in writing.

Except for field connections and field splices, the Contractor may punch material forming parts of a member composed of no greater than five thicknesses of metal $^{1}/_{16}$ in [2 mm] larger than the nominal diameter of the bolts for the following:

(1) Structural steel no thicker than ¾ in [19 mm],
(2) High strength steel no thicker than ⅝ in [16 mm], or
(3) Quenched and tempered alloy steel and non-ferrous metals no thicker than ½ in [13 mm].

Ensure the fabricator cuts clean holes without sharp, torn, or ragged edges and drills holes after bending, cambering, curving, or heat-treating of the member.

H.1.a Special Assembly

Ensure the fabricator performs the following:

(1) If the contract requires special assembly, drill the connection holes in flange and web splices full size in the assembled position,
(2) Drill connection holes in secondary members, including diaphragms, diaphragm stiffeners, lateral bracing, and lateral bracing connection plates $+^{3}/_{16}$ in [5 mm] greater than the bolt diameter to facilitate alignment,
(3) Use predrilled splice plates as a template only one time, and

(4) For oversized holes, place hardened washers meeting the requirements of ASTM F 436 under the bolt head and nut.

H.1.b Full Assembly

If the contract requires full assembly, ensure the fabricator drills bolt holes for field connections, in all members and component parts of each structural unit, from the solid to the specified size while assembled, and uses predrilled splice plates as a template only one time.

H.1.c Punched Bolt Holes

Ensure the diameter of the die does not exceed the diameter of the punch by greater than $^{1}/_{16}$ in [2 mm]. If the fabricator enlarges holes to admit the bolts, provides a written repair procedure from the fabricator to the Engineer for approval.

H.1.d Field Connection Bolt Holes

Ensure the fabricator drills holes full size to a steel template while assembled for the following:

(1) Floor beams,
(2) Stringer end field connections, and
(3) Holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames.

The Contractor may drill holes for the following full size and unassembled to a steel template if approved by the Engineer in writing:

(1) Field splices of rolled beam stringers continuous over floor beams or cross frames, and
(2) Holes for floor beams, cross frames, or bent plate diaphragms.

If using a steel template for drilling field connection holes to full size, ensure the fabricator locates the template to the correct position and angle, and bolt the template in place before drilling, and uses duplicate templates to drill matching members and the opposite faces of a single member.

H.2 Boring Pin Holes

Ensure the fabricator produces the final surface of pin holes by a finishing cut, and provides pin holes in diameters in accordance with the following:

(1) No greater than $^{1}/_{64}$ in [0.5 mm] for pins no greater than 5 in [127 mm] in diameter, and

(2) No greater than $^{1}/_{32}$ in [0.8 in] for pins greater than 5 in [127 mm] in diameter.

Ensure the distance outside-to-outside of end holes in tension members and inside-to-inside of end holes in compression members does not vary from that specified by greater than $^{1}/_{32}$ in [0.8 m]. Ensure the fabricator bores pin holes in built-up members after the completion of assembly.

I (Blank)

J Shop Assembly

Ensure the fabricator performs the following:

Complete fabrication, weld inspection, nondestructive testing, and any repairs, before placing any component in the assembly. Provide a written record of each shop assembly set-up as requested by the Engineer. Include the following assembly dimensions, both theoretical (as shown on a blocking diagram) and actual measurements, with the written record:

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

Draw temporary bolts tight enough to bring the parts into bearing and to prevent loosening of the nut. Provide a permanent bolt assembly in accordance with 2402.3.G.2, “Connections Using High-Strength Bolts.”

Disassemble pieces if necessary to remove burs, shavings, and other irregularities produced by the operation. Provide members free from twists, bends, and other deformation.

J.1 Special Assembly

Assemble major structural components, pedestrian truss bridges, overhead sign trusses, and modular and finger expansion joint devices at the shop, unless otherwise required by the contract. Line assemble beams or girders with a length no shorter than the length supported by three adjacent points of bearing and with all pieces completely assembled.

Adjust each assembly unit to the true field position with respect to alignment, camber, grade, and skew, as shown on the plans, before drilling field connections or field splice materials. The fabricator may angularly rotate the assembly from true field position, with respect to grade, if the fabricator provides shop drawings showing elevations at all points of bearing and the relative position of webs of main members,

with respect to true field position. Provide calculations to support the information shown in the drawings.

Clean metal surfaces in contact before assembling. Assemble, pin, and draw together the parts of a member before drilling or bolting.

J.2 Full Assembly

Performs full assembly as required by the contract in accordance with the following:

(1) Assemble the main members for the length as required by the contract and assemble to the full width of the structural unit, and
(2) Including components of the assembly such as diaphragms, brackets, laterals, wind frames, links, and transverse floor systems. The Department will not require the Contractor to assemble expansion and deflection devices and bearings.

J.3 Match Marking

Match-mark connecting parts assembled in the shop to assure proper fit in the field using low stress die stamps before disassembly.

Use a match marking system that uses a series of letters and numbers to indicate the exact location in the structure without continual reference to detail drawings. Do not use shop piece marks as a match-marking scheme. Mark all pieces or parts planned for assembly at a point with the same mark to avoid rotation of pieces.

Use material used for match marking capable of removal without damage to the appearance of painted or unpainted surface visible in the completed structure.

K Uncoated Weathering Steel Surfaces

Ensure the fabricator performs the following:

(1) Removes foreign matter including oil, grease, dirt, and concrete spatter from uncoated 3309, “High-Strength Low-Alloy Structural Steel,” or other types of weathered steel material in accordance with SSPC-SP 1, “Surface Preparation Specifications – Solvent Cleaning;” and
(2) Blasts clean uncoated weathering steel, including contact areas of bolted structural connections, in the shop or field in accordance with SSPC-SP6/NACE No. 3, “Commercial Blast Cleaning.”

L Coating

The Department defines coating as any protective barrier including paint, galvanizing, or metallizing.

Ensure the fabricator performs the following:

(1) Before performing work, supply a Quality Control Plan (QCP) as approved by the Engineer and meeting the requirements of the AASHTO/NSBA *Steel Bridge Fabrication QC/QA Guide Specification* and the AASHTO/NSBA *Guide Specification for Coating Systems with Inorganic Zinc-Rich Primer*, and
(2) Do not apply the coating material to a part until the Engineer inspects and approves the work.

The Engineer may reject material coated before approval in accordance with 1512, "Unacceptable and Unauthorized Work." Remove rejected material as directed by the Engineer.

L.1 Galvanizing

Galvanize in accordance with 3392, "Galvanized Hardware," or 3394, "Galvanized Structural Shapes," this section (2471), and as shown on the special provisions.

Completely seal weld contacting or welded overlapping surfaces. Degrease material for rolled or folded joints before forming.

Clean material of paint, lacquer, and crayon markings before galvanizing. Do not galvanize closed or blind sections of pipe.

Before pickling and galvanizing, blast clean steel meeting the requirements of SSPC-SP 6/NACE No. 3.

Submit an NCR to the Engineer before performing any repairs.

L.2 Metallizing

Before metalizing steel surfaces, blast and clean meeting the requirements of AWS C2.18, "Guide for Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites."

Use zinc metalizing wire or powder of a purity equal to Federal Specification MIL-W-6712 (99.9 percent zinc). Metallize to an average coating total thickness of 0.010 in [254 µm]. Coat to a thickness of at least 0.0075 in [190 µm].

Preheat the substrate to 250 °F [120 °C] to eliminate surface condensation and reduce shrinkage and differentials between the coating and the substrate. Do not metalize unless approved by the Engineer in writing.

L.3 Painting

Prepare the surface and paint in accordance with 2479, “Inorganic Zinc-Rich Paint System,” unless otherwise required by the contract.

M Fabricator Inspection

Ensure the fabricator provides QC personnel as required by the approved Quality Control Plan (QCP) and the following:

M.1 Nondestructive Testing (NDT)

Ensure the fabricator performs nondestructive testing in accordance with the appropriate ASTM specifications and applicable welding code specifications and the following:

(1) Use trained personnel, who have at least two years of experience as an American Society for Nondestructive Testing (ASNT) NDT Level II operator and qualified in accordance with ASNT-TC-1A;
(2) Submit a copy of the NDT operators training and certification records to the Engineer before performing any NDT inspections;
(3) Provide the Engineer a copy of the written practices and procedures for each NDT method used; and
(4) Submit a final written report of NDT to the Engineer, with interim test reports submitted as performed.

For the NDT of bridge components, the Department defines tension areas in accordance with the following:

(1) Any location in a rolled beam or welded girder where the superstructure curvature is greater than 4 degrees, and
(2) Any other tension area as shown on the plans.

Perform NDT for girder welds at a frequency in accordance with AASHTO/AWS D1.5, with the following modifications:

(1) One-sixth of the web depth beginning at the point(s) of maximum tension,
(2) Also test 50 percent of the remainder of the web depth, and
(3) If the tests for (1) and (2) above find unacceptable discontinuities, test the remainder of the weld.

Test all CJP groove welds in minor components by either radiographic or ultrasonic inspection in accordance with AWS D1.1 and as required by the contract.

Ensure the fabricator performs the following:

(1) Do not weld groove-welded parts to other members until the Engineer approves NDT of groove welds.
(2) Perform NDT of repair welding in accordance with the repair procedure as described in 2471.3.C.6, “Nonconformances,” at no additional cost to the Department.
(3) Perform NDT of areas required by the Engineer.

The Department may require NDT of areas not designated in the contract for such inspection. If the inspection shows the area to be defective, the fabricator shall perform the NDT at no additional cost to the Department. If the inspection is satisfactory, the Department will pay for the inspection as Extra Work in accordance with 1402, “Contract Revisions.” In addition, when NDT of an area designated in the contract for inspection shows defects, the Engineer may direct the fabricator to perform NDT of adjacent areas to determine the extent of the defective area, at no additional cost to the Department.

M.1.a Visual Testing (VT)

Ensure the fabricator performs visual inspections during the entire welding process and again after the weld is complete, cool, and clean of slag and residue.

M.1.b Dye Penetrant Testing (PT)

Ensure the fabricator checks edges of complete penetration groove welds on major structural components for 3 in [75 mm] on each side of the centerline of the weld or 1 in [25 mm] beyond either side of the weld area, whichever is greater, using Dye Penetrant Testing (PT). The fabricator may substitute Magnetic Particle Testing (MT) with approval from the Engineer.

M.1.c Magnetic Particle Testing (MT)

Ensure the fabricator performs MT on the following:

(1) At least 12 in [300 mm] of every 10 ft [3 m] of length for fillet welds in major structural components and pedestrian bridges,
(2) 100 percent of bearing stiffener welds,
(3) At least 20 percent of all weld terminations, and
(4) 100 percent of the base plate and gusset plate welds for overhead signs and high mast light poles.

Ensure the fabricator locates the tests at random areas of the weld. Do not use the prod method unless approved by the Engineer.

M.1.d Radiographic Testing (RT)

Ensure the fabricator provides developed radiographic film with a film density from 2.5 to 3.5. The Department will retain ownership of radiographic film provided by the Contractor.

M.1.e Overhead Signs

The Department considers sign posts and trusses for free standing cantilevered and non-cantilevered overhead signs as cyclically loaded structures. Bridge mounted signs are considered statically loaded structures. Provide overhead sign structures welded in accordance with the requirements of AWS D1.1, as outlined in the "AASHTO Structural Supports for Highway Signs, Luminaires, and Traffic Signals." Perform RT, UT, and MT, as outlined in the current overhead sign standards sheets. The Engineer will base acceptance for overhead signs in accordance with AWS D1.1

M.1.f CJP Welds

For minor structural components, perform NDT by radiographic testing (RT) on 100 percent of CJP welds subject to tension and 25 percent of CJP welds subject to only compression or shear. The Contractor may use ultrasonic testing (UT) with approval from the Engineer.

N Department Inspection

N.1 General

The Engineer will inspect major and minor structural steel components before use in the work. The Engineer may perform inspections at the mill, foundry, fabrication shop, or in the field.

The purpose of Department inspection(s) is to establish compliance with those test requirements and process controls outlined in the contract as required by federal and state laws. The Department inspection does not supplement or replace the supplier's own Quality Control and does not relieve the supplier of its responsibility for the correction of errors and faulty workmanship, of for the replacement of nonconforming materials.

The Department may reject work not performed in accordance with the supplier's approved QCP in accordance with 1512, "Unacceptable and Unauthorized Work."

The Department will not charge the Contractor for plant inspections by Department personnel.

Provide the Department Inspectors with suitable hard hats, face and hand shields, safety glasses, respirators, and other safety equipment necessary to ensure the Inspector's safety while performing structural metals inspections.

Notify the Engineer at least 5 business days before the fabricator begins work to allow the Engineer to perform inspections. Do not allow the fabricator to perform work or manufacture material until after notifying the Engineer. The Engineer may reject work performed without notice in accordance with 1512, "Unacceptable and Unauthorized Work," or may subject the work performed to additional NDT, at no additional cost to the Department.

The Department may reject material or work not meeting the requirements of the contract. The Contractor, in conjunction with the fabricator, may appeal to the Engineer. The Engineer will make final decisions on disputes.

The Engineer may reject material shipped to the project site without a Department inspection tag as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

N.2 Facilities for Inspection

Ensure the fabricator provides an office, access to a computer and a copy machine, and any needed tools and assistance to the Inspector for at least 30 business days before work is scheduled to start to 30 business days after the shipment of material.

Ensure the fabricator provides an inspector's office meeting the following requirements and characteristics:

(1) Floor space of at least 100 sq. ft [9.3 sq. m],
(2) Containing at least two desks, or a desk and table, two chairs, a file case, and other necessary furniture.
(3) Clean, modern, and having adequate lighting, heating, and ventilation,
(4) Located in a completely partitioned area and provided with a separate locking door,
(5) Contains telephone service and a separate dedicated computer data line.

The relevant contract unit price for steel bridge construction includes the cost of providing, maintaining, and repairing, or replacing inspection facilities as included in the cost of steel bridge construction.

O Marking and Shipping

Ensure the fabricator performs the following:

(1) Before shipping, legibly mark material according to the field erection plan, and as approved by the Engineer.
(2) Place markings on the "inside" of fascia beams on a bridge.
(3) Mark duplicate pieces unless otherwise approved by the Engineer.
(4) Bolt connection plates for members in position for shipment.

(5) Ship pins, bolts, nuts, and washers in weatherproof containers no greater than 500 lb [230 kg]. Ship pins with nuts in place.
(6) Package bolts of the same length and diameter, nuts, and washers meeting the requirements of ASTM A 325, "Packaging and Package Instructions."
(7) Pad coated material to keep the material clean and undamaged during loading, transporting, unloading, handling, and storage.
(8) Ship beams and girders in an upright position, unless otherwise approved by the Engineer. Block material to prevent buckling, warping, or twisting during transportation.
(9) Block cambered members to prevent loss of camber.

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

2472.3 CONSTRUCTION REQUIREMENTS

A Bending

Bend bars to the shapes as shown on the plans. The Contractor may bend the bars cold. If hot bending a non-coated bar, do not heat bars to temperatures greater than 1,200 °F [650 °C] and do not quench the bars.

Bar bending details shall conform to the American Concrete Institute 315, "Details & Detailing of Concrete Reinforcement," unless otherwise shown or noted in the plans. Ensure that the bar bend diameters are as shown "Recommended" in the American Concrete Institute 315.

Repair bond loss or coating damage after bending epoxy coated reinforcement bars in accordance with 3301, “Reinforcement Bars.” Clean damaged areas to remove loose or deleterious material before patching. Remove rust by blast cleaning. The Engineer, in conjunction with the Materials Engineer, will not require the repair of hairline cracks with no bond loss or other damage. Perform repairs before oxidation appears.

B Storage and Protection

Do not store metal reinforcement in a manner that will cause, induce, or accelerate corrosion or contamination of the metal. Locate timbers (dunnage) on the ground to support the bundles and keep them free of contamination. Store materials at the project site to allow the Engineer to visually inspect and check the various types of reinforcement for conformance to the dimensions as shown on the plans. Store bars of the same type together. Identify reinforcement bars with tags bearing the identification symbols as shown on the plans.

Protect coated reinforcement bars before handling or shipping to prevent damage to the coating. Pad bundling bands and lift bundles using an OSHA-approved spreader bar, multiple supports, or platform bridge to prevent bar-to-bar abrasion from sags in the bar bundle. Do not drag or drop bars or bundles. Support bars or bundles in transit to prevent damage to the coating.

If the epoxy-coated reinforcing steel is incorporated into the Project and is exposed to the weather or stored exposed to the weather for more than 60 calendar days, cover the steel to protect the material from sunlight, salt-spray and weather exposure. Provide for air circulation around the covered steel to minimize condensation under the protective covering.

C Placing, Supporting, and Tying Bar Reinforcement

C.1 General Requirements

Before placing concrete in a unit, ensure the reinforcement bars meet the condition defined in the current CRSI manual titled *Placing Reinforcing Bars*, Chapter VII, “Unloading, Storing, and Handling Bars on the Job.” Place the bars as specified in “Tolerances in Placement” section in Chapter X, “General Principles for Bar Placing, Splicing and Tying Reinforcing Bars.”

Firmly support and securely tie reinforcement bars in their proper position. Tie all outermost intersections, and enough of the intermediate intersections, to ensure that no shifting or displacement of the bars will occur during subsequent operations. Bar supports are intended to support the steel reinforcement and normal construction loads; and are not intended to, and should not be used to, support runways for concrete buggies or similar loads. Use black, soft iron wire of at least 16 gauge [1.5 mm] for

tying the reinforcement bars. Do not use welded ties. Do not place concrete before the Engineer inspects and approves the placement, support system, and ties for the reinforcement bars.

Provide supports with the following characteristics for reinforcement bars bearing on the falsework sheathing for exposed concrete surfaces:

(1) Stainless steel;
(2) Hot-dip galvanized, epoxy, vinyl, or plastic coated tips extending at least ½ in [12.5 mm] above the sheathing; or
(3) Plastic.

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

C.2 Special Requirements for Bridge Slabs

Support and tie reinforcement bars for bridge slabs in accordance with the General Requirements and the maximum spacing requirements specified in Table 2472-1. These spacing requirements define only the maximum permissible distances between ties or lines of support. Table 2472-1 does not relieve the Contractor of responsibility for providing additional supports or ties for holding and supporting bars firmly in their correct position.

For bridge slabs, use slab bolsters as the primary support for the bottom transverse reinforcement bars meeting the requirements of "Bar Support Specifications and Standard Nomenclature" in the *CRSI Manual of Standard Practice*. Place the bolsters on the falsework sheathing in continuous lines, parallel to the beams, girders, or centerline of the roadway at locations that will permit placement of supports for the top transverse reinforcement bars directly over the bolsters on the bottom transverse bars.

Use continuous lines of upper continuous high chairs with wire runners as the support system for the top transverse reinforcement bars. Place the high chairs to transfer load to the bottom bolsters without causing deflection in the bottom transverse bars. Use individual type high chairs only as supplemental support or for sections where the use of continuous type high chairs is not practical and the Engineer approves, in writing, the use of the individual type high chairs.

For all interior bays on beam span bridges, place slab bolsters and upper continuous high chairs within 6 in [150 mm] of the edge of beam flanges.

Use tie wires to tie down the top mat of bridge slab reinforcing to the in-place beam stirrups or shear connectors at spacing no greater than 5 ft [1,500 mm], as measured longitudinally along each beam.

If the support system specified in this section is not practical, the Contractor may propose an alternative support system for slab span bridges or other special designs. Provide working drawings showing the proposed support system to the Engineer. If approved by the Engineer in writing, the Contractor may use the proposed support system.

Table 2472-1
Maximum Spacing of Supports and Ties for Bridge Slabs

Bar Size Number	Maximum Spacing for Slab Bolsters and Continuous Type High Chairs, *ft [mm]*
10 and 13	3.00 [900]
16, 19, and 22	4.00 [1,200]

Support the bottom layer of longitudinal reinforcement bars for slab span bridges, cast-in-place concrete girders, beams, struts, and similar sections on beam bolsters or heavy beam bolsters commensurate with the mass to be supported. Do not use precast concrete block or brick supports on formed surfaces.

Use the upper beam bolsters or the upper heavy beam bolsters to support subsequent layers of longitudinal bottom reinforcement, except for bars that can be tied to vertical bars, unless otherwise approved by the Engineer.

After the completion of the placement and tying of the reinforcement bars for a section of bridge slab, and before ordering concrete delivery for that section, set the strike-off rails or guides to the correct elevation. Notify the Engineer when the section is ready for a final check. Operate the strike-off device over the entire section in the presence of the Engineer. Attach a filler strip, ¼ in [6 mm] less in thickness than the minimum concrete cover requirement, to the bottom of the strike-off during this check to detect areas where the top reinforcement may encroach on the required clearance. Do not place concrete for a bridge slab before the Engineer inspects and approves the deck grades.

Tie the top mat of epoxy-coated reinforcement bars at every transverse bar intersection along each continuous row of longitudinal bars. Tie the bottom mat of reinforcement bars and non-continuous rows of top mat bars at least at every second transverse bar intersection. Stagger the ties for the bottom mat along adjacent rows of longitudinal bars. Use plastic or nylon-coated tie wires.

Use plastic bar supports or epoxy-coated wire bar supports with coating resistant to abrasion. Provide epoxy coating for bar supports at least 0.005 in [127 µm] thick and in accordance with 3301, “Reinforcement Bars.” Provide plastic coated tips or additional epoxy coating on the legs of the supports for wire bar supports that bear on falsework sheathing for exposed concrete surfaces. Ensure the additional material extends at least ½ in [13 mm] above the sheathing, not including portions of the

supports other than the legs. Use a grey-colored coating with a total coating thickness on the ½ in [13 mm] portion, including the initial 0.005 in [127 µm] of epoxy coating, of at least $^{3}/_{32}$ in [2.5 mm]. Use incompressible and abrasion resistant plastic or epoxy material.

C.3 Special Requirements for Coated Bars

The Engineer will not require the Contractor to repair damage caused during shipment of coated bars or by the installation procedures if the damaged area is no greater than ¼ in × ¼ in [6 mm × 6 mm] and the sum of damaged areas in each 1 ft [300 mm] length of bar is no greater than 2 percent of the bar surface area. Repair damage greater than ¼ in × ¼ in [6 mm × 6 mm] as recommended by the manufacturer. The Engineer will reject bars with total damage greater than 2 percent of bar surface area. Remove rejected bars. Ensure the total bar surface area covered by patching material is no greater than 5 percent.

Do not flame cut coated reinforcing bar in any application.

If using an abrasive blade to cut epoxy-coated reinforcing bar and the cut ends are properly coated with a two-part epoxy patching material as recommended by the manufacturer of the epoxy coating, the Department will allow cutting of epoxy-coated bars.

Use a non-metallic vibrator head to consolidate the concrete around coated reinforcement bars and other components.

D Splicing Metal Reinforcement

Provide reinforcement in the lengths shown on the plans. Do not place splices unless otherwise shown on the plans or approved in writing by the Engineer. Place field splices at locations and with details as approved by the Engineer.

D.1 Lap Splices

Provide lap splices as shown on the plans. If not shown on the plans, provide bar reinforcement lap lengths equal to at least 36 diameters for No. 22 bar and smaller and at least 40 diameters for No. 25 bar through No. 36 bar. Lap bar reinforcement for No. 43 bar through No. 57 bar as approved by the Engineer in writing.

Lap wire mesh reinforcement at least the width of one full mesh plus 2 in [50 mm] for transverse laps or one full mesh plus 2 in [50 mm] plus two end overhangs for longitudinal laps.

D.2 Couplers for Reinforcement Bars

Provide reinforcement bar couplers at construction joints in the locations as shown on the plans and with the following characteristics:

(1) Epoxy-coated in accordance with 3301, "Reinforcement Bars,"
(2) Developing at least 125 percent of the yield strength of the reinforcement bar, and
(3) Having a fatigue design limit of at least 12 ksi [83 mPa] when tested in accordance NCHRP Project 10-35.

Submit written coupler details, yield strength and fatigue test results, and the name of the manufacturer to the Engineer for written approval before installation. If assembling threaded couplers, insert the bar into the coupler to the full depth of the thread and torque the assembly as recommended by the manufacturer.

E Spiral Reinforcement

The Contractor may provide rigid or collapsible cages of spiral reinforcement for circular columns. Finish the ends of each column spiral with one and one-half turns of the reinforcement.

The Contractor may make the spiral cages rigid by tying the vertical column bars to the spiral wires at their intersections or by using epoxy-coated metal spacer strips. Provide enough tied intersections or use enough spacer strips to ensure a rigid noncollapsible cage with properly spaced loops when the cage is in its final position. Do not tack weld the reinforcement.

Provide full-length spiral reinforcement cages. If approved by the Engineer, provide spiral reinforcement cages in two pieces with added stock to provide for lapping the two adjoining ends at least one and one-half turns.

2472.4 METHOD OF MEASUREMENT

A Reinforcement Bars

The Engineer will measure *Reinforcement Bars*, including reinforcement in bar mats, by the weight incorporated into the structure in accordance with Table 2472-2. The Engineer will only include quantities for splices shown on the plans.

Table 2472-2
Reinforcement Bars
Theoretical Weights
Nominal Dimensions

Bar Size, Designation Number*	Diameter, *in [mm]*	Weight, *lb/ft [kg/m]*
10	0.375 [9.5]	0.376 [0.560]
13	0.500 [12.7]	0.668 [0.994]
16	0.625 [15.9]	1.043 [1.552]
19	0.750 [19.1]	1.502 [2.235]

Table 2472-2 Reinforcement Bars Theoretical Weights Nominal Dimensions		
Bar Size, Designation Number*	**Diameter, *in [mm]***	**Weight, *lb/ft [kg/m]***
22	0.875 [22.2]	2.044 [3.042]
25	1.000 [25.4]	2.670 [3.973]
29	1.128 [28.7]	3.400 [5.060]
32	1.270 [32.3]	4.303 [6.404]
36	1.410 [35.8]	5.313 [7.907]
43	1.693 [43.0]	7.650 [11.380]
57	2.257 [57.3]	13.600 [20.240]
* Bar designation numbers approximate the nominal diameter of the bar in millimeters		

B Steel Fabric

The Engineer will measure *Steel Fabric* by the weight incorporated into the structure, based on the quantity shown on the plans. The Engineer will only include quantities for splices shown on the plans.

C Spiral Reinforcement

The Engineer will measure *Spiral Reinforcement* by the weight incorporated into the structure, based on the weight shown in the table in chapter 250 of the Bridge Construction Manual. The Engineer will only include quantities for splices shown on the plans.

D Couplers

The Engineer will measure *Reinforcement Bar Couplers* by the number of couplers installed as required by the contract and as directed by the Engineer.

2472.5 BASIS OF PAYMENT

The Department will pay for metal reinforcement at the contract unit prices for the contract items listed in the detailed specifications for the type of structure where the metal reinforcement is used. For structure type, with no detailed specifications, the Department will pay for metal reinforcement on the basis of the following schedule. The contract unit price for the relevant metal reinforcement contract item includes the cost of providing, fabricating, delivering, placing the metal reinforcement as specified in this section (2471), bar supports, bar chairs, spacers, and tie wire.

The contract unit price for *Spiral Reinforcement* includes the cost of metal spacer strips, bar supports, and tie wires.

Item No.:	Item:	Unit:
2472.501	Reinforcement Bars	pound [kilogram]
2472.511	Steel Fabric	pound [kilogram]
2472.521	Spiral Reinforcement	pound [kilogram]
2472.525	Couplers (Reinforcement Bars) T-___	each

2478 ORGANIC ZINC-RICH PAINT SYSTEM

2478.1 DESCRIPTION

This work consists of the following for shop or field full-system applications of organic zinc-rich paint systems for new construction and recoating of existing structures:

(1) Surface preparations;
(2) Providing and applying the coating;
(3) Protecting and curing the coating;
(4) Protecting pedestrians, vehicular traffic, and property against damage; and
(5) All work incidental to these operations.

A) Definitions

Whenever the following terms are used in this section (2478), the terms shall have the following meaning:

(1) Engineer: Shall be defined as in 1103, "Definitions," except for shop applied paint coats, where Engineer shall mean the Bridge Engineer.
(2) Contractor: Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and applies the coatings.
(3) Shop (in shop coating): The indoor facility where structural metals are prepared and coated.
(4) Field Coating: The outdoor on-site coating of new or previously coated steel structures before or after erection.
(5) Quality Assurance (QA): The process and person(s) responsible for verification of the conformance of materials and methods of application to the governing specification, in order to achieve a desired result.
(6) Quality Control (QC): The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality.

(7) Quality Assurance Inspector (QAI): The Department's representative responsible for duties specified in the Quality Assurance Plan, with the authority to accept work that meets Contract requirements.
(8) Contact surfaces: Those surfaces in the completed structure that touch other surfaces.
(9) Corner: The intersection of two surfaces.
(10) Edge: An exposed, through-thickness surface of a plate or rolled shape. This may be the as-rolled side face of a beam flange, channel flange or angle leg, or may result from thermal cutting, sawing, or shearing. Edges may be planar or rounded, and either perpendicular or skewed to adjacent faces.
(11) Non-contact surfaces: Surfaces that are not in direct contact with other surfaces.
(12) Prime Coat: Application of a zinc-rich coating to a bare metal substrate.
(13) Coating thickness: The Dry-Film Paint Thickness (DFT) above the peaks of the blast profile.
(14) Mist Coat (Fog Coat or Tack Coat): (a) thin, mist-spray application of a coating to improve adhesion and uniformity of the subsequent full application of the same coating. (b) A light coat of unspecified DFT used to prevent rust staining of steel substrates or temporarily inhibit corrosion.
(15) Stripe Coat: A coating, of sufficient thickness to completely hide the surface being coated, on all edges, corners, seams, crevices, interior angles, junctions of joining members, bolt heads, nuts and threads, weld lines, and similar surface irregularities. This coating shall be followed, as soon as practicable, by the application of the full prime, intermediate, or finish coat to its specified thickness.
(16) Qualified: Holding appropriate documentation and officially on record as competent and experienced to perform a specified function or practice of a specific skill.
(17) Coating System: The surface preparation and application of specific coating classifications (i.e., Inorganic Zinc, Polyurethane, Acrylic, Polyurea, Latex, etc.) of coating products to provide a film forming a unified whole for the purpose of corrosion protection and/or aesthetics.
(18) Paint System: A set of interacting film forming paint materials and products from a single manufacturer which combine to make up a complete coating system.

2478.2 MATERIALS

A Zinc-Rich Paint Systems 3520

Provide paint systems listed on the Approved/Qualified Products List for bridge structural steel coating, three coat systems (organic).

Deliver the paint to the site in the original containers no greater than 5 gal [20 L]. Do not alter the contents unless approved by the Engineer in writing. Package multi-component coatings in separate containers or kits.

Provide the Engineer and each paint shipment with the following:

(1) The manufacturer's material safety data sheets (MSDS),
(2) Material certifications, and
(3) Written instructions for mixing, handling, and application of the coatings.

Ensure a manufacturer's technical representative with knowledge of this paint system is available to assist during coating application.

2478.3 CONSTRUCTION REQUIREMENTS

A Contractor Qualifications and Documentation

At least 30 calendar days before starting work submit a Quality Control Plan (QCP) meeting the requirements of AASHTO/NSBA S8.1-*Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges* to the Engineer for approval or be pre-qualified on MnDOT's approved supplier list as maintained by the Engineer at www.dot.state.mn.us/bridge/.

At least 30 calendar days before starting work submit to Quality Assurance Inspector (QAI) or the Engineer documentation showing that the paint manufacturer's technical representative trained the painters, applicators, and Quality Control (QC) personnel to apply the coating system on the bridge project. Make training materials available to the Engineer upon request.

The Engineer will audit suppliers with approved QCPs once or twice a year or as otherwise determined by the Engineer to verify if the supplier is implementing its QCP. The Department will invoke its Corrective Action Process if the audit indicates non-conformance up to and including requiring the supplier hire a third party Quality Control as a disciplinary step, at no cost to the Department. The Contractor may obtain a copy of the Corrective Action Process from the Engineer.

B General

For new construction, preserve or transfer erection markings to ensure legibility when erecting members. Provide removable markings or place markings at locations not visible in the completed structure. Use marking material that will not damage the paint system.

If painting a structure erected under a previous contract, the Department will not require disassembly of portions of the structure or removal of appurtenances to expose

contact surfaces or otherwise inaccessible metal surfaces unless otherwise shown on the plans or special provisions.

For new construction projects, paint contact surfaces with the zinc primer at the recommended DFT, except for surfaces completely sealed by:

(1) Welding,
(2) Bolt heads,
(3) Nuts and washers, and
(4) Embedment in concrete (ex. shear devices and anchorages).

Coat the top surfaces of beams and girders with a mist coat of primer.

Protect the environment and property as required by national, state and Mn/DOT regulations.

Provide a system for inspection that will allow the inspector to safely access the steel components. For safety systems that require temporary fastening to the steel to support the system, use fastening hardware that will not damage the paint. Repair damages as approved by the Engineer at no additional cost to the Department.

C Inspection

The Department will appoint a Quality Assurance Inspector (QAI) as a Department representative in accordance with the Quality Assurance Plan to accept work meeting the contract requirements.

Perform QC inspections of the shop and field painting in accordance with the approved QCP.

C.1 Quality Control Program (QCP) Requirements

Identify the minimum requirements and frequencies in the QCP and submit the QCP to the Engineer for approval:

Table 2478-1
Coating Inspection Requirements

Requirement	Frequency/Extent
General	
Ambient temperature	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Dew point and humidity	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Surface temperature	Every 4 (field) h; Every 8 (shop) h or at the start of each shift
Date and time	Each lot of work

Table 2478-1 Coating Inspection Requirements	
Requirement	**Frequency/Extent**
Piece mark and bundle	Each lot of work
DFT	SSPC PA 2 or the Product Data Sheet
Visual inspection	100 percent
Prime Coat	
Primer coat batch number	Every paint kit
Verification of surface cleanliness	Examine visually within 1 h before prime painting
Temperature of mixed primer	Just before application
Proper mixing and straining	Every pot mix
Primer induction time	Every pot mix
Primer pot life	Every pot mix
Primer cure time	As recommended by the manufacturer
Proper use of stripe coats	All applicable areas, as specified in 2478.3.F, “Paint Coats.”
Primer coat evaluation and repair	Visual, 100 percent of each element
Prime recoat time	As recommended by the manufacturer
Intermediate Coat	
Intermediate coat batch number	Every paint kit
Verification of surface cleanliness	Examine visually within 1 h before applying the intermediate coat
Temperature of mixed intermediate coating	Just before application
Proper mixing and straining	Every pot mix
Intermediate induction time	Every pot mix
Intermediate pot life	Every pot mix
Intermediate cure time	As recommended by the manufacturer
Proper use of stripe coats	All applicable areas. as specified in 2478.3.F, “Paint Coats.”
Intermediate coat evaluation and repair	As recommended by the manufacturer
Finish Coat	
Finish coat component batch number	Every paint kit
Verification of intermediate coat surface cleanliness	Initial and every 4 h of painting
Temperature of mixed finish coating	Just before application
Finish coat mixing, straining, or both	Every pot mix
Finish coat pot life time	Every pot mix
Finish coat induction time	Every pot mix

Table 2478-1 Coating Inspection Requirements	
Requirement	**Frequency/Extent**
Finish coat cure time	As recommended by the manufacturer
Proper use of stripe coats	All applicable areas, as specified in 2478.3.F, “Paint Coats.”
Adhesion	As required by the Engineer
Coating system final evaluation and repair	Visual, 100 percent of each element

Provide written documentation of the measurements to the QAI or to the Engineer during the work and in its entirety at the completion of the job. The QAI or the Engineer may reject the coating system or reduce payment if the Contractor did not adhere to the approved QCP or provided inadequate documentation of adherence to the QCP. Conduct subsequent testing with the Engineer’s approval, at no additional cost to the Department, to determine QCP compliance.

D Surface Preparation

The QAI or Engineer will inspect the surface preparation as it is done, after its completion, or review the QCP documentation, or any combination of the three. Notify the Engineer at least 5 working days before beginning surface preparation, coating activities, or both.

D.1 Cleaning

D.1.a Solvent Cleaning

Clean areas containing organic and synthetic and other visible contaminants with solvent meeting the requirements of SSPC-SP 1, “Solvent Cleaning.” Protect the adjacent environment and property while solvent cleaning.

D.1.b Abrasive Blasting

Abrasive blast clean surfaces to achieve a SSPC-SP 10/NACE No. 2, “Near-White Blast Cleaning” before applying prime coat. Use job site visual standards and SSPC-VIS 1, “Guide and Reference Photographs for Steel Surfaces Prepared by Abrasive Blast Cleaning.” Perform blast cleaning operations meeting the requirements of Minnesota MPCA Rule 7025.0230 through 7025.0380.

Abrasive blast clean to achieve a profile range from 2.0 mils to 3.5 mils [50 µm to 89 µm]. Re-blast clean surfaces when the surface profile is less than 2.0 mils [50 µm]. Provide a Nonconformance Report (NCR), as specified in the QCP, to the Engineer if the profile exceeds 3.5 mil [89 µm]. Provide written documentation proving that the specified profile has been achieved.

D.1.c Post Blasting

After blast cleaning, remove blasting debris from steel surfaces using procedures that leave the surfaces free of moisture and contaminants. Use ASTM D 4285 "Standard Test Method for Indicating Oil or Water in Compressed Air" to ensure the compressed air is oil and water free. Provide structural steel members free of surface defects, such as small seams, blisters, weld spatter, fins, laps, and tears. Perform grinding up to 1/32 inch or 5% of the material thickness, whichever is less. Perform grinding parallel to the direction of the stresses. Remove surface defects and repair gouges before applying prime coat.

E Application of Paint

E.1 General

Provide prime, intermediate, and finish coats of paint in accordance with 2478.2.A, "Zinc-Rich Paint Systems."

Do not start painting until the Engineer approves the surface preparation and paint. Before applying paint, clean the surface of flash rust, dust, dirt, grease, oil, moisture, overspray, and other deleterious contaminants that will prevent the paint from adhering. Apply paint to produce a smooth and uniform film free of runs, drips, sags, pinholes, blisters, mudcracking, and other deleterious conditions.

Do not apply paint to metal surfaces when weather conditions that the manufacturer's literature defines as unsatisfactory are present, and when:

(1) The air temperature falls below 40° F [4° C],
(2) Metal surface temperatures are less than 5° F [3° C] above the dew point,
(3) Water mist is in the air, and
(4) Damp or frosted metal surfaces.

Do not apply paint if other work operations, wind, or traffic causes the air to carry dust, dirt, or sand onto the prepared or newly painted metal surfaces. Do not apply spray painted paint without protective shields that prevent scattering wet paint particles in areas where rebounding or blowing paint particles could cause harm to persons, adjacent environment, or property. The QAI or Engineer will suspend spray painting operations if the Contractor does not properly control paint application.

Mix paint before removing from shipping containers. Do not thin paint unless allowed in the manufacturer's written instructions and approved by the Engineer in writing. After mixing, strain the primer through a 30 – 60 mesh screen or a double layer of cheesecloth. Do not allow un-dispersed clumps of zinc to remain in the paint after mixing.

Before applying a subsequent coat of paint, perform the following:

(1) Cure the previous coat to the "recoat" time as defined in the manufacturer's Product Data Sheet, and
(2) Screen or scrape smooth and repaint wrinkled, detached, distorted, scuffed, abraded areas.

Remove dust or chalk-like deposits. Condition or replace defective previously applied paint coats as required by the Engineer and at no additional cost to the Department. Apply the subsequent paint coat within the maximum time interval recommended by the manufacturer. If the maximum time interval is exceeded, blast the areas to SSPC-SP 10/NACE NO. 2, "Near-White Blast Cleaning" and recoat at no additional cost to the Department.

Do not paint within 2 in [50 mm] of the zones requiring field welding as shown on the plans. Prepare and paint the heat affected areas after field welding, in accordance with this section.

When the contract specifies shop painting and the Contractor does not provide the specified coating(s) in the shop, apply the paint coat(s) for the unpainted portion at the project site.

Submit paint repair procedures to the 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.

Equip the air lines with approved water and oil traps. Use ASTM D 4285 "Standard Test Method for Indicating Oil or Water in Compressed Air" to ensure the compressed air is oil and water free.

E.3 Brushes and Daubers

The Contractor may apply paint by brushing in areas unsuitable for spray painting, such as surfaces requiring stripe coats, small surface areas where over-spray would be excessive, and small areas requiring paint repair.

If using brushes, manipulate the paint under the brush to provide a smooth, uniform coating over the entire surface, including corners and crevices. Perform final brush strokes horizontal and parallel to each other. Remove brush hairs on the paint surface.

The Contractor may use sheepskin or other approved daubers to paint surfaces inaccessible by spray or brush.

Equip the paint pot with an approved agitator during application of paint by brushing or daubers.

F Paint Coats

F.1 Measurement of Paint Thickness

The Department refers to “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. Invoke SSPC – PA2 appendix 3 for measuring dry film thickness of girders and beams.

Perform painting operations as recommended by the manufacturer’s literature, unless otherwise specified in this section. If the manufacturer’s recommended Dry Film Thickness (DFT) differs from the DFT in accordance with this section, submit a request in writing to the Engineer before painting to determine the DFT deviation from the manufacturer’s written recommendations.

Refer to 2478.3.J for deficient paint thickness.

F.2 Stripe Coats

Before applying each paint 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, intermediate, or topcoat on top of the stripe coat after the stripe coat has been allowed to set to touch and to its specified thickness, as defined in this section, after the Engineer or QAI approves the stripe coat.

Apply the stripe coats per 2478.3.J.

F.3 Prime Coat

Spray apply the coat, and primer coat after preparing the surface in accordance with this section and as approved by the Engineer and before the surface rusts. Apply primer to inaccessible areas using a brush.

Equip the paint pot with an agitator during spray painting work. Provide an agitator or stirring rod capable of reaching within 2 in [50 mm] of the bottom of the pot to keep the paint mixed during application.

Apply prime coat to a DFT average of at least 4.0 mils [100 µm] with no spot reading measuring less than 3 mils [76 µm], unless the contract requires otherwise. Do not apply final primer to a thickness greater than the manufacturer's written recommendations or to a thickness that will cause any deleterious conditions, such as sagging or mud cracking.

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.

F.4 Intermediate Coat

Apply the intermediate coat in accordance with 2478.2.A, "Zinc-Rich Paint Systems," to a DFT of at least 3.0 mil [76 µm] after the prime coat cures to the "dry-to-topcoat," as defined in the manufacturer's Product Data Sheet.

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.

F.5 Finish Coats

Fillet seal crevices and cavities along the edge of faying surfaces that are separated by 1/8 inch or more with an approved sealant that is compatible with and recommended by the coating manufacturer. Do not seal the bottom edge of faying surfaces allowing the juncture to release trapped moisture. Do not apply finish coat over the sealant until it is fully cured as recommended by the manufacturer's data page.

Apply a final coat of paint on surfaces exposed to view uniform in color and free of visible lap marks and other blemishes to a DFT of at least 2.0 mils [50 µm]. Do not apply finish coat to a thickness greater than the manufacturer's written recommendations. Ensure the finish coat color matches the color standard required by the contract.

F.6 Total Paint Thickness

Ensure the total paint thickness of the entire paint system averages at least 10 mil [250 µm]. If the Engineer finds total paint thickness deficient over any part of a structure and if the Engineer does not require additional paint applications, the Department will reduce payment for the appropriate item of work.

G Markings for Identification

Stencil the year of painting and the specification numbers of the prime, intermediate, and top coats in numerals 3 in [75 mm] high on the interior surface of

fascia beams, at the same corner displaying the bridge name plate and at the corner diagonally opposite that corner.

G.1 Stenciling after Primer

Ensure the fabricator/painter stencils the name of the paint manufacturer and the primer product name applied in the shop on the inside web of both fascia girders in characters 3 in [75 mm] high and in a contrasting color compatible with the specified paint system.

H Fasteners

H.1 Requirements for Coating

Remove all organic or other material that would interfere with the adhesion of the coating. The Contractor may use industrial cleaning solutions to remove fastener lubricants if the solutions do not contaminate or interfere with adherence of subsequently applied coating materials as approved by the Engineer.

H.2 Paint Thickness Requirements

After installing fasteners and after removing lubricant and residuals from exposed parts of fasteners, apply additional primer to meet the required primer thickness as defined in this section. Provide the required thickness of the intermediate and finish coats to fasteners as defined in this section.

I Handling, Storage, and Shipping of Painted Steel

Do not apply finish coat to a thickness greater than the manufacturer's written recommendations.

Do not damage the painted steel in the shop and field during shipping, erection, and construction of the bridge and components. Do not move or handle the painted steel items until the coating cures in accordance with the manufacturer's data sheet. Use nylon straps, padded hooks, slings, or other non-metallic lifting devices to protect coated components or products during handling and loading. Use softeners and edge protection devices to protect the steel from binding chains. Provide padded hooks and slings to hoist the steel.

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 Engineer.

Support individual items or bundles of coated products in transit in a manner that will prevent damage to the coating. Do not drop or drag individual items or bundles of coated products. Pad when shipping, bundling, or banding materials to protect the components from direct contact with packaging materials that may damage the coated products finish. Use softeners and edge protection devices in conjunction with high-density foam or other acceptable packaging materials at all points of contact.

J Paint Repair

The Contractor may use a "Tooke Gauge" to perform a destructive test to measure the DFT if it is not possible to satisfactorily determine the coating thickness of any paint coat after application. Repair the destructively tested area as approved by the Engineer and at no additional cost to the Department. Do not perform mechanical grinding to reduce paint thickness. Completely remove and recoat the paint system for deficient paint thickness, as defined in this section, for prime, intermediate, or topcoat as directed by the Engineer.

Submit paint repair procedures to the Engineer in writing for approval.

2478.4 METHOD OF MEASUREMENT

The Engineer will make area calculations. The Engineer will not make allowance in area calculations for actual areas of rivets and bolt heads, curved surfaces of welds, radii, or corners.

A Shop Painting

The Engineer will measure shop painting required by the contract based on the area of acceptable paint coverage on non-contact areas, as computed from the dimensions shown on the plans. The Engineer will not include contact areas in the measurement for payment.

B Field Painting for New Construction

The Engineer will measure field painting in the bolted field splice areas of newly constructed shop painted steel based on the field splice area of acceptable paint coverage as shown on the plans. The Department will consider the cost of paint repairs to correct damage from field storage or erection with the relevant contract unit prices for structural steel.

C Field Painting of an Existing Bridge

The Engineer will measure field painting of structural steel on the basis of the area of acceptable paint coverage, as computed from the dimensions as shown on the plans for the structure.

2478.5 BASIS OF PAYMENT

A Shop Painting

The contract square foot [square meter] for *Organic Zinc-Rich Paint (Shop)* includes the costs providing and applying an acceptable shop applied paint system, including all necessary repairs to the paint coating that occur before unloading at the project storage site.

B Field Painting of Shop Painted Components

The contract square foot [square meter] price for *Organic Zinc-Rich Paint System (Field)* includes the costs of preparing and applying field applied paint systems to shop primed bolted splice areas.

C Painting of Existing (Old) Components or Structures

The contract square foot [square meter] price for *Organic Zinc-Rich Paint System (Old)* includes the costs of surface preparation, providing, and applying coating system to existing structural steel.

D Payment

The Department will pay for organic zinc-rich paint system on the basis of the following schedule:

Item No.:	Item:	Unit:
2478.502	Organic Zinc-Rich Paint System (Shop)	square foot [square meter]
2478.503	Organic Zinc-Rich Paint System (Field)	square foot [square meter]
2478.506	Organic Zinc-Rich Paint System (Old)	square foot [square meter]

2479 INORGANIC ZINC-RICH PAINT SYSTEM

2479.1 DESCRIPTION

This work consists of the following for new work where the application of inorganic zinc-rich primer is done in the shop and where field applied intermediate and top coating is desired:

(1) Surface preparations,

(2) Providing and applying the coating,
(3) Protecting and curing the coating,
(4) Protecting pedestrians, vehicular traffic, and property against damage, and
(5) All work incidental to these operations.

A Definitions

Whenever the following terms are used in this section (2479), the terms shall have the following meaning:

(1) Engineer: As defined in 1103, "Definitions," except for shop applied paint coats, where Engineer shall mean the Bridge Engineer.
(2) Contractor: Shall mean the fabricator, paint contractor, applicator, or other entity that prepares the surfaces and applies the coatings.
(3) Shop (in shop coating): The indoor facility where structural metals are prepared and coated.
(4) Field Coating: The outdoor on-site coating of new or previously coated steel structures before or after erection.
(5) Quality Assurance (QA): The process and person(s) responsible for verification of the conformance of materials and methods of application to the governing specification, in order to achieve a desired result.
(6) Quality Control (QC): The process and person(s) responsible for administrative and production procedures employed to attain the desired product outcome and quality.
(7) Quality Assurance Inspector (QAI): The Department's representative responsible for duties specified in the Quality Assurance Plan, with the authority to accept work that meets the contract requirements.
(8) Contact surfaces: Those surfaces in the completed structure that touch other surfaces.
(9) Corner: The intersection of two surfaces.
(10) Edge: An exposed, through-thickness surface of a plate or rolled shape. This may be the as-rolled side face of a beam flange, channel flange or angle leg, or may result from thermal cutting, sawing, or shearing. Edges may be planar or rounded, and either perpendicular or skewed to adjacent faces.
(11) Non-contact surfaces: Surfaces that are not in direct contact with other surfaces.
(12) Prime Coat: Application of a zinc-rich coating to a bare metal substrate.
(13) Coating thickness: The Dry Film Paint Thickness (DFT) above the peaks of the blast profile.
(14) Mist Coat (Fog Coat or Tack Coat): (a) thin, mist-spray application of a coating to improve adhesion and uniformity of the subsequent full application of the same coating. (b) A light coat of unspecified DFT used to prevent rust staining of steel substrates or temporarily inhibit corrosion.

(15) Stripe Coat: A coating, of sufficient thickness to completely hide the surface being coated, on all edges, corners, seams, crevices, interior angles, junctions of joining members, bolt heads, nuts and threads, weld lines, and similar surface irregularities. This coating shall be followed, as soon as practicable, by the application of the full prime, intermediate, or finish coat to its specified thickness.
(16) Qualified: Holding appropriate documentation and officially on record as competent and experienced to perform a specified function or practice of a specific skill.
(17) Coating System: The surface preparation and application of specific coating classifications (i.e., Inorganic Zinc, Polyurethane, Acrylic, Polyurea, Latex, etc.) of coating products to provide a film forming a unified whole for the purpose of corrosion protection and/or aesthetics.
(18) Paint System: A set of interacting film forming paint materials and products from a single manufacturer which combine to make up a complete coating system.

2479.2 MATERIALS

A Zinc-Rich Paint Systems 3520

Provide paint systems listed on the Approved/Qualified Products List for bridge structural steel coating, three coat systems (inorganic).

Deliver the paint to the site in its original containers no greater than 5 gal [20 L]. Do not alter the contents unless approved by the Engineer in writing. Package multi-component coatings in separate containers or kits.

Provide the Engineer and each paint shipment with the following:

(1) The manufacturer's Material Safety Data Sheets (MSDS);
(2) Material certifications; and
(3) Written instructions for mixing, handling, and application of the coatings.

Ensure a manufacturer's technical representative with knowledge of this paint system is available to assist during coating application.

2479.3 CONSTRUCTION REQUIREMENTS

A Contractor Qualifications and Documentation

At least 30 calendar days before starting work submit a Quality Control Plan (QCP) meeting the requirements of AASHTO/NSBA S8.1-*Guide Specification for Application of Coating Systems with Inorganic Zinc-Rich Primers to Steel Bridges* to

the Engineer for approval . or be pre-qualified on MnDOT's approved supplier list as maintained by the Engineer at www.dot.state.mn.us/bridge/.

At least 30 calendar days before starting work submit to Quality Assurance Inspector (QAI) or Engineer documentation showing that the paint manufacturer's technical representative trained the painters, applicators, and Quality Control (QC) personnel to apply the coating system on the bridge project. Make training materials available upon request by the Engineer.

The Engineer will audit suppliers with approved QCPs once or twice a year or as otherwise determined by the Engineer to verify if the supplier is implementing its QCP. The Department will invoke its Corrective Action Process if the audit indicates non-conformance up to and including requiring the supplier hire a third party Quality Control as a disciplinary step, at no cost to the Department. The Contractor may obtain a copy of the Corrective Action Process from the Engineer.

B General

For new construction, preserve or transfer erection markings to ensure legibility when erecting members. Provide removable markings or place markings at locations not visible in the completed structure. Use marking material that will not damage the paint system.

If painting a structure erected under a previous contract, the Department will not require disassembly of portions of the structure or removal of appurtenances to expose contact surfaces or otherwise inaccessible metal surfaces unless otherwise shown on the plans or special provisions.

For new construction projects, paint contact surfaces with the zinc primer at the recommended DFT, except for surfaces completely sealed by:

(1) Welding,
(2) Bolt heads,
(3) Nuts and washers, and
(4) Embedment in concrete (ex. shear devices and anchorages).

Coat the top surfaces of beams and girders with a mist coat of primer.

Protect the environment and property as required by national, state, and Mn/DOT regulations..

Provide a system for inspection that will allow the inspector to safely access all the steel components. For safety systems that require temporary fastening to the steel to support the system, use fastening hardware that will not damage the paint. Repair damages as approved by the Engineer at no additional cost to the Department.

C Inspection

The Department will appoint a Quality Assurance Inspector (QAI) as a Department representative in accordance with the Quality Assurance Plan to accept work meeting the contract requirements.

Perform QC inspections of the shop and field painting in accordance with approved QCP.

C.1 Quality Control Program (QCP) Requirements

Identify the minimum requirements and frequencies in the QCP and submit the QCP to the Engineer for approval:

Table 2479-1
Coating Inspection Requirements

Requirement	Frequency/Extent
General:	
Ambient temperature	Every 4 (field) h; 8 (shop) h or at the start of each shift
Dew point and humidity	Every 4 (field) h; 8 (shop) h or at the start of each shift
Surface temperature	Every 4 (field) h; 8 (shop) h or at the start of each shift
Date and time	Each lot of work
Piece mark and bundle	Each lot of work
DFT	SSPC PA 2 or the Product Data Sheet
Visual inspection	100 percent
Prime Coat:	
Primer coat batch number	Every paint kit
Verification of surface cleanliness	Examine visually within 1 h before prime painting
Temperature of mixed primer	Just before application
Proper mixing and straining	Every pot mix
Primer introduction time	Every pot mix
Primer pot life	Every pot mix
Primer cure time	As recommended by the manufacturer
Proper use of stripe coats	All applicable areas as specified in 2479.3.F, “Paint Coats.”
Primer coat evaluation and repair	Visual, 100 percent of each element
Primer recoat time	As recommended by the manufacturer

Table 2479-1 Coating Inspection Requirements	
Requirement	**Frequency/Extent**
Intermediate Coat:	
Intermediate coat batch number	Every paint kit
Verification of surface cleanliness	Examine visually within 1 h before applying the intermediate coat
Temperature of mixed intermediate coating	Just before application
Proper mixing and straining	Every pot mix
Intermediate induction time	Every pot mix
Intermediate pot life	Every pot mix
Intermediate cure time	As recommended by the manufacturer
Proper use of stripe coats	All applicable areas as specified in 2479.3.F, “Paint Coats.”
Intermediate coat evaluation and repair	As recommended by the manufacturer
Finish Coat	
Finish coat component batch number	Every paint kit
Verification of intermediate coat surface cleanliness	Initial and every 4 h of painting
Temperature of mixed finish coating	Just before application
Finish coat mixing, straining, or both	Every pot mix
Finish coat pot life time	Every pot mix
Finish coat induction time	Every pot mix
Finish coat cure time	As recommended by the manufacturer
Proper use of stripe coats	All applicable areas as specified in 2479.3.F, “Paint Coats.”
Adhesion	As required by the Engineer
Coating system final evaluation and repair	Visual, 100 percent of each element

Provide written documentation of the measurements to the QAI or to the Engineer during the work and in its entirety at the completion of the job. The QAI or the Engineer may reject the coating system or reduce payment if the Contractor did not adhere to the approved QCP or provided inadequate documentation of adherence to the QCP. Conduct subsequent testing with the Engineer’s approval, at no additional cost to the Department, to determine QCP compliance.

D Surface Preparation

The QAI or Engineer will inspect the surface preparation as it is done, after its completion, or review the QCP documentation, or any combination of the three.

Notify the Engineer at least 5 working days before beginning surface preparation, coating activities, or both.

D.1 Cleaning

D.1.a Solvent Cleaning

Clean areas containing organic and synthetic and other visible contaminants with solvent meeting the requirements of SSPC-SP 1, “Solvent Cleaning.” Protect the adjacent environment and property while solvent cleaning.

D.1.b Abrasive Blasting

Abrasive blast clean surfaces to achieve a SSPC-SP 10/NACE No. 2, “Near-White Blast Cleaning” before applying prime coat. Use job site visual standards and SSPC-VIS 1, “Guide and Reference Photographs for Steel Surfaces Prepared by Abrasive Blast Cleaning.” Perform blast cleaning operations meeting the requirements of Minnesota MPCA Rule 7025.0230 through 7025.0380.

Abrasive blast clean to achieve a profile range from 2.0 mils to 3.5 mils [50 µm to 89 µm]. Re-blast clean surfaces when the surface profile is less than 2.0 mils [50 µm]. Provide a Nonconformance Report (NCR), as specified in the QCP, to the Engineer if the profile exceeds 3.5 mil [89 µm]. Provide written documentation proving that the specified profile has been achieved.

D.1.c Post Blasting

After blast cleaning, remove blasting debris from steel surfaces using procedures that leave the surfaces free of moisture and contaminants. Use ASTM D 4285 “Standard Test Method for Indicating Oil or Water in Compressed Air” to ensure the compressed air is oil and water free. Provide structural steel members free of surface defects, such as small seams, blisters, weld spatter, fins, laps, and tears. Perform grinding up to 1/32 inch or 5% of the material thickness, whichever is less. Perform grinding parallel to the direction of the stresses. Remove surface defects and repair gouges before applying prime coat.

E Application of Paint

E.1 General

Provide prime, intermediate, and finish coats of paint in accordance with 2479.2.A, “Zinc-Rich Paint Systems.”

Do not start painting until the Engineer approves the surface preparation and paint. Before applying paint, clean the surface of flash rust, dust, dirt, grease, oil, moisture, overspray, and all other deleterious contaminants that will prevent the paint

from adhering. Apply paint to produce a smooth and uniform film free of runs, drips, sags, pinholes, blisters, mudcracking, and any other deleterious condition.

Do not apply paint to metal surfaces when weather conditions that the manufacturer's literature defines as unsatisfactory are present, and when:

(1) The air temperature falls below 40° F [4° C],
(2) Metal surface temperatures are less than 5° F [3° C] above the dew point,
(3) Water mist is in the air, and
(4) Damp or frosted metal surfaces.

Do not apply paint if other work operations, wind, or traffic causes the air to carry dust, dirt, or sand onto the prepared or newly painted metal surfaces. Do not apply spray painted paint without protective shields that prevent scattering wet paint particles in areas where rebounding or blowing paint particles cause harm to persons, adjacent environment, or property. The QAI or Engineer will suspend spray painting operations if the Contractor does not properly control paint application.

Mix paint before removing from shipping containers. Do not thin paint unless allowed in the manufacturer's written instructions and approved by the Engineer in writing. After mixing, strain the primer through a 30–60 mesh screen or a double layer of cheesecloth. Do not allow un-dispersed clumps of zinc to remain in the paint after mixing.

Before applying a subsequent coat of paint, perform the following:

(1) Cure the previous coat to the "recoat" time defined in the manufacturer's Product Data Sheet, and
(2) Screen or scrape smooth and repaint wrinkled, detached, distorted, scuffed, or abraded areas.

Remove dust or chalk-like deposits. Condition or replace defective previously applied paint coats as required by the Engineer and at no additional cost to the Department. Apply the subsequent paint coat within the maximum time interval recommended by the manufacturer. If the maximum time interval is exceeded blast the areas to SSPC-SP 10/NACE NO. 2, "Near-White Blast Cleaning," and recoat at no additional cost to the Department.

Do not paint within 2 in [50 mm] of the zones requiring field welding as shown on the plans. Prepare and paint the heat affected areas after field welding in accordance with this section (2479).

When the contract specifies shop painting and the Contractor does not provide the specified coating(s) in the shop, apply the paint coat(s) for unpainted portion at the project site.

Submit paint repair procedures to the 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.

Equip the air lines with approved water and oil traps. Use ASTM D 4285 "Standard Test Method for Indicating Oil or Water in Compressed Air" to ensure the compressed air is oil and water free.

E.3 Brushes and Daubers

The Contractor may apply paint by brushing in areas unsuitable for spray painting, such as surfaces requiring stripe coats, small surface areas where over-spray would be excessive, and small areas requiring paint repair.

If using brushes, manipulate the paint under the brush to provide a smooth, uniform coating over the entire surface, including corners and crevices. Perform final brush strokes horizontal and parallel to each other. Remove brush hairs on the paint surface.

The Contractor may use sheepskin or other approved daubers to paint surfaces inaccessible by spray or brush.

Equip the paint pot with an approved agitator during application of paint by brushing or daubers.

F Paint Coats

F.1 Measurement of Paint Thickness

Perform painting operations as recommended by the manufacturer's literature, unless otherwise specified in this section. If the manufacturer's recommended Dry Film Thickness (DFT) differs from the DFT in accordance with this section, submit a request in writing to the Engineer before painting to determine the DFT deviation from the manufacturer's written recommendations.

The Department refers to "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. Invoke SSPC – PA2 appendix 3 for measuring dry film thickness of girders and beams.

Refer to 2479.3.J for deficient paint thickness.

F.2 Stripe Coats

Before applying each paint 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. After the Engineer or QAI approves the stripe coat, apply the prime, intermediate, or topcoat on top of the stripe coat after the stripe coat has been allowed to set to touch and to the thickness required in 2479.3.J, "Paint Coats."

Apply the stripe coats per 2479.3.J.

F.3 Prime Coat

Spray apply the stripe coat and primer coat after preparing the surface in accordance with this section and as approved by the Engineer and before the surface rusts. Apply primer to inaccessible areas using a brush.

Equip the paint pot with an agitator during spray painting work. Provide an agitator or stirring rod capable of reaching within 2 in [50 mm] of the bottom of the pot to keep the paint mixed during application.

Apply prime coat to a DFT average of at least 4.0 mils [100 µm] with no spot reading measuring less than 3 mils [76 µm], unless otherwise required by the contract. Do not apply final primer to a thickness greater than the manufacturer's written recommendations or to a thickness that will cause any deleterious conditions (ex. sagging or mudcracking).

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.

F.4 Intermediate Coat

Apply the intermediate coat in accordance with 2479.2.A, "Zinc-Rich Paint Systems," to a DFT of at least 3.0 mils [76 µm] after the prime coat cures to the "dry-to-topcoat," as defined in the manufacturer's Product Data Sheet.

Provide epoxy intermediate coat in a color that will contrast between the inorganic zinc-rich primer and the polyurethane topcoat.

Apply the intermediate paint coat to prime coated surfaces exposed in the completed structure.

F.5 Finish Coats

Fillet seal crevices and cavities along the edge of faying surfaces that are separated by 1/8 inch or more with an approved sealant that is compatible with and

recommended by the coating manufacturer. Do not seal the bottom edge of faying surfaces allowing the juncture to release trapped moisture. Do not apply finish coat over the sealant until it is fully cured as recommended by the manufacturer's data page.

Apply a final coat of paint on surfaces exposed to view uniform in color and free of visible lap marks and other blemishes to a DFT of at least 2.0 mil [50 µm]. Do not apply finish coat to a thickness greater than the manufacturer's written recommendations. Ensure the finish coat color matches the color standard required by the contract.

F.6 Total Paint Thickness

Ensure the total paint thickness of the entire paint system averages at least 10 mils [250 µm]. If the Engineer finds total paint thickness deficient over any part of a structure and if the Engineer does not require additional paint applications, the Department will reduce payment for the appropriate item of work.

G Markings for Identification

Stencil the year of painting and the specification numbers of the prime, intermediate, and top coats in numerals 3 in [75 mm] high on the interior surface of fascia beams, at the same corner displaying the bridge name plate and at the corner diagonally opposite that corner.

G.1 Stenciling after Primer

Ensure the fabricator/painter stencils the name of the paint manufacturer and the primer product name applied in the shop on the inside web of both fascia girders in characters 3 in [75 mm] high and in a contrasting color compatible with the specified paint system.

H Fasteners

H.1 Requirements for Coating

Remove all organic or other material that would interfere with the adhesion of the coating. The Contractor may use industrial cleaning solutions to remove fastener lubricants if the solutions do not contaminate or interfere with adherence of subsequently applied coating materials as approved by the Engineer.

H.2 Paint Thickness Requirements

After installing fasteners and after removing lubricant and residuals from exposed parts of fasteners, apply additional primer to meet the required primer thickness as defined in this section. Provide the required thickness of the intermediate and finish coats to fasteners as defined in this section.

I Handling, Storage, and Shipping of Painted Steel

Do not apply paint to members loaded for shipment except to apply touch-up paint as approved by the Engineer.

Do not damage the painted steel in the shop and field during shipping, erection, and construction of the bridge and components. Do not move or handle the painted steel items until the coating cures in accordance with the manufacturer's data sheet. Use nylon straps, padded hooks, slings, or other non-metallic lifting devices to protect coated components or products during handling and loading. Use softeners and edge protection devices to protect the steel from binding chains. Provide padded hooks and slings to hoist the steel.

Store completed items in accordance with 1606, “Storage of Materials,” and the following:

(1) Tag or permanently mark items before final storage. Include individual piece marks, bridge number, project number, manufacturer number, and the applicator job number in the identification markings, and
(2) Locate the final storage area out of any traffic lanes and in an area capable of bearing the full weight of the members or items and stable enough to maintain bundles, members or items within the supporting substrate. Inspect and store bundles, members, or items in one general location before final acceptance unless otherwise approved by the Engineer.

Support individual items or bundles of coated products in transit in a manner that will prevent damage to the coating. Do not drop or drag individual items or bundles of coated products. Pad when shipping, bundling, or banding materials to protect the components from direct contact with packaging materials that may damage the coated products finish. Use softeners and edge protection devices in conjunction with high-density foam or other acceptable packaging materials at all points of contact.

J Paint Repair

The Contractor may use a “Tooke Gauge” to perform a destructive test to measure the DFT if it is not possible to satisfactorily determine the coating thickness of any paint coat after application. Repair the destructively tested area as approved by the Engineer and at no additional cost to the Department. Do not perform mechanical grinding to reduce paint thickness. Completely remove and recoat the paint system for deficient paint thickness, as defined in this section, for prime, intermediate, or topcoat as directed by the Engineer.

Submit paint repair procedures to the Engineer in writing for approval.

2479.4 METHOD OF MEASUREMENT

The Engineer will make area calculations. The Engineer will not make allowance in area calculations for actual areas of rivets and bolt heads, curved surfaces of welds, radii, or corners.

The Engineer will measure painting of the structural steel by the square foot [square meter] based on the area of acceptable paint coverage on non-contact areas as computed from the dimensions as shown on the plans. The Engineer will not include contact areas in the measurement for payment.

2479.5 BASIS OF PAYMENT

A Shop Painting

The contract square foot [square meter] price for *Inorganic Zinc-Rich Paint System (Shop)* includes the cost of providing paint product for the primer and applying the primer in accordance with this section (2478) and 2402, "Steel Bridge Construction."

B Field Painting

The contract square foot [square meter] price for *Inorganic Zinc-Rich Paint System (Field)* includes the cost of providing and applying the paint product for the intermediate and finish coats of the approved paint system. The Department will include the cost of paint repairs to correct damage from field storage or erection with the relevant contract unit price for structural steel.

C Shop and Field Painting

The contract square foot [square meter] price for *Inorganic Rich Paint Systems (Shop and Field)* includes the costs of surface preparation, providing, and applying shop and field coatings. The Department will include the cost of paint repairs to correct damage from field storage or erection in the relevant contract unit price for structural steel.

D Payment

The Department will pay for inorganic zinc-rich paint system on the basis of the following schedule:

Item No.:	Item:	Unit:
2479.502	Inorganic Zinc-Rich Paint System (Shop)	square foot [square meter]
2479.503	Inorganic Zinc-Rich Paint System (Field)	square foot [square meter]
2479.504	Inorganic Zinc-Rich Paint System (Shop and Field)	square foot [square meter]

2481 WATERPROOFING

2481.1 DESCRIPTION

This work consists of waterproofing joints.

2481.2 MATERIALS

A Three-Ply System Materials

A.1 Asphalt Primer for Waterproofing Concrete 3165

A.2 Saturated Fabric for Waterproofing..... 3201

A.3 Asphalt for Mopping Coat 3166

B Membrane Waterproofing System..... 3757

2481.3 CONSTRUCTION REQUIREMENTS

A General

Remove form ties, fill cavities with mortar, and remove all sharp protrusions before waterproofing. Before applying the primer, ensure the concrete has cured for 72 hours and is clean, dry, smooth, and free of voids. Clear the concrete of dust and other loose material immediately before applying the primer.

Apply the waterproofing system in dry, fair weather when the air temperature is above 40 °F [4 °C].

Protect waterproofing against damage during succeeding construction operations. Repair damaged waterproofing as approved by the Engineer, at no additional cost to the Department.

B Membrane Waterproofing System

Provide a self-adhering strip of waterproofing membrane at least 12 in [300 mm] wide listed on the Approved/Qualified Products List for the membrane waterproofing system. Prime the surface on the joint as recommended by the manufacturer. Center the membrane on the joint. Provide polyethylene sheeting with a thickness of 4 mils [102 µm] and provide rubberized asphalt with a nominal thickness of 0.06 in [1.5 mm], for a total nominal thickness of 0.06 in [1.6 mm]. Ensure the face of the rubberized asphalt opposite the face bonded to the sheeting includes a removable covering. Allow the removable covering to remain on the membrane until placement of the membrane.

The Contractor may make splices in the joint waterproofing membrane using an overlap of at least 6 in [150 mm] at the splice. For splices on vertical face joints, ensure the upper strip overlays the lower strip.

C Three-Ply Joint Waterproofing

Heat and place asphalt used for waterproofing at a temperature from 300 °F to 350 °F [149 °C to 177 °C]. Frequently stir the asphalt while heating to prevent local overheating.

Apply the primers cold.

Center the waterproofing over the joint for its entire length. After preparing the surface, coat the surface with a uniform and continuous application of primer at least 2 in [50 mm] wider than the widest piece of fabric. Allow the primer coat to dry before mopping the surface with an additional uniform coat of asphalt. Place a layer of bituminized fabric 12 in [300 mm] wide with the selvedge removed from the fabric on the surface and immediately roll. Coat the surface with a second layer of asphalt, and place and roll a layer of bituminized fabric 18 in [450 mm] wide. Coat the surface with a third layer of asphalt, and place and roll a layer of bituminized fabric 24 in [600 mm] wide. Mop asphalt over the last layer of fabric at a rate of at least 1 gal per yd [4 L per m] of joint.

If splicing fabric, ensure the end splices lap at least 12 in [300 mm]. Coat the lap with asphalt immediately before making the splice. Do not make splices in the separate layers of fabric at the same location. For splices in fabric covering vertical joints, ensure the upper strip overlays the lower strip.

Perform joint waterproofing before applying surface protection courses as shown on the plans or special provisions.

2481.4 METHOD OF MEASUREMENT

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

2481.5 BASIS OF PAYMENT

The Department will pay for joint waterproofing only if the contract contains a specific pay item for waterproofing. If the contract does not specify a pay item for waterproofing, the Department will include the cost of joint waterproofing with other relevant contract unit prices.

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

Item No.:	Item:	Unit:
2481.501	Joint Waterproofing	linear foot [meter]