2401 CONCRETE BRIDGE CONSTRUCTION

2401.1 DESCRIPTION

This work consists of constructing portions of a bridge made of concrete, except for concrete piling (2452), special wearing courses (2404), and precast concrete members (2405 and 2412).

The Department defines "bridge deck slab" as the complete structural slab and wearing course constructed monolithically. The Department defines "bridge structural slab" as only the structural unit upon which will be constructed a separately cast wearing course. The Department defines "bridge slab" as either "bridge deck slab" or "bridge structural slab."

2401.2 MATERIALS

A Concrete.....2461

Provide concrete mix designations as shown on the plans for the specific item of work.

Use Class A coarse aggregate in accordance with 3137.2.B, "Classification," in concrete for bridge railings, barriers, posts, curbs, sidewalks, and median strips cast separately from the bridge deck.

B Reinforcement Bars.....3301

C Steel Fabric.....3303

D Spiral Reinforcement.....3305

E Preformed Joint Filler.....3702

F Concrete Joint Sealer, Hot Poured Type.....3723

G Concrete Joint Sealer, Preformed Type.....3721

2401.3 CONSTRUCTION REQUIREMENTS

A General

Refer to 2402, "Steel Bridge Construction," 2404, "Concrete Wearing Course for Bridges," 2451, "Structure Excavations and Backfills," 2452, "Piling," 2471, "Structural Metals," and 2472, "Metal Reinforcement," for constructing bridges.

B Falsework and Forms

Use forms for concrete except portions of footings that extend into solid rock. Do not cast concrete against the side of an earth excavation instead of forming. If the special provisions allow driving the sheets along the neat line of a footing, the Contractor may use cofferdam sheets as forms for footings.

B.1 Material Requirements, with Allowable Stresses or Loads

B.1.a Falsework Piling

Calculate safe pile-bearing capacities in accordance with 2452, "Piling."

B.1.b Structural Shapes and Fabricated Assemblies

Reduce the safe load capacity for material or fabricated assembly that has a loss of section due to corrosion, damage, or previous fabrication. Do not splice shapes used as beams at points of maximum bending stress. All splices shall develop yield on the gross section and fracture on the net section.

Design trusses, other fabricated sections, and steel beams meeting the requirements of the AASHTO *Guide Design Specifications for Bridge Temporary Works* and the AASHTO *Standard Specifications for Highway Bridges*. The Contractor may increase the allowable stresses in the AASHTO *Standard Specifications for Highway Bridges* by no greater than one-third.

Design and use form ties and other steel devices planned for casting into concrete so that the major part, or the entire device, remains permanently in the concrete. If using a device that passes through a concrete surface exposed to view in the completed structure, use a device removable to a depth of at least 1 in [25 mm] from the concrete face without spalling or damaging the concrete.

B.1.c Lumber

Provide lumber free of defects that may adversely affect its strength or the appearance of exposed concrete lines and surfaces, such as crooks, twists, warps, and variations in dimensions. Surface the side of lumber pieces that will contact concrete. If not using form lining, surface or dress and match abutting edges to prevent mortar leakage.

Working stresses for lumber shall not exceed the maximum stresses specified in the Bridge Construction Manual, Falsework and Forms section. Provide sheathing lumber, either with or without form lining, at least 1 in [25 mm] nominal thick and no greater than 8 in [200 mm] wide for exposed concrete surfaces. If a single piece of lumber will completely cover a concrete surface and the lumber is not cupped or warped, the Contractor may use wider lumber. For curved surfaces with a radius of less than 5 ft [1,500 mm], the Contractor may use sheathing thinner than 1 in [25 mm] nominal as approved by the Engineer.

B.1.d Plywood Sheathing

Provide plywood for form sheathing meeting the following requirements and characteristics:

(1) Consisting of at least five plies,
(2) Nominal thickness of at least ¾ in [20 mm],
(3) Plyform exterior grade with sanded or overlaid surfaces specially manufactured for use as form sheathing, and
(4) Strength requirements as specified in the Bridge Construction Manual, Falsework and Forms section.

The Contractor may use the plywood without backing if it meets the above requirements.

For curved surfaces with a radius of less than 5 ft [1,500 mm] and for slab sections between girders or beams, the Contractor may provide plywood sheathing thinner than ¾ in [20 mm] nominal, as approved by the Engineer.

B.1.e Form Lining

If the contract requires form lining, use plywood sheathing with a smooth surfaced material that will produce a concrete surface substantially as smooth and uniform as that obtained using sanded or overlaid plywood sheathing in good condition with no warps or damaged areas. Use the same kind of form lining material throughout an exposed concrete face. Place the form lining to produce a smooth contact surface that is free of defects. Provide smooth form lining free of defects that cause irregularities that the specified concrete finishing operations in 2401.3.F, "Finish of Concrete," cannot remove.

Provide form lining material with a uniform thickness and edges that form mortar tight joints.

Ensure that bolt, nail, or rivet heads and weld deposits are flush with the form lining face in contact with concrete.

If using form lining sheets or sections, use material that minimizes the number of joints.

B.1.f Forms for Circular Columns

Use forms that can withstand design concrete pressures without distortion. Use forms to produce a concrete surface free of visible ridges and depressions. If form lining is shown on the plans, the Contractor may use fiber molds. When using form brands not previously used, provide the Engineer with the manufacturer's data.

B.1.g Chamfer Strips

Provide chamfer strips, smooth on all sides and uniform in cross section dimensions without rounded corners. If using wood strips, provide wood strips made of straight grain soft wood. Size chamfer strips as shown on the plans and in accordance with 2401.3.B.6, "Form Construction."

B.2 Design of Falsework and Forms

Submit detailed plans for falsework and forms to the Engineer.

Provide falsework members designed to safely carry the following forces:

(1) Deadload of the falsework members only,
(2) Deadload of the green concrete, computed at 150 lb per cu. ft [23.6 kN per cu. m],
(3) A vertical live load of 20 lb per sq. ft [0.96 kN per cu. m] applied on the upper concrete surface,
(4) Deadload of the forms and other falsework members supported by the members, and
(5) Equipment loads and material stockpile loads anticipated for use during construction.

Provide forms designed to safely carry the following forces:

(1) Deadload of the forms only,
(2) The deadload of green concrete, computed at 150 lb per cu. ft [23.6 kN per cu. m],
(3) A vertical live load of 50 lb per sq. ft [2.4 kN per cu. m] applied on the upper concrete surface.
(4) All equipment loads and material stockpile loads anticipated for use during construction.

Consider the specified live load as the minimum. Adjust for concentrated loads that may produce higher live loads on a member than the minimums specified.

Provide falsework and forms designed in accordance with the following as specified in the Bridge Construction Manual, Falsework and Forms section:

(1) Concrete pressures,
(2) Standard formulas,
(3) Allowable stresses,
(4) Deflections, and
(5) Deviations of alignment.

Provide credible information regarding the performance of the proposed falsework and forms under concrete load construction for any type of construction not included in the Bridge Construction Manual, Falsework and Forms section, as requested by the Engineer.

Before using devices or fabrications that the Engineer determines the Department does not have sufficient performance information on, conduct full scale field or laboratory testing of falsework and forms at no additional cost to the Department, as directed by the Engineer.

B.3 Form Lining Requirements

Nail form lining backed by sheathing to prevent bulging. Fasten plywood at least ¾ in [20 mm] thick to its supports to ensure stiffness and close contact between the plywood and supports.

Tightly butt edges of plywood sheets and form panels without offset to form a mortar tight joint. The Engineer will allow the Contractor to patch or seal joints that will not seal with cold water putty, expandable foam, or an equivalent approved by the Engineer.

Place joints in form lining sections or between adjacent form panels following the same horizontal line. Place horizontal joints on all columns of a unit to the same level. Align joints in form lining vertically and horizontally.

On forms for concrete faces exposed to view, drill holes for form bolts through sheathing or form lining without splintering the face of the form in contact with the concrete. If using both sides of sheathing, avoid splintering on both faces.

Use form lining in accordance with 2401.3.B.1.e, "Form Lining," for formed surfaces. The Department will not require use of form lining for buried surfaces or surfaces hidden from view in the completed structure, except as shown on the plans.

If using recessed rustication strips to divide a concrete surface into panels as shown on the plans, set rustications to cover the joints in the form lining. Concrete panels with a rubbed surface finish or a special surface finish do not require form lining joints to be covered by rustication strips.

B.4 Falsework Requirements

Support falsework on piling, on ledge rock, on parts of the structure, or on temporary footings.

Do not weld on the primary stress-carrying steel members of the bridge superstructure except as specified in 2402, "Steel Bridge Construction."

Drive falsework piling to a bearing capacity and penetration that will adequately support the superimposed loads without settlement as shown in the falsework plans.

Use temporary footings to support falsework in accordance with the following:

(1) Submit geotechnical borings, testing, analysis, and calculations, including soil bearing capacity, anticipated settlement, and sliding resistance, for proposed footings showing that detrimental settlement will not occur under maximum construction loads and conditions anticipated at the site.
(2) Protect footings from undermining, freezing, or being overspread with water.
(3) Use when approved by the Engineer, otherwise support with pilings.

Cut off falsework piling in a bent to provide uniform bearing for the pile cap. Securely fasten caps to the pile heads or posts. Securely brace each falsework bent with timber of adequate size as shown on the falsework plans. Securely brace the bents to adjacent bents.

Provide falsework for superstructures in widths greater than the overall width of the superstructure to brace side forms to the falsework.

On bridges with separate roadways, support the form and falsework supports for each roadway slab with beams or girders under that roadway.

Locate primary supports for concrete slab spans and the bottom slab for concrete box girders no greater than 2 ft [600 mm] from the construction joints in the slabs.

Provide falsework for slab overhangs for steel beam spans capable of resisting torsional stresses. Use knee bracing, cross bracing, struts, ties, or other methods approved by the Engineer to prevent pronounced deflections caused by stresses. Bracing is particularly critical when slab overhangs are greater than the beam depth.

B.5 Removal of Falsework

Do not release falsework supporting concrete structures and concrete members until the completion of the curing period in accordance with 2401.3.G, "Concrete Curing and Protection," plus 1 calendar day of drying out time. Release falsework supporting post tensioned structures after stressing the post tensioning tendons as described in the specifications and shown on the plans.

Do not place loads on concrete members until completion of curing and after the release of falsework, unless otherwise approved by the Engineer.

Determine adequate strength for the complete structure using the last concrete cast affected by the release of falsework.

Loosen supporting falsework to allow the concrete to uniformly and gradually take the stresses due to its own weight.

Begin releasing the falsework at or near the center of a span for the full width of the span. Simultaneously release falsework toward both ends of the span unless otherwise approved by the Engineer. On continuous span concrete superstructures, with or without cantilevers and hinges, release falsework simultaneously and uniformly in all spans unless otherwise approved by the Engineer.

Remove falsework piles located within the roadbed to an elevation of at least 4 ft [1,200 mm] below the subgrade adjacent to the pile. Remove falsework piles located in a stream or lake bed and within the limits of low water to the elevation matching the surface of the stream or lake bed. In established navigation channels, remove falsework to an elevation of at least 2 ft [600 mm] below the surface of the channel bottom. Remove all other piles to an elevation of at least 2 ft [600 mm] below ground elevation.

Remove falsework supports used for the top slab of concrete box girder spans and steel box girder spans.

Unless otherwise approved by the Engineer, remove temporary footings unless the top surfaces of the footings are at least 4 ft [1,200 mm] below the grading grade or at least 2 ft [600 mm] under other ground surfaces.

Backfill and compact open excavations resulting from the removal of falsework in accordance with 2451, "Structure Excavations and Backfills," at no additional cost to the Department.

B.6 Form Construction

Provide forms meeting the following requirements and characteristics:

(1) Designed and constructed to safely resist the pressure of fluid concrete under vibration and of other loads incidental to the construction operations,
(2) Constructed and erected mortar tight so that the finished concrete conforms to the dimensions and contours shown on the plans, and so that undulations and waves on exposed finished concrete surfaces do not exceed the maximum shown in the Bridge Construction Manual, Falsework and Form section,
(3) Set true to the designated lines shown on the plans, and
(4) Rigidly maintained until the concrete has sufficiently hardened to allow removal of forms per 2401.3.B.8, "Removal of Forms."

For vertical construction joints in a concrete unit with a rubbed surface finish, locate joints in form sections to allow the removal of the major part of the forms to allow the initial rubbed surface finish on the cast portion.

Construct vertical forms that will permit removal independent from overhead falsework.

Construct forms in a way that rustication trips or smaller form elements will remain attached to the form upon removal from the concrete.

Place sheathing lumber horizontally unless otherwise approved by the Engineer.

Construct splices in wales so the wale remains effective continuously for its entire length. Stagger splices in each member of a double wale at least one stud space.

The Contractor may leave openings in the forms to clean out extraneous matter or to facilitate the placement of concrete if the Engineer approves the number and location of openings. Construct closures for openings to ensure a tight fit flush with the adjoining surfaces.

Unless the plans show otherwise, use chamfer strips with ¾ in [20 mm] sides to form chamfered corners where exposed intersecting concrete surfaces meet at angles no greater than 90 degrees. The Department will not require chamfered corners at the corners of beam stools under decks with mortar tight joints. If the contract does not require joint edging, use similar moldings with ½ in [15 mm] sides at all joints exposed to view. Fasten moldings at intervals no greater than 6 in [150 mm].

Set chamfer strips at the tops of pier caps supported on falsework in a manner that will allow adjustment to true bridge seat elevation after the placement of the bulk of the cap concrete.

The Contractor may provide forms for keyways at construction joints in concrete constructed with nominal lumber dimensions and with side bevels no greater than 1:10.

Provide forms for open joints capable of removal without damaging the joint after the removal of the form.

If the contract requires a construction joint between the bridge slab and railings, curbs, or medians, set the forms for subsequent placement after placement of the bridge slab in all spans that could cause a deflection in the span the superimposed concrete is cast on.

Before setting grade elevations for curbs, sidewalks, medians, and railings, free the concrete box girder spans and concrete slab spans from temporary supports.

Do not drive nails into the hardened concrete to fasten forms for roadway faces of curbs, sidewalks, and medians. Use braces and struts to maintain proper line and batter for roadway curb face, sidewalk, and median forms, if these are cast separately from the slab. Do not use internal spreaders. Remove bolts and pins set or drilled into

the slab for the form work to a depth of at least 1½ in [40 mm] below the slab surface without spalling or damaging the concrete. Fill the holes flush with non-shrink grout listed on the Approved/Qualified Products List.

If constructing a bridge with a horizontal curve as shown on the plans, construct the forms for edges of slab, curbs, copings, medians, and railings to that degree of curvature within a tolerance of ⅛ in [3 mm] in 10 ft [3,000 mm].

B.7 Treatment of Forms

Before placing reinforcement, treat the contact faces of forms with a form coating material in accordance with 3902, "Form Coating Material." Apply the form coating at the rate recommended by the manufacturer.

Protect form lining treated before erection from accumulations of dust and dirt.

Use water to flush faces of forms that contact concrete immediately before placement of concrete.

B.8 Removal of Forms

Remove forms and form ties carefully to prevent spalling or marring of the concrete surface and to avoid breaking off concrete corners.

The Contractor may remove forms for the roadway face of curbs, sidewalks, and medians when the concrete can retain its shape and if weather conditions allow the start of the specified concrete finish per 2401.3.F.2.d, "Curb, Sidewalk, and Median Finish," immediately after removing the forms. Allow other forms to remain in place for at least 12 h after casting the concrete or longer if stripping the forms will damage the concrete or prevent disengaging the form ties.

Remove column and wall forms before releasing the falsework supports from concrete supported by the column or wall.

When the contract requires a surface finishing operation to be completed within a definite period of time after casting, remove the forms in time to allow enough time for the finishing operation. Do not remove the forms sooner than the minimum time required for curing. Do not remove forms for rustication, fluting strips, and drain recesses at the same time as the face forms. Leave rustication, fluting strips, and drain recesses forms in place until it is possible to remove these items without spalling, chipping, or marring of concrete corners or edges.

Remove forms for the webs of concrete box girder spans and provide the web concrete with an ordinary surface finish before setting the forms for the top slab in place at that location.

Remove interior forms in concrete box girder spans. Remove deck forms on the interior of steel box girder spans. Clear loose material from the inside of the concrete box girders and steel box girders, and sweep the box clean.

B.9 Re-Use of Forms

The Contractor may reuse forms and form liners if they remain in good condition and strength. If the form lining between supports show conspicuous permanent set, remove the form lining and correct before reuse.

Plug or cover open holes in sheathing. Plug open holes in form lining flush with the lining. Repair blemishes on the form lining surface to a smooth and even surface. Clean adhering concrete and extraneous matter from form surfaces in contact with concrete before reuse.

C Placement of Concrete

C.1 General Requirements

Complete the placement of forms, falsework, bracing, and reinforcement bars for the entire concrete cast and have concrete placement and finishing equipment and curing material on site before placing the concrete.

Notify the Engineer at least 24 h in advance of the casting of concrete to allow the Engineer to inspect forms, reinforcement bars, materials, and equipment. Do not place concrete until the Engineer inspects and approves the work.

Perform mixing, placing, and finishing of concrete under adequate lighting conditions.

Transport and place concrete without segregating the batch materials. Place concrete in or near its final position without displacing the reinforcement while completely enveloping the reinforcement in the concrete.

Keep equipment for transporting, placing, and finishing concrete free of foreign matter and coatings of hardened concrete. Waste the water used for cleaning equipment outside of the forms as approved by the Engineer.

Clean forms and reinforcement bars and remove debris inside the forms before placing concrete.

Place concrete under water only when used for a cofferdam seal and as shown on the special provisions or as approved by the Engineer.

When placing concrete on or against earth and porous rock foundations, moisten the surfaces before placing concrete.

Footings cast in solid rock will not require side forms.

Place concrete between required or permissible joints as shown on the plans in a continuous operation. If a breakdown in the concrete placement operation occurs and the concrete placed to that point sets so that re-vibration is not possible, cover the surface of the concrete with an approved bonding agent or mortar as directed by the Engineer before placing fresh concrete against it.

Place concrete at a rate that does not exceed fluid pressure for which forms were designed. Stop casting operations at signs of overstress or excessive deflection.

Except for seals, deposit and compact concrete in continuous horizontal layers no greater than 1 ft [300 mm] thick. In columns and thin walls, the Contractor may increase the thickness by no greater than 3 ft [1,000 mm]. Place and compact concrete before the concrete in the preceding layer takes its initial set. Place layers of concrete within 1 h of placing the next layer of concrete at the same point, unless otherwise directed by the Engineer.

Do not drop concrete from a height greater than 4 ft [1,200 mm] unless confined in a vertical down spout or other approved type of pipe or unless the Engineer approves another placement method. Use as many down spouts as needed to place concrete at a horizontal level. The Contractor may use inclined pipes, belts, or chutes to discharge concrete into the hopper of the downspout if the Contractor provides approved means of preventing segregation.

Place concrete buckets as close as practical to the point of deposit before discharging concrete at a regulated rate. Do not discharge excess concrete in a pile for rehandling.

Remove laitance and foreign matter if it accumulates on the inside of the forms.

Do not mix dried or hardened concrete accumulations with fresh concrete. As the concrete rises in the forms, keep the form surfaces and reinforcement bars free of concrete spatters that may harden and become part of the mix. Remove dried concrete and dust accumulations on the form surfaces and reinforcement bars above construction joints before placing the next concrete lift. Do not damage the form surfaces, reinforcement bar coating, or the steel-to-concrete bond when removing excess concrete.

Work the coarse aggregate away from the forms. Force the concrete under and around the reinforcement bars without displacing the bars.

If casting a wall or column greater than 5 ft [1,500 mm] tall integrally with a beam, strut, or slab, allow from 30 min to 90 min, as determined by the Engineer, to elapse between placement of the concrete to the level of the bottom of the beam, strut, or slab and placement of the concrete above this level.

For caps supported by more than one column, cast columns uniformly and allow from 30 min to 90 min to elapse, as determined by the Engineer, before placing the cap.

Clean set concrete of loose material, laitance, and dirt before placing fresh concrete against it. Sand or water blast superstructure concrete to clean the set concrete. Avoid damage to coating on reinforcement bars. Before placing the fresh concrete, draw the forms for the fresh concrete tight against the set concrete. Keep the contact surfaces of the set concrete wet until depositing the fresh concrete.

If the Engineer determines that shock waves from pile driving, blasting, or other operations will damage the concrete, complete these operations before placing concrete or suspend these operations until the concrete gains adequate strength per 2401.3.G, "Concrete Curing and Protection."

Do not support runways for concrete transportation by the forms unless approved by the Engineer.

Remove the span falsework and obtain an acceptable bridge slab cure before placing concrete railings unless otherwise approved by the Engineer.

C.2 Cold Weather Protection of Concrete

Protect concrete from cold weather from October 1 to April 15 when working north of the 46th parallel and from October 15 to April 15 when working south of the 46th parallel.

C.2.a Cold Weather Protection Plan

Submit a proposed time schedule and plans for cold weather protection of concrete, to the Engineer for acceptance, including maintenance of temperatures during placement and curing. Do not place concrete until the Engineer accepts the cold weather protection plan.

C.2.b General

Preheat the forms, in-place concrete, reinforcement bars, and items including the top flanges of beams to a minimum of 40 °F [5 °C] when the temperatures of these surface areas are below freezing before placing concrete. Do not apply flames directly to concrete or steel.

Provide insulated forms, insulation, or heating and housing facilities to maintain a concrete temperature of at least 60 °F [15 °C] during the curing period. Vent the heated enclosures to prevent the buildup of carbon dioxide.

Provide imbedded temperature sensors and monitoring devices for all bridge slabs. Provide a minimum of two sensors and at least one additional sensor per 5,000 sq. ft [465 sq. m] of bridge slab.

Keep the forms, insulation, and housing enclosure in place until the completion of cold weather protection as approved defined in 2401.3.G, "Concrete Curing and Protection."

Gradually discontinue the use of cold weather protection so the rate of temperature reduction adjacent to the concrete surfaces does not exceed 20 °F [11 °C] during any 12 h period until the surface temperature reaches the ambient air temperature.

The Engineer will base anticipated concrete placement and curing temperatures on weather forecasts or on typical temperature data for the time of year at the location of the structure.

C.2.c Bridge Slabs, Box Girder Bottom Slabs, and Box Girder Webs

Place and cure concrete in bridge slabs, box girder bottom slabs, and box girder webs in accordance with the following:

C.2.c(1) Ambient Air Temperatures below 36 °F [2 °C]

If the Engineer anticipates air temperatures below 36 °F [2 °C], place concrete only after placing housing needed to heat the pour area and maintain required pour temperatures of at least 60 °F [15 °C].

C.2.c(2) Ambient Air Temperatures above 36 °F [2 °C] during Placement but below 34 °F [1 °C] during Curing

When the air temperature is greater than 36 °F [2 °C] during placement but is anticipated to fall below 34 °F [1 °C] during curing, do not place concrete until as much insulation or housing and heating are in as needed to protect the concrete from freezing. The Contractor may install insulation and housing after completion of concrete finishing, as approved in the cold weather protection plan if the insulation and housing hinders concrete placement.

C.2.d Bridge Deck Slab

Remove the conventional wet curing material from the slab surface at the end of the curing period, if opening a bridge deck slab to traffic before April 15. For 25 calendar days after removing the curing material or until April 15, whichever comes first, heat and provide housing to ensure free air circulation above the concrete surface to dry the concrete and prevent the temperature of the concrete from falling below 40 °F [5 °C].

D Compaction of Concrete

Compact concrete, except for cofferdam seals, using mechanical vibration applied internally. Operate vibrators at a frequency of at least 4,500 impulses per min [75 Hz]. Compact each batch of concrete immediately after placement.

Apply vibrators at points no farther apart than twice the radius of the vibrator's visibly effective range. Manipulate the vibrators to work the concrete around reinforcement and imbedded fixtures and into the corners and angles of the forms. Use spading to supplement vibration to produce smooth surfaces and dense concrete along form surfaces and in corners and locations unreachable by vibrators.

Apply vibration at the point of deposit of freshly deposited concrete. Vibrate long enough to compact the concrete but not so long as to cause segregation and localized areas of grout. Insert and withdraw vibrators in a vertical orientation.

Do not apply vibration to, or apply vibration directly on reinforcement bars to sections of concrete that has hardened to the degree that the concrete ceases to be plastic under vibration. Do not use vibrators to make concrete flow in the forms; this action will cause segregation.

Use non-metallic vibrator head for compaction of concrete around epoxy-coated components per 2472.3.C.3, "Special Requirements for Coated Bars."

E Joint Construction

Perform joint construction as shown on the plans and in accordance with the following:

E.1 Transverse Construction Joints

Make grooves or saw cuts ⅜ in [10 mm] wide by 1 in [25 mm] deep in accordance with the following unless otherwise shown in the plans or directed by the Engineer:

(1) At transverse construction joints in the bridge slab unless otherwise directed by the Engineer,
(2) To the full width of the roadway between gutter lines, and
(3) Directly over the construction joint before placement of curb forms.

E.2 Weakened Plane Joints

Use a grooving tool or a removable insert when casting the slab to extend and form a weakened plane under sidewalks and at other slab locations where a saw cut is not possible. Place the insert or groove to cut the fresh concrete on a straight line to a depth of 1 in [25 mm]. When using an insert, coat with oil or grease before

placement. Withdraw the insert when the concrete has set enough to retain the groove shape with the insert removed.

Locate the weakened plane to fall vertically below the sidewalk, curb, or median joint at that location. On skewed bridges with exterior girders or beams under curbs, sidewalks, or medians that are normal to the longitudinal axis of the bridge, extend the weakened plane using a removable insert. Place the insert as a continuation of the line to be cut, extending to the centerline of the exterior girders or beams.

Outward from the centerline of the exterior girders or beams, place the weakened plane common to the joint placed in the curb, sidewalk, or median. Form a vertical ½ in [13 mm] v-shape in the edge of the slab at the end of the weakened plane at that location.

E.3 Open or Filled Joints

Form the distance between faces of open joints with removable inserts, headers, or templates to provide the opening shown on the plans for the temperature range prevailing at the time of concrete placement. Refer to the tabulation shown on the plans or shop drawings for the required openings at various temperatures. The temperatures listed represent the temperature anticipated when the slab is cast. Joints may widen due to concrete shrinkage.

After placing the bridge slab adjacent to an elastomeric seal expansion joint, and after curing and drying the concrete, the Engineer will measure the constructed joint openings. The Engineer may reject openings that deviate from the size shown on the plans by greater than $^{3}/_{16}$ in [5 mm] as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work." The Department will also consider offsets at joints between segments as unacceptable work.

The Contractor may use preformed joint filler to form vertical joints. When using cork joint filler to form a vertical joint, anchor with copper nails 2½ in [65 mm] long at 20 in [500 mm] centers. Where the contract requires chamfered corners at joints created by using preformed material, trim the preformed filler back to the inside of the vee formed by the chamfer strip.

E.4 Expansion Joint Devices

Provide, assemble, and install bridge slab expansion joint devices as shown on the plans and in accordance with 2402.3.K, "Expansion Joint Devices."

F Finish of Concrete

F.1 General

Surface finish concrete that is properly set, and only during weather conditions, or with weather protection, approved by the Engineer.

F.2 Formed Surfaces

F.2.a Ordinary Surface Finish

Provide ordinary surface finish on formed surfaces of concrete structures. If applying special surface finishes to conventionally formed concrete surfaces, sand or water blast the surface before ordinary surface finishing to break the surface film and to remove laitance, form release agent, dirt, and other foreign matter that might adversely affect adhesion of special surface finishes.

Immediately after removing the forms, examine the concrete surfaces for defects. Remove and replace concrete with porosity, honey comb, or segregated materials. The Engineer will approve the time, method, and materials used to make concrete repairs. Repair small areas with mortar as specified for surface cavities. The Engineer may require formed surfaces to repair large areas. The repairs may require a bonding agent, mechanical bonds, or both. Cure repair work as approved by the Engineer. The Engineer may reject concrete sections with extensive, irreparable defects as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

Remove fins and projections from exposed surfaces and from surfaces that will be waterproofed.

Clean, saturate with water, and fill with mortar all surface cavities produced by form ties. Clean, saturate with water, and fill with mortar all surface cavities on exposed surfaces with a diameter of at least ⅜ in [10 mm]. The Department defines "exposed surfaces," as surfaces exposed to view in the completed structure, above low water, and above the final ground line. At unexposed surface locations or areas where the Engineer determines repairs will not affect the appearance of the completed structure, clean and fill cavities caused by removing falsework, brackets, form ties, or hanger rods with a silicone caulk listed on the Approved/Qualified Products List for "Moisture Cured Polymeric Joint Sealer."

Use mortar consisting of three parts standard portland cement, six parts mortar sand, and water to fill surface cavities. Use enough water to produce a mortar consistency as dry as possible to use effectively. Mix the mortar 1 h before use.

Provide a latex or acrylic-based bonding agent listed on the Approved/Qualified Products List for special surface finish. Mix the bonding agent into the mortar used

for ordinary surface finishing on areas that will receive a special surface finish. Add the bonding agent to the mixing water at a ratio of one part bonding agent to three parts water.

Fill the cavities with mortar. Compact the cavities in place, point, and trim flush with the concrete surface. On exposed surfaces, remove mortar stains or streaks outside the area of the filled cavity.

After completing the concrete work, remove visible streaks, stains, and blemishes from the surface if the special provisions do not show additional surface finishing on an exposed surface. Perform additional surface finishing on an exposed surface for which the contract that requires only ordinary surface finish when adjoining form lining sheets present sharply contrasting colors or textures. Provide sack rubbed surface finish as a corrective measure if the surface appearance remains sharply contrasting after the completion of the ordinary surface finish.

If applying the ordinary surface finish before the completion of the curing period, minimize interruption to the curing when performing the finishing.

F.2.b Sack Rubbed Surface Finish

In areas with numerous surface voids on an exposed surface, the Contractor may use sack rubbed finish to fill the smaller voids in lieu of the method described under ordinary surface finish. Fill form tie holes and other cavities of at least ⅜ in [10 mm] in accordance with 2401.3.F.2.a, "Ordinary Surface Finish."

Grind or sandblast the concrete surface to remove blemishes, discolorations, and thin mortar films covering surface voids.

After the completion of the structure, and when further construction will not produce blemishes and discolorations on the surface, perform the following operations:

(1) Saturate the surface with water and, beginning at the top, use a rubber float to apply a mortar mixture to fill the voids. Mix the mortar using the following requirements:

(1.1) One part standard portland cement,
(1.2) One part mortar sand, and
(1.3) Contains sufficient water to produce a moderately thick paste that will remain in place when applied.

Rewet the concrete surface if it dries before applying the mortar paste.

(2) After the mortar sets in the voids, but before it completely dries, rub the floated surface using a burlap sack filled with a dry mix of mortar to remove

mortar in excess of what was needed to fill the voids. The Engineer will approve equally effective means of removing the excess mortar.

(3) Produce a completed surface meeting the following requirements and characteristics:

(3.1) Free of blemishes, discolorations, and surface voids,

(3.2) Uniform in texture and appearance, except for the difference in texture between filled voids and the remainder of the surface.

Correct surfaces not meeting the requirements of this section as approved by the Engineer.

F.2.c Special Surface Finish

Provide a special surface finish for bridges and surfaces required by the contract to produce a smooth surface uniform in texture and appearance.

Use a Department-approved system listed on the Approved/Qualified Products List for "Special Surface Finish System," to apply a special surface finishing consisting of commercially packaged mortar, bonding agent, and 100 percent acrylic paint. Blend the mortar, bonding agent, and water in the proportions recommended by the manufacturer. Provide 100 percent acrylic paint in accordance with 3584, "Exterior Masonry Acrylic Emulsion Paint," and blend at a rate of 1 gal per 50 lb [3.8 L per 22.7 kg] of dry mortar mix. Produce a mixture suitable for spray application to vertical concrete surfaces at the specified coverage rate, below.

Mix and remix materials as recommended by the manufacturer.

Apply two coats of the mixture by spraying, as recommended by the manufacturer, using a total coverage rate of 16 sq. ft per gal [0.4 sq. m per L] of material. Use the first coat to cover the entire surface, taking care not to cause runs, sags, or excessive build-up.

The Contractor may begin special surface finishing operations, including any topcoat applications, at an ambient air temperature of at least 39 °F [4 °C] and rising. Suspend special surface finishing operations if the ambient air temperature falls to 45 °F [7 °C] and is dropping.

Begin surface finishing operations only when it is possible to perform the work continuously from beginning to completion on any one bridge.

Perform surface finishing so that after drying the final surface is uniform in color and texture, without evidence of laps or breaks in continuity. Perform corrective work on unsatisfactorily finished areas coated with special surface finishing or topcoat as directed by the Engineer and at no additional cost to the Department.

F.2.d Curb, Sidewalk, and Median Finish

Provide a surface finish of formed surfaces of medians, delineator curbs, and the roadway face of curbs and sidewalks in accordance with the following:

(1) Begin ordinary surface finish operations immediately after removing the forms and work continuously to completion. As the ordinary surface finish progresses, rub the surface with a cork float or fine carborundum stone to produce a paste on the surface and to expose and fill depressions and surface cavities. Float the paste to a smooth surface free of coarse texture, swirls, and ridges. Before the surface sets, brush the surface lightly with a fine bristled brush to remove cement films and produce a uniform surface with a fine grained and sanded texture, and
(2) Complete the surface finishing of the formed surface within 48 h after concrete placement.

F.2.e Railing Finish

Do not allow horizontal or vertical irregularities greater than ¼ in [6 mm] in any 10 ft [3,000 mm] length of finished concrete railing. The Engineer may reject surfaces and edges not meeting this tolerance as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work." Remove and replace unacceptable work as directed by the Engineer. Remove and replace extensive areas (greater than 10 percent of railing length) with deviations greater than ½ in [13 mm]. If the Engineer does not direct the Contractor to remove and replace unacceptable work, the Contractor may leave the work in place with the following price adjustments:

(1) For deviations from $^{5}/_{16}$ in to ½ in [7 mm to 13 mm], the Department will pay for concrete railing at 75 percent of the contract unit price, and
(2) For minor areas (less than or equal to 10 percent of railing length) with deviations greater than ½ in [13 mm], the Department will pay for concrete railing at 50 percent of the contract unit price.

F.3 Unformed Surfaces

F.3.a Miscellaneous Unformed Surfaces

Finish unformed upper horizontal and inclined surfaces, except for the surface of bridge slabs and the surface at horizontal construction joints, in accordance with the following:

Do not use steel trowels and steel shod floats. Use wood or wood shod templates and strike-offs. Use hand floats and darbies with wood, canvas, rubber, or cork contact surfaces. Use metal edgers that do not form offsets greater than $^{1}/_{16}$ in in the

concrete surface. Do not create waves in the concrete surface when edging. In lieu of using an edger, the Contractor may form rounded corners using a cove strip that does not create an offset greater than $^{1}/_{16}$ in with adjacent concrete surfaces.

Place excess concrete in the forms and compact by internal vibration. After a 30 min delay, strike off and screed the surface with a template forcing the coarse aggregate below the finished surface leaving the surface slightly above finished elevation to allow for settlement during curing. Repeat the screeding and strike-off operation to obtain the elevation shown on the plans and contour, except for edging. Waste laitance and excess mortar outside of the forms. After the final strike off and screeding, hand float the surface to correct irregularities and seal surface tears. Immediately after the water sheen leaves the surface, rework the surface to a uniform texture using a float. Tool rounded corners and edges to final radius forcing the coarse aggregate beneath the finished radius. Float to remove trails left by the edging tools.

Apply final texture and finish to the surface in accordance with the following:

(1) Brush or broom bridge curbs and sidewalks and the floor slabs, ramps, landings, and stair treads for pedestrian bridges and tunnels in a transverse direction using a fairly stiff bristled brush or broom to produce a surface finish meeting the following requirements and characteristics:

    (1.1) Visibly serrated,
    (1.2) Not slippery when wet, and
    (1.3) Uniform throughout in texture and appearance.

(2) Brush the cement film from the surface to provide a uniform, fine grained, sanded texture using a fine bristled brush.

Ensure the finished surface does not vary by greater than ⅛ in [3 mm] from a 10 ft [3,000 mm] straightedge laid longitudinally on the surface, with transverse surfaces substantially as shown on the plans.

F.3.b Bridge Slabs

F.3.b(1) General

Before placing concrete for a section of bridge slab, and after setting the strike-off rails or guides to correct elevation, check the top reinforcement for vertical position by operating the strike-off on the rails or guides in the presence of the Engineer. Attach a filler strip ¼ in [6 mm] thinner than the minimum concrete cover requirements to the bottom of the strike-off during this check to detect reinforcement bars that may encroach on the required clearance.

Place the following in a continuous operation proceeding uniformly from edge to edge of the slab or from end to end of the section:

(1) Each bridge slab section between joints,
(2) Each bridge slab section between an end bulk-head and a joint, or
(3) With no joints specified, the entire slab.

If the contract does not require a specific sequence or direction for casting slab sections, submit plans for the proposed casting procedures for approval. Before starting construction, obtain the Engineer's approval for any change to the casting plans.

Perform bridge slab placement and finishing during daylight hours. If working at night, provide lighting.

If at least two spans of continuous beams or girders support a bridge slab section, place concrete at a rate that concrete will remain plastic for at least one-half a span length back of an intermediate support until placement has proceeded to a point one-half of the span length ahead of that support. Provide approved admixtures to retard concrete setting time as required to maintain plasticity.

If simple span girders support a bridge slab section or if the Contract requires sequence casting for wide continuous beam bridge decks, place concrete at a forward rate of at least 20 ft per h [6,000 mm per h] without producing cold joints between partially hardened concrete and the adjacent newly placed concrete.

F.3.b(2) Strike-Off of Bridge Slab

On bridge slabs, strike off and screed the roadway surface after concrete placement and compaction. Rescreed to the cross-slope and longitudinal profile as required by the contract.

Remove and displace bleed water or laitance that rises to the surface outside the forms. Do not work, smooth, or disturb the concrete surface while bleed water and laitance remain on the surface.

Place the concrete at a rate that ensures the initial strike-off operation is never greater than 10 ft [3,000 mm] behind the placement operation. Maintain the head of concrete parallel with the initially screeded surface. Leave excess concrete carried in front of the screed on the surface when reaching the head of the concrete. Mix with freshly deposited concrete before compacting. When the initial strike-off operation reveals low areas, fill these areas with additional concrete before continuing. Avoid walking in the concrete after the initial pass of the screed.

Use a combined longitudinal and transverse motion of a template supported or suspended from rigid guides to strike-off and screed the surface. The Contractor may

use approved mechanically rotated templates instead of one of the screeding motions. Use rails, bulk-heads, or the side forms as screed guides for manual strike-off. Use rails as guides for power-operated strike-offs, with provisions for vertical adjustment. Support the screed rails for power-operated screeds on the exterior beams, girders, or webs of the structure unless otherwise approved by the Engineer. Obtain the Engineer's approval if planning to support screed rails on the side forms or on any falsework independent of the superstructure.

Construct screed rails in a manner that will allow vertical adjustment after concrete is placed on concrete deck girders and concrete slab span bridges. During concrete placement, check elevations and vertically adjust if necessary.

If an outside webwall of a box girder is under a sidewalk or curb, the Contractor may modify the sidewalk or curb reinforcement to accommodate the running rail system for the power strike-off machine as approved by the Engineer and at no additional cost to the Department.

Use a self propelled power-operated strike-off machine or other machine approved by the Engineer to screed the roadway surface of bridge slabs.

The Department will not require screed rails for templates used for strike-off and screeding of a bridge structural slab. If using screed rails, use screed rails in accordance with this section.

Use templates supported on slab reinforcement bars in accordance with the following requirements:

F.3.b(2)(a) Templates

Provide templates fabricated by a manufacturer with at least 10 years experience. If using templates greater than 24 ft [7,315 mm] long, demonstrate adjustments for crown breaks as approved by the Engineer. Evenly attach vibrators across template length and provide templates that will automatically shut-off vibration when forward motion stops.

F.3.b(2)(b) Template Supports

Space supports to prevent sag in the template.

For portions of template supports in contact with reinforcement, provide template supports consisting of round tubes or rods with a smooth, low friction surface. Provide skis at least 5 ft [1,520 mm] long with a gradual "turn-up" nose sufficient to prevent entrapment in reinforcement.

Support transverse reinforcement bars within 6 in [150 mm] of the location where template support skis will ride.

F.3.b(2)(c) Operations

Provide a manual or powered winch to advance the template. Do not anchor winch cables to reinforcement bars. The Contractor may attach the winch to beams using shear studs, stirrups, or lifting cables.

Spread and level concrete in front of template without causing "float" or overriding.

F.3.b(2)(d) Reinforcement

Securely tie and rigidly support top reinforcement in accordance with 2472.3.C, "Placing, Supporting, and Tying Bar Reinforcement." Before placing the concrete, demonstrate that the equipment and methods proposed for use will not damage or displace reinforcement bars. Provide additional bar support, additional supports for template, or both upon visible deflections of reinforcement.

If the use of a power-operated strike-off screed is specified, provide mechanical screeding motion with equipment moving on flanged or grooved wheels resting on the screed rails. If exterior beams or girders that lie under the roadway slab support the running rails, the Contractor may finish the area between the rail and the gutter without the use of the power-operated screed. In this area, use suitable guides to determine the required gutter profile and, after plastic shrinkage, straighten and true the area to the required profile and cross-slope. Ensure the screed carries a surplus of concrete in the front during screeding operations. Perform the final screeding to cover as long a section as practicable without stopping.

F.3.b(3) Final Finish Texture

After consolidating, screeding, and floating the concrete draw a carpet drag longitudinally along the bridge slab before the concrete attains its initial set to obtain a final finish texture. Adjust the carpet drag to produce a texture approved by the Engineer. Use a carpet drag meeting the following characteristics and requirements:

(1) Mounted on a work bridge,
(2) A longitudinal length of 3 ft [1,000 mm],
(3) Width equal to the concrete placed,
(4) Artificial grass type,
(5) Molded polyethylene pile face,
(6) Blade length of from ⅝ in to 1 in [15 mm to 25 mm], and
(7) Total weight of at least 70 oz per sq. yd [2.37 kg per sq. m].

In lieu of the carpet drag texturing, the Contractor may use coarse broom texturing as approved by the Engineer.

Immediately after carpet dragging, texture the bridge deck slab surface with a transverse metal-tine pattern produced by using a device meeting the following characteristics and requirements:

(1) Equipped with steel tines from 4 in to 6 in [100 mm to 150 mm] long and from $^{1}/_{12}$ in to ⅛ in [2 mm to 3 mm] thick,
(2) Steel tines arranged to obtain randomized grooves from ⅛ in to $^{5}/_{16}$ in [3 mm to 8 mm] deep, and
(3) Variable spacing between tines from ⅝ in to 1 in [16 mm to 25 mm],

The Contractor may use other texturing equipment that will produce an equivalent texture as approved by the Engineer. Do not texture within 1 ft [300 mm] of curbs.

Hand-float the roadway surface of bridge structural slabs only to close up areas of exposed aggregate. Texture the roadway surface as approved by the Engineer to produce a final surface serrated, grooved, or roughened greater than that normally produced by conventional brooming. Do not tear out or loosen particles of coarse aggregate during texturing.

Produce a final surface meeting the following requirements:

(1) Free of porous spots and irregularities,
(2) Have the required crown,
(3) Does not vary by greater than ⅜ in [10 mm] on a bridge structural slab when checked with a 10 ft [3,000 mm] straightedge placed longitudinally, and
(4) Does not vary by greater than ⅛ in [3 mm] on a bridge deck slab when checked with a 10 ft [3,000 mm] straightedge placed longitudinally.

F.3.b(4) Bridge Slab Finish Under Curbs, Concrete Railings, Sidewalks, and Medians

Float the top surface of the bridge slab under curbs, concrete railings, sidewalks, and narrow medians producing a rough surface with the coarse aggregate embedded in mortar. Provide a smooth finished strip 2 in [50 mm] wide at the edge of the slab and under the roadway face of curbs, concrete railings, sidewalks, and narrow medians.

Choose one of the following alternates to prepare the top surface of the roadway slab directly under wide island type medians:

(1) Sandblast or shotblast the slab surface to remove laitance. Apply a cement bonding grout to the concrete consisting of portland cement mixed with water forming a slurry having the consistency of paint before placing median concrete. Place median concrete on wet bonding grout.
(2) Drill and anchor ½ in [13 mm] diameter dowels into the slab parallel to each median gutterline. Place the dowels 1 ft [300 mm] in from the gutterlines at

2 ft [610 mm] centers. Drill the dowels at least 4 in [100 mm] into the roadway slab and projecting 4 in [100 mm] into the median concrete. Grout the dowels with an approved epoxy or set with approved mechanical anchorages.

F.3.b(5) Bridge Slab Finish for Bottom Slab Concrete Box Girders

Strike off the top surface of the concrete in the bottom slab of concrete box girders and finish to within a ¼ in [5 mm] tolerance when checked with a 10 ft [3,000 mm] straightedge. The Department will not require additional finishing of this surface.

F.3.b(6) Surface Smoothness Check

After completion of the curing period, the Engineer will check the bridge slab surface for trueness, using a 10 ft [3,000 mm] straightedge for transverse and longitudinal checks. The Engineer will perform at least two longitudinal checks in each traffic lane and one check at each gutter. Sweep the surface clean of debris before the Engineer performs the checks.

Correct surfaces outside of the specified tolerance of a 10 ft [3,000 mm] straightedge in accordance with 2401.3.F.3.b(3), "Final Finish Texture," as required by the Engineer. Mill high spots. Remove concrete in low spots designated for removal to at least 2 in [50 mm] below required grade and then recast to the proper grade with an approved product. Restore removed tine texture. The nonconforming areas not satisfactorily corrected are subject to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

Remove high spots before filling adjacent depressions. If not placing a wearing course, coat areas corrected by surface grinding with a surface sealer listed on the Approved/Qualified Products List.

F.3.b(7) Preparation of Bridge Seats

Power grind the bearing areas of bridge seats to produce a surface that does not vary by greater than $^{1}/_{16}$ in [1.6 mm] from the required plane for steel base plates or by greater than ⅛ in [3.2 mm] for elastomeric bearing pads.

G Concrete Curing and Protection

Cure newly placed concrete by providing protection against the following:

(1) Rapid loss of moisture,
(2) Freezing temperatures,
(3) High temperatures,
(4) Abrupt temperature changes,

(5) Vibration exceeding a normal or reasonable limit as specified in the Bridge Construction Manual, Chapter 5-393.362, "Vibration Protection,"
(6) Shock waves, and
(7) Prematurely applied loads.

The Department defines the curing time as the period that begins with completion of concrete placement until completion of the curing as determined by the Engineer. For cast-in-place concrete, continue curing until the concrete attains a strength based on a percentage of anticipated compressive strength in accordance with 2461.2.F.3.b, "Gradation Designation," and the following:

Table 2401-1
Curing Requirements for Concrete Bridge Elements

Bridge Element	Percent of Compressive Strength
Bridge superstructures, unless otherwise specified	65
Diaphragms and end webs not a part of box girders and cast before the bridge slab	45
Railing	45
Sections not included in superstructures	45

When the plans show a permissible construction joint, the Contractor may begin subsequent concrete placement before completion of the curing period, unless otherwise shown on the plans.

Do not subject railing concrete to loading until the concrete has attained at least 60 percent of the anticipated compressive strength.

Do not allow heavy equipment, such as ready-mix trucks, on the bridge slab until after completion of the curing period. After the curing period, operate equipment at speeds less than 10 mph [16 km/h] to minimize shock waves. Restrict mixer revolution to agitation speed while on the bridge slab. Do not allow equipment with gross weight greater than 15 ton [14 metric ton] on the bridge slab for box girder and slab span bridges until one week after completion of the curing period.

The Engineer may allow some modification of the requirement for continuous curing without interruption for the purpose of setting wall or column forms on footings, but only when the Contractor protects the concrete from freezing or excessive drying during the interruption period. Resume curing at the earliest opportunity, and cure until completion. If using heated enclosures during the curing period, vent heaters and other equipment operated within the enclosure to prevent the buildup of carbon dioxide.

If the curing period ends after October 15, extend the curing time for bridge concrete to reach 70 percent of its anticipated compressive strength.

Compute strength gain percentages in accordance with Table 2401-2. During freezing or anticipated freezing temperatures, verify the computed strength by casting and breaking control cylinders in accordance with 2461.3.G.5, "Test Methods and Specimens." The Engineer will determine if the concrete has cured adequately if the two methods produce different results.

Table 2401-2
Determination of Strength Gain of Structural Concrete*, % per 24 h

Concrete Surface Temp. ‖ °F [°C]	Previously Accumulated Strength Gain † % of 28 Day Value													
	5	10	15	20	25	30	35	40	45	50	55	60	65	70
75 [24]	15	15	15	15	14	13	12	11	10	9	8	7	6	6
70 [21]	15	15	15	15	14	13	12	11	10	9	8	7	6	6
65 [18]	14	14	14	14	13	12	11	10	9	8	7	6	6	5
60 [16]	12	12	12	12	11	10	9	9	9	8	7	6	6	4
55 [13]	10	11	11	10	9	8	8	8	8	7	6	5	5	3
50 [10]	8	9	9	8	7	7	7	7	7	6	5	4	4	3
45 [7]	6	8	7	6	6	6	6	5	5	4	4	3	3	2
40 [4]	5	6	6	6	5	5	5	4	4	3	3	3	2	2

* Table values indicate incremental strength gain for 24 h periods at temperatures from 40 °F to 75 °F [4 °C to 24 °C] when the concrete has previously accumulated a specific strength gain percentage.

‖ Represents temperature at the surface of the concrete for the section (or part section) being cured.

† Represents accumulative strength gain of structural grade concrete made with type I cement as a percentage of its compressive strength if cured for 28 days at 75 °F [24 °C].

The Contractor may also use Table 2401-1 for concrete mixtures containing no greater than 15 percent Class C fly ash as a cement substitution. Use control cylinders to determine strength gain for concrete containing ground granulated blast furnace slag in any amount or cement substitutions greater than 15 percent.

If using control cylinders to determine if concrete attained minimum strength, cure in accordance with the following:

(1) Cure sections or units requiring anticipated compressive strength of at least 65 percent for at least 96 h., and
(2) Cure sections or units requiring anticipated compressive strength of at least 45 percent of for at least 72 h.

Do not credit strength gain for any period of time when the concrete does not indicate the presence of a surface-moist condition or when the temperature at the concrete surface is less than 40 °F [5 °C]. The Engineer will consider concrete sections defective if exposed to freezing temperatures or excessive drying during the curing period. Perform the following for defective sections as directed by the Engineer:

(1) Remove and replace,
(2) Remove to a depth as directed by the Engineer and replace,
(3) Sandblast and overlay with epoxy mortar or epoxy with sand broadcast, or
(4) Cover with an epoxy seal coat.

The Department may reduce payment for defective concrete sections as directed by the Engineer.

During freezing temperatures, seal or temporarily fill anchor bolt holes and other depressions that may collect water with closed cell polystyrene or other satisfactory material.

Provide a slab placement and curing plan for each bridge to the Engineer for approval at least two weeks before placement. Include the following information in the placement and curing plan:

(1) Anticipated concrete delivery rates;
(2) Estimated start and finish time;
(3) Material, labor and equipment proposed for placing, finishing, and curing including placement of wet burlap, soaker hose, or other system to maintain the deck in a moist condition during the curing period;
(4) Number of work bridges proposed for use;
(5) Number of people responsible for the various tasks; and
(6) Bulkheading methods and materials proposed for use if the Contractor cannot maintain the proposed concrete placement rates.

Attend a pre-placement meeting 2 days to 4 days before the slab placement to review the information and details provided in the placement and curing plan.

After completing the tine texturing for bridge deck slab and after free water has disappeared from the surface, apply a membrane curing compound in accordance with 3754.B, "Requirements, Poly-Alpha Methylsytrene (AMS) Membrane Curing Compound." Apply curing compound using approved power-operated spray equipment. Provide a uniform, solid white, opaque coverage of membrane cure material on exposed concrete surfaces (equal to a white sheet of paper). Place the membrane cure within 30 min of concrete placement unless otherwise directed by the Engineer. If the Contractor fails to meet these requirements, the Department may

reduce the contract unit price for the concrete item in accordance with 1503, "Conformity with Contract Documents."

Provide curing compound for moisture retention until the placement of a conventional wet curing. Apply conventional wet curing when walking on the concrete will not produce imprints deeper than $^{1}/_{16}$ in [1.6 mm]. Keep the deck slab surface continuously wet for an initial curing period of at least 7 calendar days including weekends, holidays, or both if these fall within the 7-calendar-day curing period.

Apply conventional wet curing to bridge slabs immediately following the finishing machine or air screed. Use conventional wet curing consisting of pre-wetted burlap covered with white plastic sheeting. Place the burlap to cover 100 percent of the deck area without visible openings. Place the wet curing within 30 min after the finishing machine completes the final strike-off of the concrete surface. If the Contractor fails to place the wet curing within 30 min, the Department will monetarily deduct $500 for every 5 min period, or any portion thereof, after the initial time period until the Contractor places the wet curing as approved by the Engineer. The Department may assess the deduction more than once. Keep the slab surface continuously wet for an initial curing period of at least 7 calendar days. Use a work bridge to follow the finish machine. Provide an additional center rail on wide bridges, if necessary.

Protect concrete exposed to wind, sunlight, or temperatures that cause surface drying during the curing period by placing a wet covering as soon as the set of the concrete will allow placing of the materials without marring the surface. Do not use membrane curing compound as an alternative for wet curing, except for slope paving, footings, and other sections later covered with backfill material. Do not use membrane curing compound on an area planned for covering by and bonding to subsequent concrete construction.

Maintain a moist surface condition during the curing period.

The Engineer will accept the curing period as complete when the Contractor meets the requirements of this section.

H Slipforming of Bridge Railing

Instead of using conventional forming methods, the Contractor may slipform concrete bridge railing in accordance with the following requirements:

H.1 Reinforcement Bars

Do not tack weld reinforcement bars. Use additional reinforcement ties at rebar intersections to maintain the rigidity of the reinforcement bar cage.

Place reinforcement in accordance with 2472, "Metal Reinforcement."

H.2 Concrete Mix

Use 3Y16 concrete mix design for slipformed railing. The Engineer will reject concrete with a slump greater than 1¼ in [30 mm].

H.3 Construction Requirements

Perform the following construction requirements:

(1) Check the clear distance from the slipform template to the reinforcement bars in the presence of the Engineer. During this check, attach fill strips to the slipformer to detect areas of reinforcement bars that may encroach on the required concrete cover. Perform this check for the full distance of the anticipated subsequent pour area, less any areas of hand-formed rail.
(2) Edge the joints with a small radius edger before placing the curing materials.
(3) If shown on the plans, saw-cut the top portion of the joint to the full depth within 24 h of the concrete placement to a width of ⅜ in [10 mm].
(4) Seal the joint with a silicone sealer listed on the Approved/Qualified Products List. Seal saw-cut joints to a depth of at least 1 in [25 mm].
(5) Conventionally form the ends of the railing with the guardrail plate in place.
(6) Conventionally form the railing sections for a distance of at least 4 ft [1,200 mm] on each side of areas that the slipform machine cannot access.
(7) Maintain the gutter line or railing face location as shown on the plans. The Contractor may increase the slab overhang by no greater than 1 in [25 mm] and batter the outside of the barrier or railing by no greater than 1 in [25 mm].
(8) Use either chamfer or radii strips at horizontal and vertical edges.
(9) Restrict the time interval for delivery of ready-mix concrete to no greater than 1 h when adding the air-entraining agent to the mix at the central plant.
(l0) Wet cure the railing by applying conventional wet curing to the railing immediately following the machine. Use conventional wet curing consisting of pre-wetted burlap covered with separate white plastic sheeting or poly-coated burlap. Place the burlap to cover 100 percent of the railing area without visible openings. Place the wet curing within 30 min after the machine completes the final strike-off of the concrete surface. If the Contractor fails to place the wet curing within 30 min, the Department will monetarily deduct $500 for every 5 min period, or any portion thereof, after the initial time period until the Contractor places the wet curing as approved by the Engineer. The Department may assess the deduction more than once. Keep the railing surface continuously wet for an initial curing period of at least 7 calendar days.

I Joint and Crack Sealing

I.1 Joint Sealing

Place joint sealer material of the type as shown on the plans or special provisions in accordance with 2301.3.L, "Joint Sealing."

Seal construction joints and saw cuts in the deck, curb face, sidewalk, and median with a concrete joint sealer listed on the Approved/ Qualified List for "Moisture Cured Polymeric Joint Sealers," or in accordance with 3723, "Joint and Crack Sealer (Hot-Poured Elastic Type)," or 3725, "Hot-Poured, Extra-Low Modulus, Elastic-Type Joint and Crack Sealer."

I.2 Crack Sealing

The Engineer will visually inspect the bridge deck slab, including decks of pedestrian bridges, and will mark cracks that require sealing appearing on the top surface of the slabs. Seal cracks with a bridge surface and crack sealer listed on the Approved/Qualified Products List. Apply the sealer as recommended by the manufacturer.

2401.4 METHOD OF MEASUREMENT

A Structural Concrete

The Engineer will separately measure each grade or mix of structural concrete based on the dimensions shown on the plans.

If measuring bridge slab concrete by area, the Engineer will base the measurement on end-of-slab stationing and out-to-out transverse dimensions of the slab.

If measuring sidewalk concrete by area, the Engineer will base the measurement on the end-to-end bridge dimension along the centerline of the sidewalk and the overall width of the sidewalk block.

If measuring raised median concrete by area, the Engineer will base the measurement on the end-to-end slab dimension and overall width of the median.

The Engineer will base the measurement of median barrier concrete on the end-to-end slab dimensions.

The Engineer will measure concrete railings or concrete bases for metal railing based on the horizontal lengths between the outside end faces of railings or end posts.

The Engineer will not deduct for the volumes of concrete displaced by metal reinforcement, structural steel sections, floor drains, conduits, pile headers, chamfer

strips with side dimensions no greater than 2 in [50 mm], or for variations in camber and deflections as shown on the plans.

The Engineer will not increase concrete quantity measurements for extra concrete used to secure true conformity of the elevation profile and cross section in the finished roadway slab as shown on the plans. The Engineer will consider floor thickness as the thickness shown on the plans as the minimum thickness, unless the plans show other dimensions. The Engineer will not include concrete for keyways in quantity computations.

B Metal Reinforcement 2472.4

C Structure Excavation

If the plans show separate items for one or more classes of structure excavation, the Department will classify the excavation in accordance with 2451.3.B.2, "Types," and the Engineer will measure the excavation in accordance with 2451.4.A, "Structure Excavation," for cast-in-place structures.

D Granular Material 2451.4.B

2401.5 BASIS OF PAYMENT

The contract unit price for structural concrete of each grade mix includes the cost of constructing the bridge structure complete in place, except for costs with a separate contract unit price as shown on the plans.

If the Contractor elects to pour the concrete end diaphragms with the bridge slab, using the same concrete mix for the diaphragms as used for the slab, the Department will pay the Contract bid price for end diaphragm concrete and will not pay for the end diaphragm concrete using the relevant contract unit price for the bridge slab concrete.

The contract pound [kilogram] prices for *Reinforcement Bars*, *Steel Fabric*, and *Spiral Reinforcement* includes the costs of providing, fabricating, delivering, and placing the metal reinforcement. The contract pound [kilogram] price for *Reinforcement Bars Delivered* includes the cost of providing, fabricating, and delivering the material. The contract pound [kilogram] price for *Reinforcement Bars Placed* includes the costs of placing the material in the structure as specified.

The Department will pay for structure excavation, soil bearing tests, and backfill materials in accordance with 2451.5, "Basis of Payment, Structure Excavations and Backfills."

The Department contract unit price for the relevant concrete bridge construction contract item includes the cost of providing and placing joint sealer and crack sealer.

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

Item No.:	Item:	Unit:
2401.501	Structural Concrete (Mix No.)	cubic yard [cubic meter]
2401.511	Structural Concrete (Mix No.)	square foot [square meter]
2401.512	Bridge Slab Concrete (Mix No.)	square foot [square meter]
2401.513	Type ___ Railing Concrete (Mix No.)	foot [meter]
2401.514	___ Median Barrier Concrete (Mix No.)	foot [meter]
2401.515	Sidewalk Concrete (Mix No.)	square foot [square meter]
2401.516	Raised Median Concrete (Mix No.)	square foot [square meter]
2401.521	Structure Excavation, Class ___	cubic yard [cubic meter]
2401.539	Reinforcement Bars Delivered	pound [kilogram]
2401.540	Reinforcement Bars Placed	pound [kilogram]
2401.541	Reinforcement Bars ___	pound [kilogram]
2401.542	Steel Fabric ___	pound [kilogram]
2401.543	Spiral Reinforcement	pound [kilogram]

2402 STEEL BRIDGE CONSTRUCTION

2402.1 DESCRIPTION

This work consists of the erection of those portions of bridges and structures that are made of structural steel and miscellaneous metals.

2402.2 MATERIALS

A Structural Metals 2471

B High Strength Bolts, Direct Tension Indicators, and Pin Bolts 3391

C Elastomeric Bearing Pads 3741

2402.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Structural Steel Components of Concrete Bridges 2401

A.2 Steel Piling 2452

A.3 Assembly

Assemble bridge components in accordance with the match markings and erection plans using procedures outlined in the contract. If the contract does not specify

assembly procedures, assemble in accordance with recognized practices and as shown on the approved shop detail drawings.

B Handling and Storage of Materials

Store girders and beams in an upright position. Keep materials clean, dry, and in a properly drained area. Cover and shelter members that will be stored for greater than 3 months and provide for air circulation around the members.

C Straightening Bent Materials

Straighten plates, angles, and other shapes using methods that will not fracture or damage the metal. Do not heat the metal unless allowed by the Engineer, in conjunction with the Structural Metals Engineer. If allowed and before performing any straightening operations, submit a straightening procedure to the Engineer for review and approval by the Structural Metals Engineer. Do not heat metal to temperatures greater than 1,200 °F [650 °C].

After heating and straightening, allow the metal to slowly cool before inspecting for evidence of fracture or other damage. Repair galvanized and metallized coating in accordance with 2471, "Structural Metals."

D Falsework Design and Construction

At least six weeks before starting construction of the structural steel erection falsework, provide the Engineer with three copies of the detailed plans and specifications and two copies of the associated calculations for the proposed system to construct the falsework. Design the falsework to meet the requirements of AASHTO *Guide Design Specifications for Bridge Temporary Works* and AASHTO *Standard Specifications for Highway Bridges*. Have the plans and specifications prepared by a Professional Engineer, checked by a second Professional Engineer for completeness and accuracy, and certified by one of the Professional Engineers. Ensure the documents include details to allow the construction of the proposed system by reference to the plans and specifications only. Show the design criteria on the first sheet of the plans.

Provide the following in the falsework plans, as a minimum:

(1) The size of load-supporting members and transverse and longitudinal bracing,
(2) Connection details for load-supporting members,
(3) Design-controlling dimensions, including the following:

    (3.1) Beam length and spacing,
    (3.2) Post location and spacing,
    (3.3) Overall height of falsework bents,

(3.4) Vertical distance between connectors in diagonal bracing, and
(3.5) Other dimensions critical to the design.

(4) The location and method used to adjust falsework to final grade.

Do not erect the structural steel until meeting the following requirements:

(1) Provide the Engineer with plans and specifications meeting the above requirements,
(2) Ensure the Professional Engineer certifying the plans and specifications for the falsework and forms inspects the falsework after erection, and
(3) Ensure the Professional Engineer inspecting the as-constructed falsework certifies in writing the approval of the as-constructed falsework.

Provide timber meeting the following requirements for falsework piles or members;

(1) Sound wood,
(2) Straight, and
(3) Good condition.

Provide straight steel members of adequate strength for the intended use.

Maintain the falsework in place until after the completion of the bolting of the field connections and the Professional Engineer designer of the falsework approves the release of falsework supports. Remove falsework in accordance with 2401, "Concrete Bridge Construction."

Except for attachment of screed rail support pipes, do not weld on primary stress-carrying members of the bridge structure to fasten appurtenances not shown on the plans or on the approved detail drawings. The Contractor may weld screed rail support pipes to the top flange with ¼ in [6 mm] longitudinal fillet welds no greater than 2 in [50 mm] long. Do not weld in the negative moment area, as shown on the plans as "Area A," of the top flange of primary stress-carrying members of the bridge structure.

Prepare the base metal and weld during ambient weather conditions in accordance with 2471.3.F, "Structural Welding."

E Preparation and Erection

Before placing bearing plates and shoes, prepare the corresponding concrete surfaces using methods approved by the Engineer so as to provide a uniform bearing surface.

Immediately before assembly, remove temporary protective coatings from pins and pin holes, and clean the contact surfaces at connections of foreign matter. Clean

the contact area between pins and bushings to bare metal for pin holes provided with bronze bushings before assembling.

Paint surfaces inaccessible after erection as required before fit-up.

F Field Fit-up

Erect structural steel members in a manner that will provide safety to the workers, inspectors, and the public at all time, and without damaging the steel members. Temporarily anchor, brace, and stabilize primary members, such as beams and girders, as erected to prevent sliding, tipping, buckling, or other movement, before placing diaphragms.

If the plans show active vehicular or railroad traffic to travel beneath beams before the complete erection of the beams and diaphragms in a span, submit an erection plan to the Engineer detailing the temporary works required to brace and stabilize beams. Have the erection plan prepared by a Professional Engineer, checked by a second Professional Engineer for completeness and accuracy, and certified by one of the Professional Engineers.

The erection plan will specify the required bolt tension and the numbers of bolts to install in permanent diaphragm connections and in bracing to stabilize the beam. Use struts, bracing, tie cables, and other devices used for temporary restraint of a size and strength capable of withstanding the stresses developed. Erect and brace at least two adjacent girders, including diaphragms and fully tightened bolts, in any one span before suspending operations for the day.

The Department defines "fully assembled" as the assembly of transversely interconnected beams, girders, diaphragms, and floor beams but not necessarily stringers, expansion devices, or other members that have no significant affect on the main structural members or that have an independent adjustment capability.

If the contract requires "fully assembly," fully assemble simple spans before starting permanent bolting. If the contract required "full assembly" of continuous spans, do not begin permanent bolting on a span in the continuous series until completion of the full assembly of the immediately adjacent spans in the same series. The Engineer may allow permanent bolting of field splices in beams for continuous spans on the ground before full assembly of adjacent spans, provided the beams to be spliced are positioned on firm supports adjusted to provide the alignment, camber, grade, and skew shown on the plans. If using shoring towers to correct alignment, camber, grade, and skew, the Contractor may permanently bolt continuous beams in one span before full assembly of adjacent spans.

Before placing the permanent connectors, fill half of the holes in splices in primary stress-carrying members with erection pins and bolts (half bolts and half pins

with balanced distribution). For primary stress-carrying members carrying live loads during erection, use additional bolts and erection pins to compensate for the additional loads. Provide connections for primary members, diaphragms, and other secondary members with a sufficient number of holes filled with erection pins and bolts to draw plates into full contact and to properly match the holes before placing the permanent connectors.

Before assembling, coat pins and pinholes, including pinholes with bronze bushings, with a lubricant listed on the Approved/Qualified Products List.

Provide erection bolts in the same diameter as the permanent connectors. Do not use erection pins larger than the diameter of the hole or smaller than the hole diameter minus $^{1}/_{32}$ in [1 mm]. Unless the contract requires otherwise, use erection washers with erection bolts.

Draw pin nuts tight, except for pin nuts with cotter keys. Upset the exposed thread at the face of the nut by centerpunching to prevent backoff. If tightening pin nuts with cotter keys ensure the cotter key can be freely inserted and the pin is free to turn without binding under the Lomas nut.

Do not place permanent connectors before the Engineer approves the fully assembled required section. Make vertical adjustments at splice points as directed by the Engineer, based on elevations taken at these points. Shift the spans if required to provide for proper anchorage and expansion device locations.

Check bearing plates and assemblies for contact before placing the permanent connectors. Correct deviations from full bearing between parts, or between the bridge seat and the bearing plates as approved by the Engineer. Readjust diaphragms, cross frames, or splice plates, if required to correct deviations. For extreme deviations, the Engineer may direct re-cambering or other re-fabrication procedures. The Contractor may use properly shaped and sized fills or shims to correct minor deviations as approved by the Engineer.

G Connections

Unless the contract requires or the Engineer approves otherwise, provide field connections made with high strength bolts or pin bolts. Use the same type of fastener throughout the structure, unless the Engineer approves otherwise.

G.1 Welded Connections

Weld field connections in accordance with 2471, "Structural Metals."

G.2 Connections Using High Strength Bolts

G.2.a General

Install bolts with heads outward for the webs of fascia girders. Install bolts with heads downward for the flanges of beams and girders spanning highways, streets, roadways, and walkways.

G.2.b Bolted Parts

Ensure the slope of surfaces of bolted parts in contact with the bolt head and nut is no greater than 1:20 with respect to a plane normal to the bolt axis. Assemble bolted parts to fit solidly together. Do not separate bolted parts by gaskets or other interposed compressible material.

Assemble joint surfaces, including those adjacent to the bolt heads, nuts, or washers, free of the following:

(1) Scale, except tight mill scale,
(2) Dirt,
(3) Loose scale,
(4) Burrs,
(5) Other foreign material, and
(6) Other defects preventing solid seating of the parts.

Ensure contact surfaces of friction-type joints are free of coating materials such as oil, galvanizing, and rust inhibitors.

G.2.c Installation

G.2.c(1) Bolt Tension

Clean contaminants and corrosion from the threaded portions of bolts and nuts, before installing. Lubricate and dye nuts in accordance with 3391, "Fasteners."

Use the turn-of-nut or direct tension method to tighten nuts on threaded bolts. For limited clearances for bolts and wrench operations, tighten the bolts using either method to turn the bolt while preventing the nut from rotating.

If using impact wrenches, provide wrenches capable of performing the required tightening of each bolt in 10 s.

Tighten each fastener to provide the minimum bolt tension shown in Table 2402-1 when all fasteners in the joint are tight:

Table 2402-1 Bolt Tension	
Bolt Size, *in [mm]*	**Minimum Tension*, *Kips [KN]***
¾ [19]	28 [125]
⅞ [22]	39 [173]
1 [25]	51 [227]
1⅛ [29]	56 [249]
1¼ [32]	71 [316]
* Equal to the proof load meeting the requirements of the length measurement method in ASTM A 325	

G.2.c(2) Washers

Provide fasteners with a hardened washer placed under the nut or bolt head being turned during tightening.

Provide high strength bolts with a hardened washer under the bolt head and the nut if used in conjunction with full sized punched holes.

If an outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a smooth beveled washer to compensate for the lack of parallelism.

G.2.c(3) Direct Tension Indicator (DTI) Tightening

If using DTIs to provide the minimum bolt tensions in Table 2402-1, install the indicators, including snug tight fit-up, as recommended by the manufacturer except for the following:

(1) Insert a hardened flat washer between the DTI and fastener if bolting through a short-slotted or oversized hole in accordance with 2471.3.H.1.a, "Special Assembly."
(2) If installing a DTI under the turned element, use a hardened washer to separate the turned element from the DTI meeting the requirements of AASHTO LRFD Bridge Construction Specification 11.5.6.4.7.
(3) Provide compressible washer-type indicators meeting the requirements of ASTM F 959.
(4) Inspect DTIs as recommended by the manufacturer, except provide a device capable of measuring deformation of the direct tension indicator and capable of insertion into at least one space between the protrusions.

G.2.c(4) Turn-of-Nut Tightening

The Department defines "snug tight" as the minimal use of an impact wrench or the full effort of an adult using an ordinary spud wrench to bring all plies of the

connection together in firm contact. Use enough bolts tightened to a "snug tight" condition to bring all parts of the joint into full contact. Complete the initial operation in accordance with 2402.3.F, "Field Fit-up." Place bolts in the remaining holes in the connection and snug tight. Match mark and additionally tighten nuts and bolts by the amount of nut rotation specified in this section, and progress with tightening systematically from the most rigid part of the joint to its free edges. Do not rotate the part not turned by the wrench.

For coarse thread heavy hexagon structural bolts and heavy hexagon semi-finished nuts, rotate nuts from snug tight condition in accordance with the following:

(1) If both faces are normal to bolt axis (with or without use of beveled washers), rotate nuts ⅓ turn for bolt lengths no greater than 4 diameters, ½ turn for bolt lengths greater than 4 diameters to 8 diameters, and ⅔ turn for bolt lengths greater than 8 diameters to 12 diameters.
(2) If one face is normal and the other is sloped no greater than 1:20 (beveled washers not used), rotate nuts ½ turn for bolt lengths no greater than 4 diameters, ⅔ turn for bolt lengths greater than 4 diameters to 8 diameters, and $^{5}/_{6}$ turn for bolt lengths greater than 8 diameters to 12 diameters.
(3) If both faces are sloped no greater than 1:20 (beveled washers not used), rotate nuts ⅔ turn for bolt lengths no greater than 4 diameters, $^{5}/_{6}$ turn for bolt diameters from 4 diameters to 8 diameters and, 1 turn for bolt lengths from 8 diameters to 12 diameters.

Measure bolt length from the underside of head to extreme end of the bolt. Measure nut rotation as relative to bolt regardless of the element (nut or bolt) being turned. Rotate nuts within the allowable tolerance of $^{1}/_{6}$ turn over and zero rotation under the rotation specified in list items (1), (2), and (3) above.

G.2.d Inspection

The Engineer will observe the installation and tightening of bolts to determine that the tightening procedure and bolt tightening tensions comply with the requirements in this section. The Engineer will inspect the test bolt tension in accordance with the following procedure unless otherwise specified:

G.2.d(1) Calibration of Inspection Wrench

Provide a manual inspection wrench calibrated in accordance with the following:

Test each combination of bolt production lot, nut lot, and washer lot as an assembly. Test 3 assemblies per combination. Individually place bolts of the same grade, size, and condition, as the bolts under inspection in a calibration device capable

of indicating bolt tension. Place a washer under the part turned in tightening each bolt. Provide test bolts in the same length as the bolts used in the structure.

Tighten each test bolt in the calibration device to an initial condition equal to 15 percent of the specified bolt tension and then to the minimum tension specified for its size in accordance with Table 2402-1, "Bolt Tension." Apply the inspecting wrench to the tightened bolt and turn the nut or head 5 degrees, or 1 in [25 mm] at 12 in [300 mm] radius in the tightening direction. Measure the torque applied. Average the torque as measured in the tests of 3 bolts and use this "job-inspecting torque" in accordance with 2402.3.G.2.d(3), "Inspection Procedure for Direct Tension Indicators (DTI)."

Provide the inspection wrench and the bolt tension-indicating device as specified in this section. Allow the Engineer to witness the prescribed calibration tests.

During calibration in accordance with 2402.3.G.2.d(1), ensure the bolt and nut withstand rotation to two times the number of turns as specified in 2402.3.G.2.c(4), "Turn-of-Nut Tightening," without showing visible evidence of stripping the threads or failure of the bolt or nut.

G.2.d(2) Inspection Procedure for Calibrated Wrench

At the Engineer' option, either the Engineer or the Contractor in the Engineer's presence may operate the inspecting wrench as follows:

(1) Inspect the tightened bolts in the structure by applying, in the tightened direction, the inspecting wrench and its job-inspecting torque to a randomly selected 10 percent of the bolts or at least 2 bolts in each connection.
(2) Accept connections as properly tightened if nut or bolt heads do not turn when applying the job-inspecting torque as indicated in item (1) above. If a nut or bolt head turns during the application of job-inspecting torque, apply the job-inspecting torque to all bolts in the connection. Retighten and re-inspect nuts or bolt heads turned by the job-inspecting torque. The Contractor may retighten the bolts in the connection and resubmit the connection for the specified inspection procedure.

G.2.d(3) Inspection Procedure for Direct Tension Indicators (DTI)

Check the performance of the DTIs in the field before bolting.

Use the gap between the protrusions to indicate the tension in the bolt.

At the Engineer's option, either the Engineer or the Contractor in the Engineer's presence may operate the tapered leaf thickness (feeler) gauge as follows:

(1) An initial visual inspection of the DTIs after the bolts are snug tight. Remove and replace DTIs completely crushed during snugging.
(2) Place a feeler gauge into a randomly selected 10 percent of the DTIs or at least 2 DTIs in each connection to inspect the tightened bolts in the structure. Measure the gap between the washer and the bolt head in the spaces between the protrusions using the tapered leaf thickness (feeler) gauge. Tighten the bolt to 1.05 times the required installation tension. Ensure an average gap for coated DTIs of at least 0.005 in [0.125 mm]. Do not tighten DTIs beyond crushing of the protrusion.
(3) If the feeler gauge can be inserted into all of the spaces between the protrusions of a DTI, retighten the bolt and retest.
(4) If the feeler gauge cannot be inserted into any of the spaces between the protrusions of more than 10 percent of the DTIs during the inspection, replace the affected bolts.

G.3 Connections Using Pin Bolts

Install pin bolts in accordance with 2402.3.G.2.a, "Connections Using High Strength Bolts, General," 2402.3.G.2.b, "Bolted Parts," and the following:

Provide a special tool capable of the following to drive the pin bolts:

(1) Partial swaging of the collars to allow for adjustment during erection when pinning and bolting the work,
(2) Producing the required tension in the bolt,
(3) Swaging the collar into the annular locking grooves, and
(4) Forming the collar into the size and shape recommended by the manufacturer before the pin tail breaks.

Provide a device capable of indicating the actual bolt tension to test the pin bolts before use. Provide at least 3 typical bolts of each size and length for tests from the supply of bolts used in the work. Test other bolts during the bolting operation, as directed by the Engineer. Use the same installation tool used for tightening and swaging the bolts for the field connections to apply tension in the bolts during the testing procedures.

Recover the expendable pin tails from the driving tool as the pin tails break from the bolt. Do not allow expendable pin tails from the driving tool to drop and create hazards.

Obtain the Engineer's approval of the testing and installation procedures for pin bolts.

H Setting Anchor Bolts

Unless the contract requires otherwise, drill holes for anchor bolts to the diameter and depth shown on the plans. Accurately set and fix the bolts with portland cement grout that completely fills the holes. During freezing weather, the Contractor may use other products, as approved by the Engineer, to set and fix the bolts.

Set nuts for anchor bolts as shown on the plans and provide for clearance where required. Center punch the bolt thread at the face of the nuts to upset the thread and prevent back-off.

Use templates to accurately set anchor bolts at the proper location and elevation that are to be cast in the concrete.

I (Blank)

J Bearing Assemblies and Hangers

Plumb rocker bearings and hangers at 45 °F [7 °C]. Consider elongation resulting from total load deflection when setting these devices.

K Expansion Joint Devices

Provide expansion joint devices by the type shown on the plans as given in the item name. The type number identifies the required minimum movement capability in inches [millimeters] of the device as installed. The maximum movement capability of the joint device as installed may range up to 50 percent greater than the specified minimum.

Provide shop detail drawings for expansion joint devices in accordance with 2471.3.B, "Shop Detail Drawings." Include detailed instructions for installation and tabulated joint openings for the various temperatures shown on the plans.

The Contractor may use joint devices with movement capability greater than 50 percent of the specified minimum if the joint devices meet the functional requirements and the shop drawings indicate the sizes proposed.

Provide steel components of expansion devices in lengths that will facilitate installation under roadway and traffic conditions existing during placement. Do not splice in the gland except at "tee" intersections requiring vulcanized splices. Provide smooth faced welded gutter sections at the grip surface.

Galvanize structural steel surfaces of the expansion devices, including anchorages, after manufacture in accordance with 3394, "Galvanized Structural Shapes." Provide bolts for roadway sections of the expansion devices that meet the Type 316 requirements in 3391.2.E, "Stainless Steel Bolts." Provide bolts for curb, sidewalk, median, and barrier cover plates that meet the Type 316 requirements in 3391.2.E, "Stainless Steel Bolts," or galvanize in accordance with 3392, "Galvanized

Hardware." Straighten steel extrusions and roadway plates after galvanizing to a tolerance of ±⅛ in [3mm] in 10 ft [3 m].

Install expansion devices in accordance with the shop drawings and as directed by the Engineer. Remove joint-forming material from the joint opening.

Provide a watertight expansion joint installation. Test the watertight quality of the complete expansion joint installation at all points by filling the joint opening or portions thereof with water as directed by the Engineer, then observe the test for 1 hour.

L Field Painting

After completing the erection work, clean and paint structural metals in accordance with 2478, "Organic Zinc-Rich Paint System," or 2479, "Inorganic Zinc-Rich Paint System," whichever is applicable.

2402.4 METHOD OF MEASUREMENT

The Engineer will measure structural metals placed in bridges or other structures by weight, length, area, or unit complete in place.

A Weight

The Engineer will calculate the weight of all structural steel shapes, structural steel plates, steel sheets, and steel bars based on the net finished dimensions as shown on the plans using the theoretical density of 490 lb per cu. ft [7,849 kg per cu. m]. The Engineer will not make allowances for the fabrication of girder, cambers, haunches, and sweeps, or for the machining of surfaces. The Engineer will not make deductions for open holes and incidental bevels or chamfers. The Engineer will increase the summation of the weights of structural steel, exclusive of steel piling, by 1.5 percent to compensate for incidental metals such as the following:

(1) Permanent bolts no greater than 6 in [150 mm] long,
(2) Shop or field high strength bolts,
(3) Field shims,
(4) Weld metal deposits,
(5) Extra material used to make weld procedure tests,
(6) Shop galvanizing,
(7) Metallizing, and
(8) Overruns, etc. for which the Engineer does not make measurements.

The Engineer will calculate the weight of bolts greater than 6 in [150 mm] long and tie rods used for connecting structural steel parts, including nuts and washers,

from the nominal weight shown in the AISC *Manual of Steel Construction*. The Engineer will include this weight with the measurement of structural steel.

The Engineer will calculate the weight of non-incidental metals, other than steel, using the theoretical densities shown in the AISC *Manual of Steel Construction* using the above measurement limitations, except the Engineer will not measure the weight of bolts, nuts, rivets, washers used in the fabrication and erection, and will not apply a percentage increase to the weight.

B Length

B.1 Metal Railing

Unless otherwise shown on the plans, the Engineer will measure the length based on the sum of the lengths of the various sections as shown on the plans and as measured at the base of the rail.

B.2 Pipe

Unless otherwise shown on the plans, the Engineer will measure the length based on the sum of the lengths of all the runs, measured on the centerline of the pipe and fittings.

B.3 Expansion Joint Devices

The Engineer will measure expansion joint devices of each type by length based on the out-to-out distance along the centerline of each expansion device.

B.4 Other Items

The Engineer will base linear measurement of items not specifically covered herein between the limits as shown on the plans.

C Area

The Engineer will measure the area based on the net finished dimensions unless otherwise shown on the plans. The Engineer will not make deductions for open holes.

D Complete Unit

The Engineer will include the component parts in the measurement of the complete assembly of a unit.

2402.5 BASIS OF PAYMENT

The contract unit price for the specific structural steel item includes the cost of temporary support and restraint in accordance with 2402.3.F, "Field Fit-up."

The contract unit price for structural metals includes the weight of all structural metals in a single total.

The contract unit price for *Furnishing Structural Steel, (Spec. No.)* includes the cost of providing and fabricating in accordance with 2471, "Structural Metals;" surface preparation and shop coat painting in accordance with 2478, "Organic Zinc-Rich Paint System," or 2479, "Inorganic Zinc-Rich Paint System," unless otherwise required by the contract; and delivering the materials to the project site.

The contract unit price for *Erecting Structural Metals* includes the cost of erecting the structural metals complete in place and, if the plans do not include a contract pay item for field coat painting, the cost of field coat painting.

The contract unit price for *Structural Steel, (Spec. No.)* includes the cost of providing and fabricating in accordance with 2471, "Structural Metals;" surface preparation and shop coat painting in accordance with 2478, "Organic Zinc-Rich Paint System," or 2479, "Inorganic Zinc-Rich Paint System," unless otherwise required by the contract; delivering the materials to the project site, and erecting the materials.

The contract unit price for metal railings includes the cost of coating, metal posts, fittings, castings, anchor bolts, and accessories required for erection.

The contract unit price for *Expansion Joint Devices, Type* ___ includes the cost of providing and installing the devices complete in place, including curb, sidewalk, median, barrier sections, coverplates, and waterproof glands.

The contract unit price for *Elastomeric Bearing Pad, Type* ___ and *Elastomeric Bearing Assembly, Type* ___ includes the cost of providing and installing the pads or assemblies complete in place.

The Department will pay for steel bridge construction on the basis of the following schedule:

Item No.:	Item:	Unit:
2402.504	Sheet Metal, (Spec. No.)	pound [kilogram]
2402.521	Structural Steel, (Spec. No.)	pound [kilogram]
2402.532	Furnishing Structural Steel, (Spec. No.)	pound [kilogram]
2402.533	Erecting Structural Metals	pound [kilogram]
2402.546	Floor Drain, Type ___	each
2402.555	Rigid Steel Conduit	pound [kilogram]
2402.560	Metal Pipe (Spec. No.)	pound [kilogram]
2402.583	Ornamental Metal Railing ___	linear foot [meter]
2402.584	Structural Tube Railing Design ___	linear foot [meter]
2402.585	Pipe Railing	linear foot [meter]
2402.586	Plate Railing	linear foot [meter]

Item No.:	Item:	Unit:
2402.590	Elastomeric Bearing Pad, Type ___	each
2402.591	Expansion Joint Devices, Type ___	linear foot [meter]
2402.592	Elastomeric Bearing Assembly, Type ___	each
2402.595	___ Bearing Assembly	each

2403 TIMBER BRIDGE CONSTRUCTION

2403.1 DESCRIPTION

This work consists of constructing timber bridge structures, or portions of bridge structures made of timber.

2403.2 MATERIALS

A Timber

A.1 Stress-rated Timber and Lumber

Provide stress-rated timber and lumber in accordance with 3426, "Structural Timber" for the grade specified.

Provide lumber for laminating meeting the following requirements:

(1) Graded in accordance with 3426, "Structural Timber;"
(2) Allowable working stress, base resistance, or both values, as required by the contract; and
(3) Meeting the requirements of ANSI/AITC A190.1

A.2 Timber Piling.....3471

A.3 Other Lumber 3457

B Preservative Treatment

Provide timber treated with preservative in accordance with 3491, "Preservatives and Preservative Treatment of Timber Products," unless otherwise required by the contract.

C Adhesives

Provide adhesives meeting the requirements for wet-use (waterproof) in accordance with ANSI/AITC A 190.1 and AITC 405.

D Dowels

Provide dowels made of hot rolled steel in accordance with 3306, "Low-Carbon Structural Steel" and galvanized in accordance with 3394, "Galvanized Structural Shapes."

E (Blank)

F Plank for Laminated Floors

Provide plank strips for laminated floors surfaced on one side to a uniform thickness no greater than 3 in [75 mm] (SIS). Unless the plans show otherwise, the Department will not require surfacing to a uniform width.

Provide 50 percent of the strips at least 16 ft [5 m] long. Use strips at least 6 ft [2 m] long, except to fill skews. Provide strips in variable lengths to ensure joints on one stringer are no closer than each third strip.

G (Blank)

H Railings

Provide timber and lumber for railings free from blemishes that detract from the appearance of the finished work. Surface timber and lumber for railings on four sides (S4S).

I (Blank)

J Hardware

Galvanize hardware, including nails, spikes, and timber connectors after fabrication in accordance with 3392, "Galvanized Hardware."

Provide bolts in accordance with 3391.2.C, "Bolts for Wood Construction" unless otherwise shown on the plans.

Provide driftbolts with counter-sunk heads and chisel points, lag screws, and rods in accordance with 3306, "Low-Carbon Structural Steel" for incidental items.

Provide properly proportioned plate washers to develop the full strength of the bolt. Provide round washers with diameters, and square washers with side dimensions, at least 3.5 times the diameter of the bolt and with a thickness of at least one-half the diameter of the bolt, unless otherwise shown on the plans. The Contractor may cut washers for bolts no greater than ½ in [12 mm] in diameter from medium steel plate.

Provide timber connectors of standard manufactured products in the size and type as shown on the plans.

2403.3 CONSTRUCTION REQUIREMENTS

A Cutting and Framing

Cut, frame, and bore treated timber before treatment.

Drive nails and spikes to set the heads flush with the surface of the wood. The Engineer may reject wood pieces or members with deep or frequent hammer marks in exposed wood surfaces.

B (Blank)

C Handling and Storage

Handle, transport, and store timber without damaging portions that will remain in the completed structure. Do not split or damage the surfaces and edges. Do not puncture the treated surface of treated timber with pointed tools, temporary bolts, or spikes.

D Framing

Accurately cut and frame lumber and timber, true and exact to a close fit to construct the joints with an even bearing over the entire contact surfaces. Do not shim the joints or construct open joints.

D.1 Holes in Untreated Timber

Bore holes in untreated timber with diameters in accordance with the following types of hardware:

Table 2403-1
Holes in Untreated Timber

Hardware Type	Bore Hole Diameter
Round driftbolts and dowels	$^1/_{16}$ in [2 mm] less than the diameter of the bolt or dowel
Square driftbolts or dowels	Equal to the least dimension of the bolt or dowel
Machine bolts	Same diameter as the bolt
Rods	$^1/_{16}$ in [2 mm] greater than the diameter of the rod
Lag screws	No larger than the body of the screw at the root of the thread

D.2 Holes in Treated Timber

Bore holes in treated timber at least $^1/_{16}$ in [2 mm] larger than the holes specified in Table 2403-1.

E Field Treatment

Carefully trim and coat the following in treated piles and timbers with a preservative in accordance with 3491, "Preservatives and Preservative Treatment of Timber Products," and meeting the requirements of AWPA Standard M4:

(1) Field cuts (except pile cut-offs),
(2) Daps,
(3) Field bored holes, and
(4) Abrasions.

Wait at least 2 h between each application.

For pile cut-offs, treat the tops of treated timber piles used in timber bridge construction with three applications in accordance with the requirements in this section.

F Piling

Provide timber piling in accordance with 2452, "Piling."

G Sills

Finish concrete pedestals, where required for the support of framed bents, to ensure even load bearing transfer to sills or posts placed on the pedestals. Extend the dowels for anchoring the sills at least 9 in [225 mm] above the tops of pedestals. Set dowels while casting pedestals.

Provide sills with true and even bearing on piles or pedestals. Drift-bolt sills to the piles using bolts extending into the piles at least 9 in [225 mm]. Remove earth from around the sills to provide free air circulation.

Use dowels extending at least 6 in [150 mm] into posts and sills to fasten posts to sills.

H Caps

Place timber caps to obtain an even and uniform bearing over the tops of the supporting posts or piles and to provide an even alignment of their ends. Use driftbolts extending at least 9 in [225 mm] into posts or piles to secure caps, except wing pile caps. Place the driftbolts in the center of each post or pile.

I (Blank)

J Bracing

Fasten bracing to the pile or post and cap using bolts at least ¾ in [20 mm] in diameter in tandem with split or tooth ring connectors. Use wire spikes, boat spikes,

or spike grid connectors to bolt and spike intermediate intersections as shown on the plans.

K Stringers and Bridging

Size stringers at bearings. For stringers one panel long, place with knots near the edges in the top portion of the stringers. For stringers two panels long, place with knots near the edges in the compression edges of the stringers and stagger lapped joints over the supports.

Provide outside stringers with butt joints. Provide lapped interior stringers to take bearing over the full width of the floor beam or cap at each end. Toenail or bolt to fasten lapped ends of stringers as required by the contract.

Accurately frame cross bridging members with bevel cut ends. Place cross bridging members providing full bearing at each end against the sides of stringers. Use two nails at each end to hold each cross bridging member securely. Set the cross bridging before placing the floor. Tightly set and nail the top ends home. Nail the lower ends only enough to hold the bridging in place. After placing the floor and wearing surface, readjust the lower ends of cross bridging, draw tight to the face of the stringers, and fully nail as required by the contract.

Place block or header bridging before laying the subfloor. Fully nail the blocks at the top and only temporarily nail at the bottom. After placing the entire floor, complete nailing of the bridging. If using bolts or lag screws to fasten block bridging as shown on the plans, do not final tighten the bolts or lag screws until after placement of the entire floor.

Cut block bridging square and to the accurate length to avoid the need for shims. If end shims are necessary, use zinc or galvanized sheet steel. Use end shims the size of the end of the block, with additional width to allow nailing along one side of block. Use galvanized roofing nails to hold shims in place.

Place cross bridging at the center of each span unless otherwise shown on the plans.

L (Blank)

M (Blank)

N Prefabricated Timber Panels

Provide and install nail or glue laminated timber panels for use in bridge superstructures in accordance with the following:

N.1 Nail Laminated Panels

Cut individual timber members for use in the panels to the proper length and drill dowel holes. Treat members with preservative in accordance with 3491, "Preservatives and Preservative Treatment of Timber Products." Fabricate members into panels.

Provide panels fabricated as shown on the plans and assemble at the fabrication plant before delivery to the project. Match-mark the panels before shipment. Provide panel lengths with a tolerance of ⅛ in [3 mm] of the dimension shown on the plans. Install the panels to provide an overall deck width within ¼ in [6 mm] of the panel dimension shown on the plans.

N.2 Glued Laminated Deck Panels

Provide and install glued laminated deck panels as shown on the plans and meeting the requirements of this section, the American National Standards for Wood Products – Structural Glue Laminated Timber – ANSI/AITC A 190.1, and AITC 405. Provide shop details to the Engineer. Do not begin fabrication work until the approval of the shop details by the Engineer in accordance with 2471.3.B, "Shop Detail Drawings."

N.2.a Appearance Grades

Surface finish the panels meeting the requirements of AITC Industrial Appearance Grade, except the Department will not require finishing the roadway surface of the panels. Place individual planks to achieve the maximum corrugation on the roadway surface.

N.2.b Dowel Holes

Drill dowel holes $^{1}/_{16}$ in [2 mm] greater in diameter than the dowel and ½ in [12 mm] deeper than necessary to provide the planned dowel projection before the preservative treatment process.

N.2.c Marking and Protection

Match-mark the panels before shipment. Do not end seal, surface seal, or wrap the panels.

N.2.d Preservative Treatment

Fabricate glue-laminated desk panels; remove excess glue from all panel surfaces, except on roadway surfaces, before treating with preservative.

N.2.e Inspection 3491.3

Provide an independent commercial inspection agency's Certificate of Compliance, including the test results, and an approval certification mark on each panel, showing conformance with the requirements of this section (2403).

N.2.f Assembly

Verify dowel projection and conformance with dimensions as shown on the plans at the project site before assembly.

O (Blank)

P (Blank)

Q (Blank)

R Railings

Frame railings as shown on the plans. Ensure accurate railing alignment during erection.

S Hardware

Place driftbolts in the structure with the chisel point at right angles to the grain of the unbored sections of the timbers connected.

Use plate washers for bolts at least ½ in [12 mm] in diameter, unless using bolt heads and nuts that provide an equivalent bearing surface and strength.

Provide timber connectors of the type shown on the plans. Install the split ring and the shear plate in precut grooves of the dimensions as shown on the plans or as recommended by the manufacturer. Use pressure equipment to force the toothed ring and the spike grid into the contact surfaces of the timber joint. Simultaneously and uniformly imbed connectors of this type at a joint. Install the claw plate using a combination of precut grooving and pressure equipment.

2403.4 METHOD OF MEASUREMENT

A Treated or Untreated Timber

The Department will separately measure treated timber and lumber and untreated timber and lumber by the unit of measure based on nominal sizes and lengths incorporated in the structure. The Engineer will not provide allowance for waste except beveled ends.

The Department will measure panels by the number of acceptable units of each type provided and installed, including panel hardware.

B Hardware

The Department will measure hardware by weight if the contract includes a specific contract item for hardware. The Department will include of the cost of nails, dowels, or panel hardware with other relevant contract items.

2403.5 BASIS OF PAYMENT

The Department will pay for timber bridge construction on the basis of the following schedule:

Item No.:	Item:	Unit:
2403.501	Untreated Timber	Mbm*[cubic meter]
2403.502	Treated Timber	Mbm*[cubic meter]
2403.506	Hardware	pound [kilogram]
2403.508	Prefabricated Timber Panels, Type ___	each
2403.510	Glued Laminated Deck Panels, Type __	each

* 1,000 board-feet measure

2404 CONCRETE WEARING COURSE FOR BRIDGES

2404.1 DESCRIPTION

The work consists of constructing a portland cement concrete wearing course on a bridge structural slab or approach panel.

2404.2 MATERIALS

Provide a wearing course made of low slump concrete placed at least 2 in [50 mm] deep in accordance with the following:

A Low Slump Concrete

Provide low slump concrete in accordance with 2461, "Structural Concrete," and as modified by the following:

A.1 Mix Requirements

Do not substitute ground granulated blast furnace slag or fly ash cement in the low slump concrete.

Provide No. 3U17A concrete mix using the maximum quantity of water-reducer meeting the requirements of the Concrete Manual.

A.2 Slump Requirements

Provide No. 3U17A concrete mix with a slump as specified in 2461, "Structural Concrete."

A.3 Air Content Requirements

Provide No. 3U17A concrete mix with an air content as specified in 2461, "Structural Concrete."

B Bonding Grout

Provide grout consisting of portland cement mixed with water to form a slurry with the consistency of paint to bond the new concrete to the bridge structural slab. Coat the in-place concrete, including vertical joints, immediately before placing the concrete wearing course.

C Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound 3754

2404.3 CONSTRUCTION REQUIREMENTS

A General

Provide equipment to proportion, mix, place, and finish the concrete as approved by the Engineer.

Place the concrete wearing course on the bridge structural slab after the slab has cured for at least 7 days unless the contract requires a longer curing period for the bridge structural slab. Place the concrete wearing course on the approach panels after the panels have cured for at least 72 h.

Mix concrete in accordance with the Concrete Manual requirements for the equipment used. Mix the concrete until uniform in composition and consistency. Provide concrete at a rate allowing the finishing operations to proceed at a steady pace and completion of the final finishing in accordance with 2404.3.D, "Concrete Placement and Texturing." Provide placing and finishing equipment, including adequate hand tools, to place and work the concrete to the correct level for strike-off.

B Finishing Machine

Use a power-operated finishing machine approved by the Engineer and meeting the following requirements:

(1) Designed for normal operating conditions that provide an elapsed time between depositing the concrete on the bridge deck and the final screeding no greater than 15 min.
(2) Capable of obtaining positive machine screeding of the plastic concrete,

(3) Contains a screed capable of extending at least 6 in [150 mm] beyond the edge of a subsequently placed section and capable of overlapping the edge of a previously placed section at least 6 in [150 mm].
(4) Capable of forward and reverse motion under positive control, and
(5) Contains screeds capable of being raised to clear the screeded surface when traveling in reverse.

Demonstrate the capability of the finishing machine to produce results in accordance with 2404.3.D, "Concrete Placement and Texturing," under the project conditions, unless otherwise directed by the Engineer.

Place rails on the outside of the wearing course area to support the traveling finishing machine. Provide rail anchorages for horizontal and vertical stability. Do not ballistically shoot rail anchorages into concrete that will not be overlaid.

After setting the rails to the grade and elevation shown on the plans and before placing the concrete, check the clear distance from the bottom of the screed to the top of the prepared concrete surface in the presence of the inspector. Attach a fill strip or other approved device to the bottom of the screed during this check to detect areas encroaching on the wearing course thickness shown on the plans. Set sufficient screed rails to perform the clearance check in one continuous run over a distance equal to one complete day's placement. Make corrections as directed by the Engineer to obtain the thickness shown on the plans.

When necessary, place longitudinal joints at the edge of traffic lanes as approved by the Engineer.

C Deck Preparation

Within 48 h before placing the concrete wearing course, clean the slab surface and shotblast the entire bridge surface and approaches to be overlaid. Shotblast to remove surface film, laitance, fractured concrete particles, and other materials that may impede the bond of the concrete wearing course. Remove the steel shot before placing the concrete wearing course.

Control and abate the dust generated by the blasting operation meeting the requirements of MPCA Rule 7011.0150. Submit the proposed plan for dust abatement to the Engineer at least 14 days before starting the work.

Power sweep the bridge and approach slabs before blasting. Use the least amount of water necessary to minimize the dust from the sweeping operation.

Provide housing for the blast wheel or blasting nozzles meeting the following requirements and characteristics:

(1) Contains a negative air emission control system that draws the confined air and dust into a filtered collection system.
(2) Contains an exhaust system with the capacity for relieving the pressure generated within the housing by the blasting equipment, and
(3) Sides and corners flexible at the bottom to allow the bottom of the housing to contact the deck surface during blasting operations.

Clean the filter collection system to ensure proper filtration.

Provide a housing and filter collection system constructed, maintained, and operated to eliminate avoidable dust emissions.

After blasting, hand sweep or use a "pickup" type power sweeper equipped with adequate dust storage capacity to sweep the prepared surface. Remove minor debris remaining after the sweeping operation by air blasting. Provide an air supply system with an oil trap placed in the air supply line between the storage tank and the nozzle.

Shotblast, sweep, and clean the bridge structural slab before placing the concrete wearing course. Allow time for the Engineer to inspect the surface during daylight hours.

Within 12 h of placing the concrete wearing course, use potable water to pre-wet the deck surface to a saturated surface dry condition (not absorbing water from or contributing water to the concrete mixture). Maintain the saturated surface dry condition for at least 6 h. Do not allow free water on the surface when placing the bonding agent as stated in 2404.2.B, "Bonding Grout."

D Concrete Placement and Texturing

Place and finish concrete at a linear rate, measured parallel to the centerline of the bridge, of at least 40 ft [12 m] per h under normal working conditions. Do not place concrete wearing course placement widths greater than 24 ft [7.3 m], unless otherwise shown in the special provisions.

Place joints in the concrete wearing course directly above the original joints constructed in the bridge structural slab and in accordance with 2401.3.E, "Joint Construction." Make saw cuts as soon as the concrete can be cut without raveling the surface and expeditiously to minimize the exposure of the uncured concrete to surface drying. Seal saw cuts with joint sealer in accordance with 3723, "Joint and Crack Sealer (Hot-Poured Elastic Type)," or 3725, "Hot-Poured, Extra-Low Modulus, Elastic-Type Joint and Crack Sealer."

After consolidating, screeding, and floating the concrete, draw a carpet drag longitudinally along the pavement before the concrete attains its initial set. Mount the drag on a bridge over the concrete surface. Provide a carpet drag 4 ft [1.2 m] long and

as wide as the concrete placed Adjust the carpet drag to produce a texture as approved by the Engineer.

Use artificial grass type carpeting for the drag containing a molded polyethylene pile face with a blade length from ⅝ in [16 mm] to 1 in [25 mm] and a total weight of at least 70 oz per sq. yd [2.35 kg per sq. m]. Provide backing made of a strong, durable material not subject to rot. Adequately bond the backing to the facing to withstand use as a carpet drag for concrete. As an alternative to the carpet drag texturing, the Contractor may perform coarse broom texturing as approved by the Engineer.

Immediately following the carpet drag, use a device meeting the following requirements to perform transverse metal-tine texturing on the wearing course, unless otherwise approved by the Engineer:

(1) Equipped with 4 in [100 mm] to 6 in [150 mm] long steel tines,
(2) Steel tines $^{1}/_{12}$ in [1 mm] to ⅛ in [2 mm] thick (cross section),
(3) Steel tines arranged to obtain randomized grooves ⅛ in [3 mm] to $^{5}/_{16}$ in [8 mm] deep, and
(4) Grooves variably spaced from ⅝ in [15 mm] to 1 in [25 mm].

Do not extend tining into areas within 1 ft [0.3 m] of a gutter.

Ensure the final surface does not vary by greater than ⅛ in [3 mm] within a 10 ft [3 m] straightedge laid longitudinally on the final surface. This surface tolerance includes areas near expansion devices and other breaks in the continuity of the wearing course.

Remove and replace the surface areas not meeting the tolerances specified above. Alternatively, grind the high spots on the surface areas not meeting the tolerances specified above as directed by the Engineer. The Department defines uncorrected nonconforming areas as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work."

Perform sealing operations in accordance with 2401.3.I, "Joint and Crack Sealing."

If the National Weather Service predicts a daytime temperature of at least 80 °F [27 °C] for a scheduled concrete placement, reschedule the placement or begin the concrete placement from 7:00 p.m. to 5:00 a.m. For concrete placement beginning after 7:00 p.m. and not completing before 5:00 a.m., terminate the placement at or after 5:00 a.m. when the air temperature reaches or exceeds 80 °F [27 °C]. Do not place concrete wearing course if the air temperature falls below 40 °F [5 °C] or if the slab surface shows signs of frost.

Notify the Engineer at least 24 h in advance of scheduling a night operation. Provide artificial lighting to ensure quality workmanship and adequate inspection.

Except if heating and housing the concrete, do not place concrete for wearing courses in accordance with the following requirements:

(1) Before April 15th,
(2) After September l5th, north of the 46th parallel, or
(3) After October 1st, south of the 46th parallel.

The Contractor may place concrete for wearing course before April 15 or after September 15 or October 1 as specified above, if heating and housing the deck and performing the following:

(1) Submit a plan and proposed time schedule for cold weather protection and maintenance of acceptable curing temperatures to the Engineer. Do not begin work until the Engineer approves the cold weather protection plan and all materials identified in the plan or on site.
(2) Provide the concrete with suitable housing immediately after placement allowing free air circulation above the surface and protecting the concrete against freezing rain or snow.
(3) Provide pre-heating for the structural slab before concrete placement if necessary. Provide insulation blankets or heating facilities to maintain the curing temperatures in item (4) below.
(4) For low slump concrete, maintain the concrete surface or enclosure temperature at 60° F [16° C] or higher for the first 96 h after concrete placement. Do not expose the concrete to temperatures lower than 40° F [5° C] until at least 26 calendar days after the initial 96 h period, and.
(5) Do not remove the housing enclosure until fulfilling the cold weather protection needs as approved by the Engineer.

E Low Slump Concrete

E.1 Mixer Requirements

Provide mixing equipment in accordance with 2461, "Structural Concrete," except use a continuous mixer with metered proportioning capability. The Department will calibrate the mixer. Allow the Department at least 7 days lead time to establish mix settings. Mix concrete at the job site.

E.2 Finishing Machine Requirements

Provide a finishing machine meeting the following requirements and characteristics:

(1) Contains at least one oscillating screed, and

(2) Designed to consolidate the concrete to 98 percent of rodded density by vibration.

Install identical vibrators or pillow blocks with eccentric cams to provide at least one vibrator or source of vibration for each 5 ft [1.5 m] of screed length. If only vibrating one screed, vibrate the front screed. Ensure the bottom face of the screed is at least 5 in [125 mm] wide and contains a turned-up or rounded leading edge to minimize surface tearing. Ensure each screed produces a pressure of at least 75 lb per sq. ft [366 kg per sq. m] of screed area on the bottom face. Provide each screed with positive control of the vertical position, angle of tilt, and shape of the crown. Equip the finishing machine with an adjustable power-operated paddle or auger to strike off concrete in front of the first screed.

E.3 Concrete Placement

Scrub the bonding grout into the deck surface at a controlled rate (based on field conditions) to prevent drying before covering with the concrete wearing course.

Mechanically strike off the concrete slightly above final grade before consolidating and screeding to final grade.

Saw the wearing course at transverse and longitudinal joints to a straight, vertical edge. Remove trimmings before placing the adjacent wearing course. Do not operate impact equipment in the adjacent lane during the first 72 h after placing the concrete unless otherwise approved in writing by the Engineer. Use thinned bonding grout to paint vertical joints with adjacent concrete after finishing and texturing to assure the vertical joint is sealed.

E.4 Curing Requirements

Coat the concrete with membrane curing compound in accordance with 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," within 30 min after placing the concrete. Use an airless spraying machine containing the following:

(1) A recirculating bypass system that continuously agitates the reservoir material,
(2) Separate hose and nozzle filters, and
(3) A multiple or adjustable nozzle system to provide variable spray patterns.

Before application, agitate the curing compound in the shipping containers to obtain a homogeneous mixture. Apply the compound to provide a uniform, solid white opaque coverage equal to a white sheet of paper on exposed concrete surfaces Respray areas that appear to have a coating that is less than a white sheet of paper. Respray membrane film damaged before the placement of the wet cure.

Apply the membrane within 30 min after placing concrete. Apply the membrane within 45 min after depositing concrete if revibrating the concrete as directed by the Engineer. If the Contractor fails to apply membrane curing in the required time after depositing concrete, the Department will consider this as unacceptable work in accordance with 1512, "Unacceptable and Unauthorized Work." Remove and replace concrete in areas not coated with membrane curing compound within the required time at no additional cost to the Department.

When the concrete can be walked on without damage, place wet burlap or curing blankets in accordance with 2401.3.G, "Concrete Curing and Protection," for at least 96 h. Maintain burlap in a wet condition for the entire curing period.

Do not allow vehicular traffic on the concrete wearing course during the 96 h curing period. If the daily mean temperatures during the 96 h curing period fall below 60 °F [16 °C], provide additional curing time before allowing traffic on the surface as required by the Engineer.

2404.4 METHOD OF MEASUREMENT

The Engineer will measure the concrete wearing course by surface area based on the dimensions shown on the plans. The Engineer will not deduct the surface area of expansion devices or other miscellaneous appurtenances.

2404.5 BASIS OF PAYMENT

The Department will pay for concrete wearing course for bridges on the basis of the following schedule:

Item No.:	Item:	Unit:
2404.501	Concrete Wearing Course ___	square foot [square meter]

2405 PRESTRESSED CONCRETE BEAMS

2405.1 DESCRIPTION

This work consists of providing and installing prestressed concrete beams and double Tee-beams for use in bridge superstructures.

2405.2 MATERIALS

Provide concrete produced in a central-mix plant in accordance with 2461.3.F.3, "Certified Ready-Mix Plant Program." The Contractor may use Type I, Type II, or Type III portland cement.

Use Mix No. 1W36 or Mix No. 3W36 concrete for prestressed beams.

Use Mix No. 3W36 concrete for double Tee-beams.

B Reinforcement Bars 3301

C Structural Steel 3306

D High-Strength Low-Alloy Structural Steel 3309

E Seven-Wire Strand for Prestressed Concrete 3348

F Structural Steel Pipe 3362

G Galvanized Structural Shapes 3394

H Galvanized Hardware 3392

I Zinc-Rich Paint Systems 3520

J Plastic Curing Blankets 3756

2405.3 CONSTRUCTION REQUIREMENTS

Provide beams manufactured from a precast/prestressed concrete plant certified by the PCI or by another organization approved by the State Materials Engineer and in accordance with the following:

(1) 2401, "Concrete Bridge Construction,"
(2) 2471, "Structural Metals,"
(3) 2472, "Metal Reinforcement," and
(4) PCI Manual for Quality Control: Precast and Prestressed Concrete.

A General

The State Materials Engineer is the Engineer with authority concerning all matters of plant fabrication and inspection prior to delivery of the materials to the project. The Engineer has authority concerning all matters of fabrication at the project site.

Submit a written notification to the Engineer immediately after placing orders for prestressed concrete beams. Include the name and address of the supplier and the beam manufacturing location.

Notify the Materials Engineer at least 7 calendar days before the beginning manufacturing operations. If the Contractor casts the beams at the bridge site, notify the Engineer at least 7 calendar days before casting to permit inspection of the forms and reinforcement.

If casting the beams at a plant away from the bridge site, provide an office in accordance with 2031.3.A, "Basic Requirements," with air conditioning and access to sanitary facilities. The Department will not require laboratory space.

If, on any day, the Department inspects beam casting at a plant away from the bridge site and less than two beams are cast, the Department will deduct from any moneys due or becoming due to the Contractor the total cost of inspection for that day.

Provide a PCI Level II Certified Technician on site at the start of fabrication and throughout fabrication of the prestressed beams. Provide PCI Level I Certified Technicians to perform quality control functions. Provide a PCI Level II Certified Technician as a supervisor for the quality control staff.

Take precautions to prevent contamination of prestressing steel with oil, dirt, or other deleterious substances and to prevent damage that may result in weakening the prestressing steel that may result in its failure under stress. The Materials Engineer may reject nicked or kinked prestressing steel. Do not allow sparks or pieces of molten metal from welding or burning equipment to contact the prestressing steel. Do not use prestressing steel as a ground for welding equipment.

Galvanize all steel inserts or devices that will be within 1 in [25 mm] of the exposed surface of the finished structure. Galvanize or coat with zinc-rich primer all other steel inserts or devices included in the beam.

Prepare shop drawings for structural metals in accordance with 2471.3.B, "Shop Detail Drawings."

B Forms

Provide forms designed to withstand pressure from concrete, vibration, and impact without distortion. Set and maintain forms mortar tight, free of warp, and on a rigid foundation. Set the side form at right angles to the vertical axis of the beams and with the plane of bearing surfaces flat and true. Set side forms during casting as shown on the plans. Maintain side forms during casting until the concrete sets. Provide a tight fit without offset for joints in sectional forms.

Set forms for prestressed concrete beams so the dimensions of the beam after prestress transfer will conform to the plan dimensions in accordance with 2405.3.H, "Tolerances."

Treat the face of the forms in contact with the concrete with form coating material in accordance with 3902, "Form Coating Material," before setting the form in position. Clean the forms of accumulations of oil and other substances before use.

Provide beam end blocks as shown on the plans. The Contractor may increase the length of the end blocks as much as12 in [300 mm] to accommodate sectional forms. Provide end blocks of the same length for beams of the same length in any one span.

C Steel Units

Place, support, and tie reinforcement bars for prestressed concrete beams in accordance with 2472, "Metal Reinforcement."

Cover the reinforcement bars with concrete at least 1 in [25 mm] thick.

Set sole plates for prestressed beams so that after prestress transfer the sole plate locations match the plan locations within the tolerance specified for the plan length of pretensioned beams. Place the sole plates in contact with the bottom form. Maintain position of the sole plates during placement of concrete.

Position floor drains as shown on the plans. Fasten the floor drains to the forms to ensure that concrete placement does not alter the alignment or location.

Remove loose rust, dirt, oil, and other foreign substances from prestressing tendons before erecting the beam side forms.

The Contractor may construct hold-down devices for deflected strands so that the Contractor can remove the device for a distance of at least 1 in [25 mm] from the face of the concrete and plug the hole with mortar. Use free-rolling devices (hold-down and hold-up) at all deflection points. The device may rest on the bottom form and remain in-place. If resting the device on the bottom form, galvanize the part in contact with the form for a distance of at least 1 in [25 mm] from the form.

D Placement of Concrete

Cast the beams in an upright position. Place the concrete in each beam without interruption. Modify the casting procedure if the length of the beams and placement conditions cause a cold joint to form when continuing each lift full length before placing a subsequent lift.

Vibrate the concrete in each beam internally, externally, or both to produce uniformly dense concrete. Do not displace enclosures or steel units when vibrating. Internally vibrate in accordance with 2401.3.D, "Compaction of Concrete," using a vibrator with a non-metallic vibrating head no greater than 1¼ in [32 mm] in diameter operating at a frequency of at least 100 Hz [100 cps].

After striking off the top surface of the beams to the required level, work and hand float the surface to seal open tears in the surface and depress coarse aggregate. Use transverse brooming to roughen the surface.

E Concrete Curing

E.1 General

Begin curing operations immediately after the concrete initially sets. Continue curing until prestress transfer.

E.2 Curing Methods

Use any of the following to cure the beams:

(1) Covering of burlap or canvas kept continuously wet,
(2) Continuous water spray or mist,
(3) Complete airtight seal using plastic curing blankets, or
(4) The moist air or steam method of curing in accordance with 2405.E.3, "Steam Curing" including methods using an external heat source.

E.3 Steam Curing

Delay the introduction of steam into the curing enclosure, for curing purposes, until the concrete has taken its initial set and at least 3 h after placing the concrete. During the delay period, maintain a temperature within the curing chamber of at least 50° F [10° C] and no greater than 9° F [5° C] higher than the temperature of the concrete at the time of placement. The Contractor may only use steam to maintain the curing enclosure temperature within the limits.

Do not allow steam jets to impinge directly on the concrete or on the forms. Do not allow the rate of rise in temperature adjacent to the concrete to rise at rates greater than 27° F [15° C] per hour. Provide free circulation around the top, sides, and ends of the concrete units. Do not allow the temperatures adjacent to the concrete greater than 158° F [70° C]. Use saturated steam within the curing enclosure. Maintain a temperature in the concrete unit of at least 50° F [10° C] during the curing period. Do not allow a difference in temperature adjacent to the concrete within the enclosure to be greater than 9° F [5° C].

After the expiration of the steam curing period, reduce the temperature inside the chamber at a rate no greater than 40° F [22° C] per hour until the temperature inside and outside of the chamber equalize. After removing beams from the chamber, protect the beams to avoid cooling at a rate greater than 40° F [22° C] per hour until reaching the air temperature at the storage site.

If removing side forms before the completion of the steam curing cycle (including temperature taper off process), only remove and leave uncovered the minimum area of the curing enclosure at any one time needed to remove each individual form section. Close the open area in the enclosure immediately upon removing each form section or within 15 min after first uncovering the area.

When removing the beams from the casting bed during the cooling-off process, take appropriate measures to keep the beams warm during the moving operations, and immediately resume the cooling-off process at the storage area.

Provide two continuous recording thermometers for each casting enclosure with a casting bed length no greater than 100 ft [30 m]. Provide an additional thermometer for each additional 100 ft [30 m], or fraction thereof, in the length of the casting bed within each enclosure. Locate thermometers in each curing enclosure as approved by the Materials Engineer. Submit complete temperature recording charts for all cures to the Materials Engineer.

Discontinue steam curing and use one of the other approved curing methods, if the records indicate noncompliance with temperature and time element specifications for steam curing.

F Tensioning

F.1 Equipment

Tension prestressing tendons using hydraulic jacks or dynamometers and hydraulic jacks. Equip each jack pump with a hydraulic pressure gauge. Calibrate jacks, gauges, and pumps as a unit under conditions similar to operating conditions. Provide a dated, certified calibration curve for each combination used. Recalibrate equipment presenting erratic results during tensioning operations.

Ensure the hydraulic pressure gauges can accurately determine the actual stress on the jacks within a tolerance of 2 percent of the total indicated stress during final elongation of the prestressing tendons.

Calibrate the dynamometer used to measure an initial tension. Ensure the dynamometer can accurately determine the initial tension within a tolerance of 5 percent.

F.2 General Procedures

Conduct the tensioning procedure so that it is possible to compare the indicated stress on the tendons based on gauge pressures and the indicated stress based on the corresponding elongation of the tendons at any time during the tensioning operation. If the two indicated stresses, corrected for friction loss, differ by no greater than 5 percent, stress the tendons so the lower of the two indicated stresses equals the

required tension in the tendon. Do not tension any tendon to an indicated stress greater than 85 percent of its specified yield point strength. If the indicated stresses differ by greater than 5 percent, stop tensioning operations. Determine the source of the discrepancy and correct it before resuming tensioning operations.

When the tensioning operation includes more than two girders with all deflection points included, demonstrate proper tension at both ends. When tensioning more than four girders with all deflection points included, measure and ensure proper elongation on the interior girders that are more than one girder from an end.

Do not tension prestressing strands in the bundled position with direct contact between adjacent strands. Maintain a clear space of at least ¼ in [6 mm] between adjacent strands during tensioning. Depress tensioned strands into a bundled position with contact between adjacent strands after the completion of tensioning.

Record the gauge pressures, indicated stresses, and elongations, and submit the record to the Materials Engineer.

The Contractor may tension strands as a group if the strands in the group are from the same manufacturer and the strands receive the same initial tension. When tensioning, consider initial strand tension no greater than 150 lb [650 N] per strand to be zero tension. If the contract requires an initial tension greater than 150 lb [650 N] per strand, use a dynamometer to measure the tension. Add the elongation due to the initial tension to the final elongation measurement.

Tension the deflected strands so that final tension is uniform in all parts of the strand. Provide freely turning rollers to reduce frictional forces at the deflection points.

Correct tension-elongation measurements for losses due to slippage of grips or anchorages, and friction to obtain the prestress force shown on the plans.

If a temperature differential in the strands at the time of tensioning and at the time of concrete placement exceeds 15° F [8° C], consider the change in the final elongation measurements to obtain the required prestress force at the time of casting. Base the change in elongation due to temperature on a ⅛ in per 100 ft [1 mm per 10 m] of strand length for each 15° F [8° C] variation in temperature. Tension prestressing tendons when the ambient air temperature is greater than 32° F [0° C] and rising.

G Prestress Transfer

Do not remove beams from casting beds until after the prestressed transfer. Perform the prestress transfer after the control cylinders indicate that the concrete has

reached a compressive strength of at least 4,500 psi [31 MPa] unless otherwise shown on the plans. Make the prestress transfer when the concrete is still warm and moist.

During the prestress transfer sequence keep the lateral eccentricity of the prestress to a minimum and prevent cracking in the top flange of the beams. The Contractor may perform the prestress transfer by the gradual release of hydraulic jacks, by heating exposed portions of individual strands to failure, or by a combination of these two methods. If heating the individual strands, heat in accordance with the following:

(1) Heat each individual strand simultaneously on the strand at no less than two locations along the casting bed. Sequence heating each strand along the bed and with the sequence of perform the prestress transfer between individual strands in a manner that will prevent damage, and
(2) Heat with a low oxygen flame played along the strand for a distance of at least 5 in [125 mm]. Control the heat to ensure that failure of the first wire in the strand does not occur for at least 5 sec after the application of heat followed by gradual elongation and failure of the remaining wires.

Completely strip the forms from the beams before beginning prestress transfer.

H Tolerances

After prestress transfer, check the dimensions of the prestressed concrete beam to verify that the dimensions match what the plans show within the tolerances in the PCI, *Structural QC Manual, MNL-116.*

The Materials Engineer will measure differential camber between adjacent members of the same design with the beams erected in the final position.

The Engineer or the Materials Engineer may reject members that do not meet the dimensions shown on the plans or the specified tolerances.

I Rejection

The Materials Engineer may reject beams failing to meet the requirements of this section or beams showing the following after the removal of forms:

(1) Honeycombing,
(2) Stone pockets,
(3) Sand streaks, or
(4) Imperfect mixing and casting.

The Materials Engineer will not reject beams showing minor surface cavities or irregularities that do not impair the service value if repaired as approved by the Materials Engineer. Make repairs after the Materials Engineer, inspects the irregularities. Use repair materials and methods approved by the Materials Engineer.

J Marking, Handling, Storage, and Transportation

The Department will allow beams to be moved from the casting bed to a nearby storage area after attaining the minimum compressive strength for prestress transfer. Do not transport or install beams until the beam attains a compressive strength of at least 5,000 psi [35 MPa], as evidenced by control cylinders. When casting off-site, do not ship the beam until it has reached the full design strength shown in the plans.

Mark each beam with the casting date and piecemark. If casting beams away from the bridge site, mark each beam with the name or trademark of the manufacturer and the bridge number. The Department will stamp each approved beam with the official mark of the Department before shipment. Complete repairs before the Department stamps the unit. Do not ship beams without the Department stamp of approval. After completing the repair work, notify the Materials Engineer at least 1 full business day before intent to ship. The Engineer will perform a final inspection of units upon delivery.

Ensure markings remain in evidence after erection, but not readily visible in the completed structure.

Keep prestressed beams in an upright position at all times. Support prestressed beams during storage, lifting, and transportation at two points only. Considering beam stresses and stability, determine the support point locations in accordance with standard PCI methods.

Obtain permits as required by road authorities.

K Installation

After erecting each prestressed beam, temporarily brace and tie each beam in a manner approved by the Engineer to preclude sliding, tipping, or other movement that may occur before placing diaphragms and the slab. Arrange the work schedule to erect and brace at least two adjacent I-beams in any one span before suspending operations.

Install and permanently fasten the prestressed concrete beams as shown on the plans.

Provide intermediate diaphragms for prestressed concrete beams as shown on the plans.

Provide structural steel shapes and plates for the steel intermediate diaphragm option in accordance with 3306, "Low-Carbon Structural Steel," or 3309, "High-Strength Low-Alloy Structural Steel." Galvanize structural steel plates and shapes in accordance with 3394, "Galvanized Structural Shapes."

Provide fasteners, including washers, for the intermediate steel option in accordance with 3391, "Fasteners." Provide fasteners meeting the requirements of ASTM A 325, Type 1. When used with galvanized structural steel, use ASTM A 325, Type 3. Galvanize fasteners for use with galvanized structural steel in accordance with 3392, "Galvanized Hardware."

Use cast-in-place anchorages to connect the steel intermediate diaphragms to the fascia beams. Provide anchorages capable of providing an ultimate pull-out strength of at least 65 kN [15 kips] per anchorage.

Provide plastic or galvanized steel material to form holes in beam webs to connect bolts for steel intermediate diaphragms.

In addition to the ordinary surface finish, provide a special surface finish in accordance with 2401, "Concrete Bridge Construciton," on the outer face of the exterior beams of a bridge. Apply the special surface finish with the beams in place and in conjunction with the final finish of the remainder of the structure.

2405.4 METHOD OF MEASUREMENT

The Engineer will separately measure *Prestressed Concrete Beams Type* ___ as individual units regardless of minor variations in Plan details between beams of the same type.

The Engineer will measure *Prestressed Concrete Beams* ___ by summation of the individual lengths, out to out, along the centerlines of beams.

The Engineer will measure intermediate diaphragms for prestressed concrete I-beams by length based on the horizontal distance from centerline to centerline of beam along the axis of the diaphragms.

2405.5 BASIS OF PAYMENT

The contract unit price for prestressed concrete beams includes the costs of manufacturing, transporting, and erecting the beams in the final position, and the cost of temporary bracing in accordance with 2405.3.K, "Installation."

The contract unit price for prestressed concrete beams includes the cost of constructing the intermediate diaphragms complete-in-place and structural steel or concrete and reinforcement bars as shown on the plans.

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

Item No.:	Item:	Unit:
2405.501	Prestressed Concrete Beams Type ___	each

Item No.:	Item:	Unit:
2405.502	Prestressed Concrete Beams ___in [mm]	linear foot [meter]
2405.505	Prestressed Concrete Double Tee-Beam Type ___	each
2405.511	Diaphragms for Type ___ Prestressed Beams	linear foot [meter]

2406 BRIDGE APPROACH PANELS

2406.1 DESCRIPTION

This work consists of constructing bridge approach panels.

2406.2 MATERIALS

A Concrete.....2461

A.1 Mix Designation ..... Mix No. 3A42

B Reinforcement Bars.....3301

C Curing Materials

C.1 Burlap Curing Blankets.....3751

C.2 Poly Alpha Methylstyrene (AMS) Membrane Curing Compound.....3754

C.3 Linseed Oil Membrane Curing Compound.....3755

C.4 Plastic Curing Blankets.....3756

D Granular Materials.....3149

E. Form Coating Material 3902

2406.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

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

B Forms

Provide forms made of non-reactive metal, wood, or other material capable of maintaining the concrete until the concrete can retain the molded shape. Provide forms with a height at least equal to the approach panel thickness of the formed

concrete as shown in the plans. Support the forms on the foundation to maintain the line and grade as shown on the plans.

On curves with a radius of 100 ft [30 m] or less, use flexible or curved forms of the radius as shown on the plans.

Before placing the concrete, coat the contact surfaces of all forms with form coating material.

C Placing and Finishing Concrete

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

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

Provide the same surface texture as the bridge deck and construct in accordance with 2401, "Concrete Bridge Construction," or 2404, "Concrete Wearing Course for Bridges."

Finish edges with a ⅜ in [10 mm] radius edging tool.

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

D Joint Construction

Place joints as shown on the plans.

E Metal Reinforcement

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

F Workmanship and Finish

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

The Engineer will measure the surfaces of the panels with a 10-foot [3-meter] straightedge. The Engineer will consider horizontal or vertical deviations in the surface equal to or greater than ⅜ in [10 mm] in any 10 ft [3 m] length of the finished concrete approach panel to be unacceptable work. Remove and replace extensive areas with deviations greater than ½ in [13 mm]. Remove and replace unacceptable work as directed by the Engineer.

If the Engineer does not direct the removal and replacement of the unacceptable work, the Contractor may leave the work in-place and the Engineer will adjust the contract unit price as follows:

(1) For ⅜ in [10 mm] to $^{9}/_{16}$ in [14 mm] deviations, payment at 75 percent of the contract unit price.
(2) For minor areas with deviations over $^{9}/_{16}$ in [14 mm], payment at 50 percent of contract unit price.

G Concrete Curing and Protection

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

(1) Place the membrane curing compound conforming to 3754, "Poly-Alpha Methylstyrene (AMS) Membrane Curing Compound," or 3755, "Linseed Oil Membrane Curing Compound," within 30 min of concrete placement or once the bleed water has dissipated, unless the Engineer directs otherwise in accordance with 2406.3.G.1.a, "Membrane Curing Method." Place the membrane curing compound on the edges within 30 min after permanent removal of the forms or curing blanket, unless the contract requires otherwise.
(2) Place plastic curing blankets or completely saturated burlap curing blankets in accordance with 2406.3.G.1.b, "Blanket Curing Method," as soon as practical without marring the surface.

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

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

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

G.1 Curing Methods

G.1.a Membrane Curing Method

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

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

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

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

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

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

G.1.b Blanket Curing Method

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

G.2 Protection Against Rain

Protect the concrete from damage due to rain. Have available, near the site of the work, materials for protection of the edges and surface of concrete. Should any

damage result, the Engineer will suspend operations until the Contractor takes corrective action and may subject the rain-damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

G.3 Protection Against Cold Weather

If the national weather service forecast for the construction area predicts air temperatures of 34 °F [1 °C] or less within the next 24 h and the Contractor wishes to place concrete, submit a cold weather protection plan in accordance with 2406.3.G.3.a, "Cold Weather Protection Plan."

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

G.3.a Cold Weather Protection Plan

Submit a written cold weather protection plan to the Engineer for approval. The plan shall include a proposed time schedule for concrete placement and curing, and plans for adequately protecting the concrete during placement and curing. Do not place concrete until the Engineer approves the Contractor's cold weather protection plan.

H Backfill Construction

Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 h. Resume vibratory and backfilling operations after the concrete has reached a minimum compressive strength of 2,000 psi [13.7 MPa] or a flexural strength of 250 psi [1.7 MPa]. Cast concrete control specimens in accordance with 2461.3.G.5, "Test Methods and Specimens." The Engineer will test the control specimens. If damage results from any of these operations, the Engineer will suspend all operations until the Contractor takes corrective action and the Engineer approves of a new method. The Engineer may subject damaged concrete to 1503, "Conformity with Contract Documents," and 1512, "Unacceptable and Unauthorized Work."

The Contractor may hand operate concrete consolidation equipment and walk behind vibratory plate compactors 24 h after placing the concrete, and other equipment as approved by the Engineer, in conjunction with the Concrete Engineer. The Contractor may also use rollers in "static" mode and fine grading machines.

As soon as possible after the curing is complete and without subjecting the concrete work to damaging stresses, perform the backfill or embankment construction to the elevations shown on the plans. If the contract does require a specific backfill

material, use suitable grading materials from the excavations in accordance with 2105, "Excavation and Embankment." Place and compact the backfill material in accordance with 2105, "Excavation and Embankment."

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

I Preformed E8H Expansion Joint Sealers

Select preformed expansion joint material for the E8H expansion joints from the Approved/Qualified Products List.

Install expansion joint material in accordance with the manufacturer's recommendations and as shown on the plans.

2406.4 METHOD OF MEASUREMENT

If the contract contains a contract item (or contract items) for the construction of bridge approach panels, the Engineer will measure their construction as complete-in-place items. The Engineer will measure the total area of all panels of the same basic design. If the contract does not contain this contract item, the Engineer will measure their construction under the relevant contract items provided for pavement construction.

The Engineer will measure the length of expansion joints along the joint line as shown on the plans.

2406.5 BASIS OF PAYMENT

The cost of the following is included in the contract unit price for *Bridge Approach Panels*:

(1) Providing and placing concrete, steel, drainage system, and polyethylene sheeting;
(2) Constructing the integrant curb, terminal headers, and concrete sills;
(3) Protecting and curing the concrete, and
(4) Other incidental work not specifically included for payment under other contract items.

The cost of constructing the joints complete in-place as shown on the plans, including the providing and placing of all materials such as filler, and sealer material is included in the contract unit price for *Expansion Joints, Design E8H*.

Item No.:	Item:	Unit:
2406.553	Bridge Approach Panels	square yard [square meter]
2406.531	Expansion Joints, Design E8H	linear foot [meter]

2411 MINOR CONCRETE STRUCTURES

2411.1 DESCRIPTION

This work consists of constructing concrete structures of miscellaneous types and varied designs, with or without metal reinforcement, and including box culverts, retaining walls, culvert headwalls, open flumes, and other cast-in-place items.

2411.2 MATERIALS

A Concrete.....2461

Provide mix designations as shown on the plans.

B Reinforcement Bars.....3301

C Steel Fabric.....3303

D Preformed Joint Fillers.....3702

E Geotextile Filter.....3733

2411.3 CONSTRUCTION REQUIREMENTS

Construct minor concrete structures in accordance with 2401.3, "Concrete Bridge Construction, Construction Requirements," and the following:

A General

The Department considers the structure locations shown in the plans as approximate only. The Engineer will establish the exact locations in the field. Each structure shall conform to the planned design, but the Engineer may change the dimensions to fit on-site conditions. Do not order materials until the Engineer establishes the exact locations and dimensions.

Construct box culverts in accordance with the standard box culvert plans pertaining to construction joints, reinforcement bar splicing, and computation of quantities except as modified by the following:

(1) Stagger transverse construction joints at least 4 ft [1,200 mm] in relation to any other joint that would result in a plane of weakness through the culvert structure.
(2) Where long culverts result in lengths of reinforcement bars that are impractical for use, but are less than 60 ft [18.3 m] long, the Department will allow additional splices at no additional cost to the Department.

(3) The Engineer will calculate pay quantities for concrete and reinforcement bars using the formulas as shown on the box culvert plans. The Engineer will adjust the formula quantities to account for additional materials due to design modifications made by the Engineer or to provide for a completed structure in accordance with the plans and special provisions.

Dispose of excavated materials not needed for backfilling excavations in accordance with 2105.3.D, "Excavating Operations," at no additional cost to the Department.

B Falsework and Forms

Use form lining on vertical faces exposed to view in the completed work. If required by the special provisions, provide detailed falsework or forming plans.

C Concrete Curing and Protection

Provide curing protection for concrete structures in accordance with 2401.3.G, "Concrete Curing and Protection," until the concrete has attained a strength gain of at least 45 percent.

D Geotextile Filter

Provide and install geotextile as shown on the plans.

2411.4 METHOD OF MEASUREMENT

The Engineer will measure structural concrete using the dimensions as shown on the plans. The Engineer will separately measure each grade or mix of concrete. The Engineer will not make allowances for quantities in excess of the minimum dimensions shown on the plans and will not make deductions for volumes displaced by metal reinforcement, chamfer strips, or other incidentals.

The Engineer will measure metal reinforcement in accordance with 2472.4.A, "Reinforcement Bars." If the Contractor provides additional splices in the reinforcement bars, the Engineer will not include the additional bar for these splices in the pay quantity.

If the contract requires separate items for structure excavation or granular backfill material, the Engineer will measure quantities in accordance with 2451, "Structure Excavations and Backfills," only for structures with estimated quantities as shown on the plans.

2411.5 BASIS OF PAYMENT

The contract unit price for each grade or mix of structural concrete includes the costs of constructing the structures complete and in place. The Department will pay separately for metal reinforcement, structure excavation, and backfill materials if the contract contains specific unit prices for these items.

The contract unit price for concrete structures of each design or type includes the costs of constructing the structures complete and in place. If the contract contains a unit price for a surface area, the Department will pay separately for concrete in accordance with 2461.5, "Structural Concrete, Basis of Payment."

The contract unit prices for other applicable contract items include the cost of providing and installing geotextile fabric.

The Department will pay separately for structure excavation and special backfill materials only when the contract contains unit prices for volume and the plans show an estimated quantity for specific structures. The Department will not provide separate payment for structure excavation and special backfill materials if the contract contains unit prices for structures by individual unit.

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

Item No.:	Item:	Unit:
2411.501	Structural Concrete (Mix No.)	cubic yard [cubic meter]
2411.503	Concrete (Type of Structure)	square yard [square meter]
2411.505	Concrete Structure, Design ___	each
2411.507	Concrete (Type of Structure) ___	each
2411.511	Structure Excavation, Class ___	cubic yard [cubic meter]
2411.521	Granular Backfill ___ *	cubic yard [cubic meter]
2411.523	Aggregate Backfill ___ *	cubic yard [cubic meter]
2411.541	Reinforcement Bars ___	pound [kilogram]

* Specify the basis of measure (LV or CV) after the item name. See 2451.4.B, "Granular Materials."

2412 PRECAST CONCRETE BOX CULVERTS

2412.1 DESCRIPTION

This work consists of installing precast concrete box culverts.

2412.2 MATERIALS

A Concrete **2461**

B Reinforcement Bars **3301**

C Steel Fabric **3303**

D Joint Sealer Materials

D.1 Preformed, Type A or B **3726**

D.2 Bituminous Mastic **3728**

E Granular Materials **3149**

F Geotextile, Type II **3733**

G Precast Concrete Box Culverts **3238**

2412.3 CONSTRUCTION REQUIREMENTS

Construct precast concrete box culverts in accordance with 2411, "Minor Concrete Structures," 2451, "Structure Excavations and Backfills," and 3236, "Reinforced Concrete Pipe," and the following:

A Foundations

Prepare foundations in accordance with 2451.3.C, "Foundation Preparations," except provide granular bedding in accordance with 3149.2.F, "Granular Bedding," and at least 6 in [150 mm] thick. Use a template to shape the bedding to a flat base. Use a mechanical hand compactor to compact the bedding adjacent to the bottom corner radii.

B Laying Precast Concrete Box Culvert

Lay precast concrete box culvert sections with the groove end of each section up-grade. Tightly join the sections. Use concrete pipe ties meeting the requirements of Mn/DOT Standard Plate 3145 to tie individual sections together. Seal the joint on the bottom of the box culvert with preformed mastic. Place a strip of geotextile material at least 24 in [600 mm] wide centered over the top and sides of the joint. Prevent displacement of the geotextile material during backfilling operations.

If required by the contract, provide a flexible watertight seal in the joints of the precast concrete box culvert using a preformed rubber, preformed plastic, or bituminous mastic seal listed on the Approved/Qualified Products List.

Apply mastic joint sealer materials as recommended by the manufacturer. Wipe clean the inside of joints after sealing. Use precast concrete plugs to plug lifting holes. After plugging, seal and cover lifting holes with mastic or mortar.

2412.4 METHOD OF MEASUREMENT

A Culvert Excavation

If the contract contains separate pay items for culvert excavation, the Engineer will classify and measure excavation for concrete box culverts in accordance with 2451.4.A, "Structure Excavation."

B Precast Concrete Box Culverts

The Engineer will measure precast concrete box culverts by length. The Engineer will determine the length by adding the nominal laying lengths of the individual sections incorporated into each structure. The Engineer will take separate measurements for each contract pay item size.

The Engineer will measure transition sections between two different box culvert sizes as the larger or more costly size, except for special sections designated for measurement as each.

C End Sections and Other Appurtenant Items

The Engineer will separately measure end sections and other appurtenant items such as flap gates and other specially identified units, having contract pay units described as "each", by the number of complete units of each type and size incorporated into the box culvert structures.

The Engineer will measure cast-in-place concrete work, other than end sections and culvert extensions, in accordance with 2411, "Minor Concrete Structures."

D Granular Materials

The Engineer will not separately measure granular bedding for concrete box culverts.

If the contract includes contract pay items for special backfill or bedding, the Engineer will measure special backfill or bedding for precast concrete box culverts in accordance with 2451.4.B, "Granular Materials."

2412.5 BASIS OF PAYMENT

The contract unit price for *Precast Concrete Box Culvert* and *Precast Concrete Box Culvert End Section* will include the cost of providing and installing culverts and end sections, excavations, drop-wall, foundation preparation, granular bedding material, and backfill, unless the contract includes separate contract pay items for the

work. The Department will include the cost of cast-in-place concrete work for extending an existing box culvert with the adjacent precast box culvert. The Department will include the cost of the 6 in [150 mm] granular bedding for precast concrete box culverts with the relevant contract pay items for precast concrete box culverts.

The Department will pay for precast concrete box culverts on the basis of the following schedule:

Item No.:	Item:	Unit:
2412.511	___ x ___ Precast Concrete Box Culvert	linear foot [meter]
2412.512	___ x ___ Precast Concrete Box Culvert End Section	each

2422 CRIB WALLS

2422.1 DESCRIPTION

This work consists of using preformed galvanized metal units or precast concrete crib units to construct crib type retaining walls.

2422.2 MATERIALS

A Metal Cribbing.....3351

B Concrete Cribbing 3661

C Hardware

Provide hardware in the type and size as shown on plans. Galvanize hardware in accordance with 3392, "Galvanized Hardware."

2422.3 CONSTRUCTION REQUIREMENTS

A Foundation Preparations

Prepare foundation in accordance with 2451.3.C, "Foundation Preparations."

B Erection

Erect crib walls as shown on the plans for the type being constructed. The Engineer will adjust the planned length of the structure during construction to allow for the use of standard length units.

C Backfilling

Place excavated material within the limits of the excavation, whether inside or outside the crib. Use suitable excavated material to fill the crib. Backfill outside of the crib as the crib filling progresses maintaining a maximum elevation difference of 8 in [200 mm] between the inside and outside of the crib. Place the material in layers no greater than 8 in [200 mm] thick. Thoroughly compact each layer before placing the next layer.

Dispose of excavated material not used for backfilling as directed by the Engineer. If the excavated material is not suitable for use as backfill, backfill with the same material provided for crib filling.

D Crib Filling

Fill the interior of the crib with material approved by the Engineer. Fill the crib as the erection of the cribbing units progresses.

Use earth material approved by the Engineer to fill the interior of the cribs for the retention of an embankment at locations with no wave action against the face of the wall. Place layers no greater than 8 in [200 mm] thick. Thoroughly compact each layer before placing the next layer.

For walls subjected to wave or current action, use boulders or quarry run rock to fill the interior of bar type cribs, and use pit run gravel or quarry run rock for bin type cribs. Provide rocks larger than the vertical distance between bars to fill bar type cribs. Place the material to minimize the void content and without damaging the cribbing units.

2422.4 METHOD OF MEASUREMENT

A Excavation

The Engineer will classify and measure excavation in accordance with 2451, "Structure Excavations and Backfills," if the contract includes pay items for structure excavation.

B Crib Walls

The Engineer will separately measure crib walls of each type by the overall area of the front face of the wall, based on actual completed dimensions.

C Crib Filling

The Engineer will measure crib filling by volume, vehicular measure, only if the contract includes pay items for crib filling.

2422.5 BASIS OF PAYMENT

The Department will pay for crib filling if the contract includes relevant pay items.

If the Contractor constructs the crib in conjunction with an adjacent embankment and if no special crib filling material is required by the contract, the Department will pay for crib filling as embankment at the relevant contract unit price for embankment. If crib filling material is used for backfilling, the Department will pay for the material used at the contract unit price for crib filling.

If the Contractor does not construct the crib in conjunction with an adjacent embankment or if a special crib filling material is required by the contract, the Department will pay for crib filling as extra work in accordance with 1402, "Contract Revisions," or at the relevant contract unit price.

The Department will pay for structure excavation in accordance with 2451, "Structure Excavations and Backfills," if the contract includes relevant pay items. If the contract does not specify a contract unit price for structure excavation, the Department will include the cost of structure excavation with other relevant contract pay items.

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

Item No.:	Item:	Unit:
2422.501	Structural Excavation, Class ___	cubic yard [cubic meter]
2422.506	Metal Crib Walls	square foot [square meter]
2422.507	Concrete Crib Walls	square yard [square meter]
2422.511	Earth Crib Filling	cubic yard [cubic meter]
2422.512	Gravel Crib Filling	cubic yard [cubic meter]
2422.513	Rock Crib Filling	cubic yard [cubic meter]

2433 STRUCTURE RENOVATION

2433.1 DESCRIPTION

This work consists of widening, rebuilding, or restoring structures, including removal as shown on the plans and in the special provisions.

2433.2 MATERIALS

Except as otherwise specified, provide materials in accordance with Division III.

2433.3 CONSTRUCTION REQUIREMENTS

A General

A.1 Traffic Provisions

Provide traffic provisions as shown in the special provisions. Unless the contract requires otherwise, provide flaggers, and erect and maintain temporary curbs, rails, extra warning lights, special signs, and other protective devices as required by the Engineer and in accordance with 1710, "Traffic Control Devices," at no additional cost to the Department.

If the contract requires, construct temporary sidewalks for pedestrian use entirely outside of the vehicular traffic lanes. Construct temporary sidewalks for pedestrians at least 4 ft [1,200 mm] wide and with 6 ft [1,800 µm] high protective screening and handrails as shown on the plans.

A.2 Explosives

Do not use explosives to remove any portion of a structure being widened or reconstructed. The Contractor may use explosives to remove material not directly connected to the remaining structure as approved in writing by the Engineer and in accordance with 1711, "Use of Explosives."

A.3 Field Measurements

Consider the dimensions of the old structure as shown on the plans as approximate. Before making shop detail drawings and before manufacturing, take measurements of the old structure to ensure proper joining of the old and new work. Provide the measurements to the Engineer. Show field measurements on the shop detail drawings.

B Removal and Disposal Requirements

Remove and dispose of materials encountered in the renovation of existing structures in accordance with 2442, Removal of Existing Bridges" and meeting the requirements of the web based Building and Bridge Demolition Manual and the following:

Stabilize peeling lead paint by coating with a paint listed on the Approved/Qualified Products List to prevent the peeling paint from flaking during demolition, or scrape and contain the peeling paint. If painting, apply 16 mil [400 µm] of paint. If applying paint on a bridge over water, attach a diaper apron or other containment method if necessary to prevent drips of paint from contaminating the water.

Remove old concrete or stone masonry within the limits shown on the plans and without damaging the remaining structure. Make saw cuts at least 1 in [25 mm] deep on faces exposed to view to produce a straight line between new and old concrete.

Cut keyways into the concrete that remains in place without damaging the remainder of the structure as shown on the plans.

Do not impair the supporting capacity of the foundation soil and do not damage the remaining structure if removing piling located within the new footing area.

If old piles interfere with the planned spacing of new piles, drive the old piling to determine bearing capacity and suitability for use in the new construction, as directed by the Engineer. Unless otherwise required by the contract, the Department will pay for extra pile driving as extra work in accordance with 1402, "Contract Revisions."

C Concrete Construction

Perform concrete construction in accordance with 2401, "Concrete Bridge Construction," and the following:

(1) Place and secure bolt anchors and other fasteners as specified in the special provisions and in accordance with the manufacturer's installation recommendations,
(2) If no surface finishing of old concrete is shown on the plans, provide a surface finish for at least 2 ft [600 mm] of the adjoining portion of the old concrete to blend the finish of the new with the old work, and
(3) Unless otherwise shown on the plans, drill holes and install bolt anchorages to the size and depth in accordance with the manufacturer's recommendations.

D Reinforcement Steel

Place reinforcement steel in accordance with 2472, "Metal Reinforcement," and the following:

(1) Unless otherwise shown on the plans or the special provisions, do not cut reinforcement bars that extend through the cut line closer than 40 diameters to the cut line, and
(2) If any reinforcement bar loses more than 10 percent of its section due to damage from the removal of old concrete, install an approved bolt anchor or clamp capable of developing the strength of the damaged bar, at no additional cost to the Department and as directed by the Engineer.

E Structural Steel Construction

Provide structural steel manufactured in accordance with 2471, "Structural Metals." Erect structural steel in accordance with 2402, "Steel Bridge Construction," and the following:

(1) If practicable, subpunch holes for field connections between new and old steel in the shop. Ream the holes to proper size in the field after assembly. If making the holes for these connections in the field, clamp the parts together and drill the holes using the holes in the old steel as a template. Do not use a flame-cutting torch to make the holes,
(2) Clean rust, scale, and foreign matter from the tops of existing steel stringers and floor beams in contact with new timber or concrete, and coat with primer in accordance with 2478, "Organic Zinc-Rich Paint System," or as directed by the Engineer. Allow the paint to dry for at least 24 h.
(3) Clean foreign matter from the contact surfaces of old steel and coat with the designated primer paint in accordance with 2478, "Organic Zinc-Rich Paint System," before permanently connecting to the new steel.

F Masonry Construction

Construct masonry as shown on the plans.

Make connections to old stone masonry at the old mortar joints. Step the joints to old stone masonry as directed by the Engineer.

Clean mortar and loose or fractured material from old stone masonry at the joint before placing the new masonry. Immediately before placing new concrete or stone masonry, wet the surface of the old masonry.

G Timber Construction

Perform timber construction in accordance with 2403, "Timber Bridge Construction," and the following:

(1) Use new nails, spikes, and hardware throughout the work,
(2) Before placing either new or old timber on the structure, clean the contact surfaces of the timber, and
(3) Apply at least two coats of copper naphthenate or another compatible preservative material meeting the requirements of AWPA M4 to contact surfaces, except treat new treated timber and designated old structure parts with oil paint. Allow each application of preservative to dry for at least 2 h before applying the next coat.

2433.4 METHOD OF MEASUREMENT

A Structure Removals

The Engineer will measure structure removals by lump sum.

B Item Removals

The Engineer will measure removal of specified items by the unit of measure for the contract item as shown on the plans and in accordance with the following:

B.1 Lump Sum

The Engineer will measure item removals by lump sum, including the entire item as required by the contract or as approved by the Engineer.

B.2 Mass

The Engineer will measure removal of structural steel by weight in accordance with 2402.4.A, "Weight."

B.3 Length

The Engineer will measure the length of item removals longitudinally along the center of the unit and within the limits shown on the plans or approved by the Engineer.

B.4 Area

The Engineer will measure item removal by area on the basis of actual width and length measurements and within the limits shown on the plans or as approved by the Engineer.

B.5 Volume

The Engineer will measure item removal by volume, except for timber, on the basis of actual dimensions of the unit as removed. The Engineer will measure timber based on nominal sizes and actual lengths.

B.6 Each

The Engineer will measure item removal by each complete item removed for the required work.

C Anchorages

The Engineer will separately measure *Anchorages* of each type shown on the plans by the number of units complete in place.

D Placing Used Materials

The Engineer will separately measure the placement of used materials by the unit of measure for the contract item as shown on the plans and in accordance with place used items.

2433.5 BASIS OF PAYMENT

The contract unit price for deck removal includes the cost of cleaning and painting, unless otherwise shown on the plans. The Department will pay for structure renovation on the basis of the following schedule:

Item No.:	Item:	Unit:
2433.501	Structure Removals	lump sum
2433.502	Remove*	cubic yard [cubic meter]
2433.503	Remove*	pound [kilogram]
2433.505	Remove*	square foot [square meter]
2433.506	Remove*	linear foot [meter]
2433.507	Remove*	lump sum
2433.509	Remove*	each
2433.510	Place Used*	each
2433.511	Place Used*	pound [kilogram]
2433.512	Place Used*	lump sum
2433.513	Place Used*	Mbm‖ [cubic meter]
2433.515	Place Used*	linear foot [meter]
2433.516	Anchorages, Type___	each

* Specify item name
‖ 1,000 board-feet measure

2442 REMOVAL OF EXISTING BRIDGES

2442.1 DESCRIPTION

This work consists of removing and disposing of existing bridges.

2442.2 MATERIALS

Use explosives for the removal of existing bridges in accordance with 1711, "Use of Explosives," and as approved by the Engineer.

2442.3 CONSTRUCTION REQUIREMENTS

A General

The Department will not require salvage of material during bridge removal, unless otherwise shown on the plans or as required by the special provisions. Remove material, not required for salvage for the Department, using methods that will not damage salvaged members.

Place salvaged material in stockpiles at locations as directed by the Engineer. If the Contract requires delivery of salvaged material to a storage yard or other designated location, place salvaged material on dunnage or sound wooden pallets. Dispose of material not required for salvage in accordance with 2104.3.C, "Removal Operations," and 2104.3.D, "Disposal of Materials and Debris."

Completely remove portions of substructures, including piling and minor obstructions, where removals interfere with the new structure. Remove existing piles under new footings to the bottom of the new footings. Remove existing substructure units located outside the limits of the new structures to the elevation of the stream bed or to an elevation at least 2 ft [600 mm] below the final ground surface. In established navigation channels, remove existing substructure units located outside the limits of the new structures to an elevation of at least 2 ft [600 mm] below the established bottom of the channel. Remove substructure units and piles located within the roadbed to an elevation at least 4 ft [1,200 mm] below subgrade. If located on a railroad grade, remove substructure units and piles to an elevation of 4 ft [1,200 mm] below base of rail, unless otherwise shown on the plans or in the special provisions.

Remove piles, drift material, sheet piling, and other minor construction located within the right-of-way that are not a part of the existing bridge, if obstructing the stream channel or presenting an unsightly appearance as determined by the Engineer. Remove ice breakers, existing piers, and similar units, as required by the contract. The Department will consider the removal of items not required by the contract and not visible on inspection of the site of the work as extra work in accordance with 1402, "Contract Revisions." The Department will not pay for material removed solely for the Contractor's convenience.

Fill pits or trenches resulting from the removal operations with earth material approved by the Engineer. Place backfill above water level in layers no greater than 1 ft [300 mm] thick. Compact each layer in accordance with the methods in 2105.3.F.2, "Quality Compaction Method."

If removing a bridge from a location not on the site of the new structure, excavate and dispose of the embankments adjoining the abutments as directed by the Engineer and in accordance with the following:

(1) To slopes conforming to the natural ground surface, or
(2) To a 1V:2H slope beginning at the intersection of the front face of the abutment and continuing until intersecting with the natural ground surface.

Do not constrict the stream channel except as required by the contract or as approved by the Engineer.

If removing part of an existing concrete pavement, remove the pavement to an existing joint or cut the pavement on a straight line at right angles to the centerline of the road. If cutting, use a saw to cut the top surface at least 1 in [25 mm] deep without damaging the pavement remaining in place. During excavation, prevent undermining or disturbing the foundation material under pavement remaining in place.

B Structural Steel

Dismantle salvaged structural steel in sections, individual members, or parts as shown on the plans or as directed by the Engineer. Unless otherwise required by the contract, remove structural steel in the reverse sequence of the original erection. Remove structural steel without damaging any structural members. Only cut field driven rivets. Use pilot nuts to draw pins.

Match-mark members with valve-action opaque paint markers in accordance with a diagram provided by the Department. Similarly mark pins, pin nuts, loose plates, and ring fills to indicate proper location. Securely wire or bolt loose parts to adjacent members, or pack loose parts in properly identified boxes.

Coat pins, pin-holes, and machined surfaces with a lubricant listed on the Approved/Qualified Products List.

Remove rivets with a pneumatic chipping tool. Do not use torches unless specifically required by the contract.

Stockpile structural steel on suitable skids. Arrange dissimilar parts in separate piles. Stack structural steel to avoid damage to the members.

C Timber

Remove timber and lumber with minimal breakage or splitting. Remove nails, spikes, fastenings, and hardware from timber and lumber. Clean timber of dirt and all other foreign matter except paint and bituminous surfacing material.

2442.4 METHOD OF MEASUREMENT

The Engineer will measure each total bridge removal and will not separately measure salvage material types or salvage portions of work for each bridge removed.

2442.5 BASIS OF PAYMENT

The contract unit price for *Removing Existing Bridge* includes the cost of excavation, removal, disposal, backfill, grading of the work area, and removal of obstructing or unsightly piles, drift material, sheeting piling, and minor construction in the right-of-way, unless otherwise required by the contract.

The Department will pay for the removal of existing bridges or material salvage on the basis of the following schedule:

Item No.:	Item:	Unit:
2442.501	Remove Existing Bridge	lump sum
2442.502	Salvage and Haul Material (Bridge)	lump sum