

DIVISION 4
MAJOR STRUCTURES
SECTION 400
TEMPORARY STRUCTURES

400-1 DESCRIPTION

Furnish any design calculations and drawings that are required; furnish members and deck materials for structures, and any other materials that are necessary; erect, maintain, remove and dispose of temporary structures required for the maintenance of pedestrian, highway, and other traffic. Approaches to temporary structures are not a part of this work.

Construct temporary structures in accordance with the contract. Maintain traffic over the temporary structure in accordance with Division 11.

400-2 MATERIALS

Use materials for temporary structures that conform to the requirements of Division 10 of the Specifications or previously used materials conforming to the requirements of the Specifications. Obtain approval for the use of salvaged materials and materials not covered by Division 10 prior to their use. The use of untreated timber is allowed unless otherwise required.

400-3 PLANS**(A) Furnishing Plans**

Use the plans for the structure furnished by the Department or submit a design in accordance with Subarticle 400-3(B).

Design the structure when the plans furnished by the Department do not include detail plans for the structure. For all contractor designs, furnish one set of design calculations and 11 sets of detail drawings of the structure in accordance with Subarticle 400-3(B).

Submit detail drawings and design calculations for temporary structures for review and comment prior to beginning work. Do not perform any work until the detail drawings are reviewed and accepted. Acceptance of such drawings does not relieve the Contractor of any responsibility for safely and continuously maintaining traffic.

(B) Design Requirements for Contractor Furnished Drawings

Provide temporary structures of such carrying capacity, dimensions, grades, and alignment as required by the contract, or as directed. Design temporary structures carrying highway and pedestrian traffic in accordance with the *AASHTO Standard Specifications for Highway Bridges*. Have a North Carolina Licensed Professional Engineer design and detail the temporary structure and construct the temporary structure in accordance with this design.

Indicate on the plans, the Specifications for the materials used in the temporary structure.

400-4 CONSTRUCTION REQUIREMENTS

Construct and maintain temporary structures to adequately and safely carry traffic during the entire period for which they are required.

Remove and dispose of the temporary structures after they are no longer required in accordance with Article 402-2.

Upon removal of the temporary structure, all material furnished by the Contractor for use in this structure is the property of the Contractor unless otherwise provided in the contract.

Remove temporary piling to the streambed level or to 0.3 m below existing ground.

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400-5 MEASUREMENT AND PAYMENT

The price and payment below will be full compensation for all items required to provide temporary structures including but not limited to those items contained in Article 400-1.

The work covered by this section will be paid for at the contract lump sum price for *Construction, Maintenance, and Removal of Temporary Structure at Sta. _____*.

Payment will be made under:

Pay Item	Pay Unit
Construction, Maintenance, and Removal of Temporary Structure at Sta. _____	Lump Sum

**SECTION 402
REMOVAL OF EXISTING STRUCTURES**

402-1 DESCRIPTION

Excavate as necessary to remove the structure; dismantle, salvage, and stockpile materials and components of the structure and preserve those portions that should remain intact, and dispose of waste and debris.

Maintain traffic over the existing structure in accordance with Division 11 unless otherwise stipulated by the contract. Comply with the posted load limits of the existing structure. The maintenance of the existing structure, if required, will be performed by Department forces.

402-2 REMOVAL OF EXISTING STRUCTURE

(A) General

Use approved methods and operations for removal of structures. Upon removal, all materials become the property of the Contractor unless otherwise indicated in the contract. Dispose of waste and debris from the structures in accordance with Section 802.

Perform removal operations while preventing damage to adjacent property. Protect new construction during blasting or other operations necessary for the removal of the existing structure.

Unless otherwise required by the contract, remove substructures down to the streambed or 0.3 m below the natural ground surface. Remove the substructure as necessary to avoid interference with construction of the proposed structure.

Prevent erosion of soil and silting of rivers, streams, lakes, reservoirs, water impoundment, ground surfaces, or other property. Do not deposit excavated materials and do not construct earth dikes or other temporary earth structures in rivers, streams, or impoundment or so near to such waters that they are carried into any river, stream, or impoundment by stream flow or surface runoff. Limit the use of equipment in any body of water to those operations that are impossible or impractical to perform in any other way, and control them as to minimize erosion and siltation. Do not drop components of structures into any body of water. Remove existing bridges over water by sawing or other non-shattering methods. Submit, and await approval for, a plan for bridge demolition for these bridges prior to beginning removal. Remove any component of a structure from the water so as to minimize siltation.

(B) Requirements for Materials Which Remain the Property of the Department

Pile materials salvaged from the structure neatly on the right of way at locations as directed.

Do not use any materials, either temporarily or permanently, which are removed from the structure unless so permitted by the contract.

Remove structural materials carefully without damage.

Do not use explosives to remove concrete floor slabs from steel superstructures that remain the property of the Department.

(C) Requirements for Partial Removal

Perform partial removal true to the lines indicated on the plans. Submit, and await approval for, a plan for partial removal of bridges prior to beginning removal. Do not remove concrete by blasting or other method that may cause damage to the concrete or reinforcement that is used in the completed structure.

Use equipment and methods to remove portions of a concrete structure undergoing widening which are sufficient to obtain plan lines and slopes without undue spalling at edges of the concrete. Do not use an iron ball or pile hammer to remove portions of a concrete structure undergoing widening.

402-3 MEASUREMENT AND PAYMENT

The price and payment below will be full compensation for all items required to remove temporary structures including but not limited to those items contained in Article 402-1.

When the contract includes the item of *Removal of Existing Structure at Sta.* _____, the work of removing the structure will be paid for at the contract lump sum price for this item.

Payment will be made under:

Pay Item	Pay Unit
Removal of Existing Structure at Sta. _____	Lump Sum

**SECTION 410
FOUNDATION EXCAVATION**

410-1 DESCRIPTION

Excavate any material as necessary for the construction of foundations and end bent caps for bridges, retaining walls of reinforced concrete or reinforced masonry, arch culverts, and box culverts without floor slabs in accordance with the contract, or as directed. Excavate, perform exploratory drilling at footings to a depth not to exceed 1.5 m, blast, drain and divert water, bail, and pump. Provide and remove bracing, shoring, sheeting, cribbing, and cofferdams; substructure scour protection, subsurface drainage, drawings; and backfill, haul, and dispose of materials.

Do not deposit excavated materials or construct earth dikes or other temporary earth structures in rivers, streams, or impoundment or so near to such waters that they are carried into any river, stream, or impoundment by stream flow or surface runoff. As an exception to the above, obtain written approval for the use of confined earth materials in cofferdams for structure foundations.

410-2 MATERIALS

Refer to Division 10.

Item	Section
Subdrain Fine Aggregate	1044-1
Stone, No. 78M	1005

410-3 FOUNDATION EXCAVATION

Notify the Engineer in sufficient time before beginning the excavation to allow measurements of the undisturbed ground.

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Where necessary for safety, slope, shore, brace, or protect by cofferdams the foundation openings in accordance with local and State safety standards. Perform foundation excavation and related work in such sequence that no portion of the structure is endangered by subsequent operations. Adequately protect completed portions of a structure during blasting operations.

Consider the dimensions and elevations of footings, as shown on the plans as approximate only. The Engineer may order, in writing, such changes in dimensions or elevations of footings as necessary to secure a satisfactory foundation.

Notify the Engineer after excavating each foundation. Do not place concrete prior to obtaining approval for the excavation depth, the character of the foundation, and permission to proceed. Perform drilling as may be required by the Engineer in order to obtain information as to the depth to which the rock or other hard foundation material extends below the bottom of the footing.

Clean all rock or other hard foundation material of all loose material and cut to a firm surface, either level, stepped, or serrated, as directed. Clean out all seams and fill with concrete, mortar, or grout. Remove all loose and disintegrated rock and thin strata. Leave the rock surface in a rough condition to form an adequate key against lateral movement of the footing.

When the footing rests on an excavated surface other than rock, take special care not to disturb the bottom of the excavation until immediately before placing reinforcing steel and concrete. Remove foundation material softened and weakened by exposure and inundation down to sound, solid material before placing steel and concrete.

When using foundation piles, complete the excavation of each pit before driving piles.

When pile driving liquefies the soil, or the bed is otherwise unsuitable as determined by the Engineer, remove the material as required and backfill to the required elevation with an approved granular material. Such work will be paid for as extra work in accordance with Article 104-7.

410-4 COFFERDAMS

(A) General

The term cofferdam designates any temporary or removable structure constructed to hold the surrounding earth, water, or both, out of the excavation. It includes timber cribs, any type of sheet piling, removable steel shells, or similar structures, all necessary bracing, and the use of pumping wells or well points for the same purpose. Have cofferdams located in bodies of water designed, detailed, and sealed by a North Carolina Licensed Professional Engineer when the distance from the water surface to the bottom of the excavation is 1.5 m or greater.

(B) Construction

Design and construct cofferdams to adequate depths and heights, safely, and as watertight as is necessary for the proper performance of the work. Provide interior dimensions of cofferdams as to give sufficient clearance for the construction and inspection of forms and to permit pumping outside the forms. Provide at least 1.5 m of clearance between the proposed edge of footing and inside face of cofferdam when a keyed footing is required and at least 1 m when a keyed footing is not required. Right, rest, or enlarge cofferdams that are tilted or moved laterally during the process of sinking to provide the necessary clearance.

Construct cofferdams to protect plastic concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. Do not leave timber or bracing in cofferdams that could extend into the substructure concrete without permission.

(C) Removal

After the completion of the substructure, unless otherwise provided in the contract, remove cofferdams with all sheeting and bracing to the stream bed or 0.3 m below existing ground. Take care not to disturb or injure the finished concrete.

410-5 PUMPING

Perform pumping operations in accordance with Article 414-5.

410-6 PRESERVATION OF CHANNEL

Unless otherwise required by the contract or permitted by the Engineer, do not excavate in stream channels outside of cofferdams. Do not disturb the natural stream bed adjacent to the structure without permission. Backfill any excavation or dredging made at the site of the structure outside of the cofferdam limits to the original ground surface or river bed with approved material.

Remove materials placed within the stream area and leave the stream in its original condition, unless otherwise permitted.

410-7 UTILIZATION OF EXCAVATED MATERIAL

Use suitable excavated material as backfill. Use suitable material that is not required for backfill to form embankments, subgrades, or shoulders. When so used, no additional payment will be made for utilization of the material under other pay items or for stockpiling the material for use under other pay items. Furnish disposal areas for excavated unsuitable materials and suitable materials not required in connection with other work included in the contract. Do not place excavated material in a stream or other body of water or wetland.

Do not deposit excavated material at any time so as to endanger the partly finished structure, either by direct pressure or indirectly by overloading banks adjacent to the operations, or in any other manner.

410-8 BACKFILLING AND FILLING

Use approved material for backfill that is free from large or frozen lumps, wood, or other undesirable material. Where there is not an adequate quantity of suitable backfill material available from the excavation, provide suitable backfill material compensated in accordance with Subarticle 410-12.

Refill all excavated spaces not filled with permanent work with earth up to the ground surface existing before the excavation. Place backfill to provide adequate drainage as soon as concrete surfaces are finished in accordance with Subarticle 420-17(B) and the concrete is inspected and approved. The Engineer has the authority to suspend all operations until such backfilling is acceptably completed.

Eliminate any slope adjacent to the excavation for abutments, wingwalls, and retaining walls by stepping or serrating to prevent wedge action.

Compact all portions of the backfill that become a part of roadway typical sections or their foundations in accordance with Subarticle 235-4(C). Place all other portions of the backfill in layers not more than 150 mm depth of loose measure and compact to a density comparable to the adjacent undisturbed material.

Place backfill or embankment material simultaneously insofar as possible to approximately the same elevation on both sides of an abutment, pier, or wall. If conditions require placing backfill or embankment higher on one side, do not place the additional material on the higher side until the concrete develops the minimum specified strength for the class of concrete required for the structure.

Do not place backfill or embankment behind the walls of concrete culverts, abutments of bridges other than rigid frames, or abutments of rigid frame structures until the top slab is placed and has developed the minimum compressive strength required by Article 420-20. Place backfill and embankment simultaneously behind opposite abutments of rigid frames or sidewalls of culverts. Place backfill for abutments of

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bridges to a minimum elevation of 0.3 m below the bridge seats before setting beams or girders.

Place backfill so as not to cause excess lateral forces against the structure by heavy equipment or from earth masses transmitting pressures caused by earth moving equipment. Place backfill immediately adjacent to the structure by hand operated mechanical tampers. Do not operate heavy earth moving equipment within 3 m of the structure in backfilling operations.

410-9 SUBSURFACE DRAINAGE AT WEEP HOLES

Place a stone drain consisting of 0.03 m³ of No. 78M stone contained in a bag of porous fabric at each weep hole. Place subdrain fine aggregate beneath, around, and over the stone drain so that the stone drain is covered by a layer of subdrain fine aggregate at least 0.3 m thick. Connect all drains with a horizontal drain of subdrain fine aggregate at least 0.3 m square in cross section. In the case of abutments and retaining walls, in addition to the above requirements, place a vertical drain of subdrain fine aggregate at least 0.3 m square in cross section at each weep hole to an elevation 0.6 m below the subgrade or surface of the embankment.

When embankment placement around the structure is part of another contract, the portion of the subsurface drainage system described above, which is located in such embankment, is not considered part of the work of this section.

410-10 SUBSTRUCTURE SCOUR PROTECTION

Provide substructure scour protection as indicated in the plans. Place the 50 mm to 150 mm size stone after removing footing formwork and while dewatering the excavation. Place the riprap stone before removing the cofferdam sheeting, either before or after allowing the excavation to flood. When not using sheeting, place each stone type to the required thickness and extend horizontally to the undisturbed material.

Use 50 mm to 150 mm size Scour Protection Stone which is hard and durable in nature. While no specific gradation is required, distribute the various sizes of stone reasonably equally within the required size range. Use stone that is essentially cubical in shape.

410-11 BLASTING ADJACENT TO HIGHWAY STRUCTURES

Conduct blasting operations adjacent to highway structures in accordance with the following requirements.

Submit and await approval of a blasting plan prior to conducting any blasting operation.

Do not conduct blasting operations within 18 m of any structure until the concrete strength reaches 16.5 MPa. After the concrete achieves a strength of 16.5 MPa, limit the maximum peak particle velocity to 100 mm/sec. measured at the closest structure extremity.

For multi-column bents with column heights up to 12 m and a combined span length for the two adjacent spans of 49 m or less, adhere to the following criteria:

- (A) Do not blast within 2 m without obtaining prior written approval.
- (B) At distance of 2 m to 3 m do not use a quantity of explosives more than 0.22 kg per delay period.
- (C) From 3.3 m to 18.3 m, use a maximum charge weight per delay of 0.22 kg + 0.22 kg of explosives per 0.3 m of distance over 3 meter.

No vibration measurements are required if the above criteria are met. If unable to meet the above criteria, monitor the structure with an engineering seismograph to determine whether the 100 mm/sec. limit is exceeded. If the 100 mm/sec. limit is exceeded, the Engineer will evaluate each subsequent blast, and if deemed necessary, will apply more restrictive controls than those above to prevent damage.

Payment of blasting operations is included in the bid price for Foundation Excavation at the affected substructure unit.

410-12 MEASUREMENT AND PAYMENT

Foundation Excavation on a Cubic Meter Basis

When the contract calls for payment of foundation excavation on a cubic meter basis, it will be measured and paid on a cubic meter basis for the actual number of cubic meters of materials, measured in their original position within the limits described below and computed by the average end area method, that are acceptably excavated.

The upper limits for measurement are the actual ground surface at the time of starting work, except that where the excavation is performed in cut areas excavated under Section 225, the upper limits are the roadway plan typical section. For keyed footings the upper limits of the keyed section are as shown on the plans. A keyed footing is a footing that is placed without forms for the keyed depth in an excavation whose sides, as near as practicable, are located at the neat line dimensions of the footing and are vertical.

When the foundation material is other than rock, the lower limits for measurement are the elevation of the bottom of footing as established by the plans or as directed. When the foundation material is rock, the lower limits for measurement are the actual rock elevations after the foundation is approved.

As an exception to the lower limits established above, when in the opinion of the Engineer excess excavation is performed due to carelessness or negligence on the part of the Contractor, the Engineer notifies the Contractor of that portion of the excavation which is not measured for payment.

Horizontal limits for measurement are established by vertical planes located 450 mm outside of the neat line dimensions of the footing as established by the plans or directed in writing by the Engineer. For keyed footings the horizontal limits for measurement of the keyed section are established by vertical planes located at the neat line dimensions of the footing as established by the plans or directed in writing.

Measurement includes mud, muck, or similar semi-solid material within the limits described above provided such material is present at the time excavation begins and cannot be drained away or pumped without the use of a jet or nozzle.

No measurement is made of the following excavation, as such excavation is considered incidental to the work covered by this section:

Excavation necessary to construct end bent caps and the berm adjacent to the cap.

Excavation necessary to construct pile encasement.

Excavation outside of the limits described in this subarticle.

Excavation necessary from heaving of a foundation due to the driving of piles.

Excavation necessary from overbreaks or slides.

Mud, muck, or similar semi-solid material which can be drained away or pumped without the use of a jet or nozzle.

Excavation made before the Engineer makes measurements of the undisturbed ground.

Excavation necessary due to exposure or inundation allowed by the Contractor, or carelessness on the part of the Contractor.

Foundation excavation will be paid for at the contract unit price per cubic meter for Foundation Excavation except as otherwise provided below.

Where the Engineer directs the Contractor in writing to excavate below the original plan elevation of the bottom of the footing, payment for such excavation will be made as follows:

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For excavation made below the original plan elevation of the bottom of the footing to an elevation 1 meter below such plan elevation, payment will be made at the contract unit price per cubic meter for *Foundation Excavation*.

For excavation made below an elevation 1 meter below the original plan elevation of the bottom of the footing but not more than 2 meters below such plan elevation, payment will be made at 150 percent of the contract unit price per cubic meter for Foundation Excavation.

For excavation made below an elevation 2 m below the original plan elevation of the bottom of the footing, payment will be made as provided in Article 104-7 for extra work.

In areas where piles have been driven, removal of material and backfilling with approved granular material, in accordance with Article 410-3, will be paid for as extra work as provided in Article 104-7.

Foundation Excavation on a Lump Sum Basis

When the contract calls for payment of *Foundation Excavation* on a lump sum basis, no measurement will be made of any foundation excavation made at such locations.

The prices and payments below will be full compensation for all items required to complete foundation excavation.

When the contract calls for payment on a lump sum basis, payment will be made at the contract lump sum price for *Foundation Excavation for Bent No. _____ at Station _____*, or *Foundation Excavation for End Bent No. ____ at Station ____* except as otherwise provided below.

Where the Engineer directs the Contractor to excavate below the original plan elevation of the bottom of the footing by a distance which is less than 1 meter the character of the work will not be considered to be materially changed and no additional compensation will be allowed for the foundation excavation at such location.

Where the Engineer directs the Contractor in writing to excavate more than 1 meter below the original plan elevation of the bottom of the footing, payment for such excavation will be made as provided in Article 104-7 for extra work.

Furnishing and Hauling Backfill Material

Where it is necessary to provide backfill material from sources other than excavated areas or borrow sources used in connection with other work in the contract, payment for furnishing and hauling such backfill material is made as provided in Article 104-7 for extra work. Placing and compacting such backfill material is not considered as extra work, but is considered incidental to the work covered by this section.

When the Contractor has been directed by the Engineer to drill in the vicinity of a footing to obtain subsurface information, such drilling in excess of a 1.5 meter depth will be paid for as provided in Article 104-7 for extra work.

Payment will be made under:

Pay Item	Pay Unit
Foundation Excavation	Cubic Meter
Foundation Excavation for Bent No. _____ at Station _____	Lump Sum
Foundation Excavation for End Bent No. ____ at Station ____	Lump Sum

**SECTION 412
UNCLASSIFIED STRUCTURE
EXCAVATION**

412-1 DESCRIPTION

Excavate any material not classified as foundation excavation, box culvert excavation, or channel excavation whose removal is required for the construction of bridges, retaining walls of reinforced concrete or reinforced masonry, arch culverts, and box culverts without floor slabs, and which is classified as unclassified structure excavation on the plans, in accordance with the contract or as directed. Excavate, blast, brace, shore, provide sheeting and cribbing, backfill, haul, and dispose of materials.

Do not deposit excavated materials, nor construct earth dikes or other temporary earth structures, in rivers, streams, or impoundment or so near to such waters that they are carried into any river, stream, or impoundment by stream flow or surface runoff.

Dispose of all timber, stumps, and debris in accordance with Article 200-5.

412-2 PRESERVATION OF CHANNEL

Unless otherwise required by the contract, do not excavate in stream channels. Do not disturb the natural streambed adjacent to the structure without permission.

Do not place material in a stream without approval. Remove materials placed within the stream area and leave the stream in its original condition, unless otherwise permitted.

412-3 UTILIZATION OF EXCAVATED MATERIAL

Use and place suitable excavated material in accordance with the requirements of Articles 410-7 and 410-8.

Notify the Engineer a sufficient time before beginning the excavation so that measurements may be taken of the undisturbed ground.

412-4 MEASUREMENT AND PAYMENT

Unclassified Structure Excavation will be measured and paid for as the actual number of cubic meters of materials, measured in their original position and computed by the average end area method, which is acceptably excavated in accordance with the contract or as directed by the Engineer. Original cross sections for the determination of excavation quantities are taken before any excavation is done.

No measurement is made of any materials excavated outside of the limits shown on the plans or directed in writing by the Engineer, or any materials excavated before the Engineer makes measurements of the undisturbed ground.

The price and payment below will be full compensation for all items required to complete unclassified structure excavation including but not limited to those items contained in Article 412-1.

When the contract includes the item of *Unclassified Structure Excavation at Station* ___ the work will be paid for at the contract lump sum price.

Payment will be made under:

Pay Item	Pay Unit
Unclassified Structure Excavation	Cubic Meter
Unclassified Structure Excavation at Station _____	Lump Sum

**SECTION 414
BOX CULVERT EXCAVATION**

414-1 DESCRIPTION

Excavate all material necessary for the construction of box culverts with floor slabs in accordance with the contract or as directed. Excavate, blast, drain and divert water, bail, pump, brace, shore, provide sheeting, cribbing, cofferdams, culvert foundation conditioning, subsurface drainage and drawings; backfill, haul, and dispose of materials.

Do not deposit excavated materials, nor construct earth dikes or other temporary earth structures in rivers, streams, or impoundment or so near to such waters that they are carried into any river, stream, or impoundment by stream flow or surface runoff. As an exception to the above, obtain written approval for the use of confined earth materials in cofferdams for structure foundations.

414-2 MATERIALS

Refer to Division 10.

Item	Section
Subdrain Fine Aggregate	1044-1
Stone, No. 78M	1005
Foundation Conditioning Material	1016

414-3 FOUNDATION EXCAVATION

Notify the Engineer a sufficient time before beginning the excavation so that measurements may be taken of the undisturbed ground if desired by the Engineer. Do not disturb the existing ground at the culvert site without permission.

Where necessary for safety, slope, shore, brace, or protect by cofferdams the foundation openings in accordance with local and State safety standards. Perform foundation excavation and related work in such sequence that no portion of the culvert will be endangered by subsequent operations. Protect completed portions of a culvert from blasting.

Remove and dispose of boulders, vegetative matter, and any other objectionable material.

Notify the Engineer after excavating each foundation. Do not place any concrete until obtaining approval of the excavation depth, the character of the foundation material and permission to proceed.

Take special care not to disturb the bottom of the excavation until immediately before placing reinforcing steel and concrete.

414-4 CONDITIONING CULVERT FOUNDATION

Excavate to a depth as directed below the bottom of the barrel or wing footing and replace the excavated material with foundation conditioning material.

When the foundation material beneath a portion of the barrel or wing footing is rock or incompressible material, and softer material is beneath the remainder of the barrel or wing footing, excavate the rock material within the neat lines of the barrel or footing to a depth of 300 mm below the bottom of the barrel and footings and backfill with foundation conditioning material.

Use Class VI, Select Material foundation conditioning material as defined in Section 1016.

414-5 PUMPING

Pump from the interior of any foundation enclosure in such a manner as to preclude the possibility of the movement of water over or through any fresh concrete. Do not pump while placing concrete or for a period of at least 24 hours thereafter, unless done from a suitable sump separated from the concrete work by a substantially watertight wall.

414-6 UTILIZATION OF EXCAVATED MATERIAL

Use suitable excavated material in accordance with Article 410-7.

414-7 BACKFILLING AND FILLING

As soon as practical after completing the box culvert, place the backfill and redirect the stream through the culvert.

Use approved material for backfill that is free from large or frozen lumps, wood, or other undesirable material. Where there is not an adequate quantity of suitable backfill material available from culvert excavation, provide suitable backfill material compensated as provided in Subarticle 410-12.

Eliminate any excavated slope adjacent to backfill areas by stepping or serrating to prevent wedge action.

Compact all portions of the backfill that become a part of roadway typical sections or their foundations in accordance with Subarticle 235-4(C). Place all other portions of the backfill in layers not more than 150 mm in depth of loose measure and compact to a density comparable to the adjacent undisturbed material. Refill all excavated spaces not filled with permanent work with earth up to the ground surface existing before the excavation.

Do not place backfill or embankment behind the walls of culverts until after placing the top slab and allowing development of the minimum compressive strength required by Article 420-20.

Place backfill or embankment material simultaneously insofar as possible to approximately the same elevation on both sides of the culvert and do not carry it to an elevation higher than 0.3 m above the top of footing or bottom slab until the concrete develops the minimum required strength for the class of concrete used.

414-8 SUBSURFACE DRAINAGE AT WEEP HOLES

Place subsurface drainage in accordance with Article 410-9.

414-9 MEASUREMENT AND PAYMENT

The prices and payments below will be full compensation for all items required to complete box culvert excavation including but not limited to those items contained in Article 414-1.

Foundation Conditioning Material, Box Culvert will be measured and paid for in metric tons of material that is placed within the established limits. The number of metric tons of material is determined by weighing the material in trucks in accordance with the requirements of Article 106-7. No deduction will be made for any moisture contained in the material at the time of weighing. Such price and payment will be full compensation for all excavation made below the bottom of the barrel and wing footings in addition to furnishing, hauling, and placing the foundation conditioning material.

Culvert Excavation, Sta. _____ will be paid for at the contract lump sum price. No measurement for payment will be made for this pay item, and no adjustment in the contract lump sum price will be made unless the size, length, elevation, or location of the culvert is revised. In the event of a revision in the size, length, elevation, or location of the culvert, such revision will be considered an alteration of plans or details of construction in accordance with Article 104-3.

Where it is necessary to provide backfill material from sources other than excavated areas or borrow sources used in connection with other work in the contract, payment for furnishing and hauling such backfill material is made as provided in Article 104-7 for extra work. Placing and compacting such backfill material is not considered extra work, but is considered incidental to the work covered by this section.

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Payment will be made under:

Pay Item	Pay Unit
Culvert Excavation, Sta. _____	Lump Sum
Foundation Conditioning Material, Box Culvert	Metric Ton

**SECTION 416
CHANNEL EXCAVATION**

416-1 DESCRIPTION

Excavate any material outside of the pay limits of foundation excavation, unclassified structure excavation, or box culvert excavation, which is classified as channel excavation in the plans. Place suitable excavated material as directed, drain and divert water, pump, blast, haul, dispose of materials, and backfill.

Do not deposit excavated materials, nor construct earth dikes or other temporary earth structures in rivers, streams, or impoundment or so near to such waters that they are carried into any river, stream, or impoundment by stream flow or surface runoff.

416-2 CONSTRUCTION REQUIREMENTS

Notify the Engineer a sufficient time before beginning the excavation so that measurements may be taken of the undisturbed ground. Do not disturb the existing ground without permission.

Remove and dispose of boulders, vegetative material, and any other objectionable material.

Use and place suitable excavated material in accordance with the requirements of Articles 410-7 and 410-8.

416-3 MEASUREMENT AND PAYMENT

Channel Excavation will be measured and paid for on a cubic meter basis. Materials will be measured in their original position within the limits described below and computed by the average end area method, that are acceptably excavated in accordance with the contract or as directed. The upper limits for measurement are the actual ground surface at the time of starting work. The lower limits for measurement are established by the plans or as directed in writing.

No measurement is made of the following excavation:

Mud, muck, or similar semi-solid material which can be drained away or pumped without the use of a jet or nozzle.

Excavation before the Engineer makes measurements of the undisturbed ground

Excavation that is within the pay limits of other excavation

Excavation that is outside of the limits shown on the plans or as directed in writing.

Where the item *Channel Excavation* is not included in the contract, no measurement or payment is made of any channel excavation, as payment at the contract unit or lump sum price for the various items in the contract will be full compensation for the work covered by this section.

This price and payment will be full compensation for all items required to complete channel excavation.

Payment will be made under:

Pay Item	Pay Unit
Channel Excavation	Cubic Meter

SECTION 420 CONCRETE STRUCTURES

420-1 DESCRIPTION

Construct cast-in-place concrete structures and the cast-in-place concrete portions of composite structures in conformity with the lines, grades, and dimensions shown in the contract. Furnish and place concrete, joint filler and sealer, curing agents, epoxy protective coating, deck drains, expansion anchors, and any other material; erect and remove all falsework and forms; protect concrete in wind, rain, low humidity, high temperatures, or other unfavorable weather; construct joints and weep holes; finish and cure concrete; protect concrete from rust stains; and groove bridge floors. For reinforced concrete deck slabs, in addition to the above, furnish and place reinforcing steel and bridge scuppers; and design, furnish, erect, and remove all bridge deck forms including any appurtenances required by the Engineer to stabilize exterior girders during overhang construction.

420-2 MATERIALS

Refer to Division 10.

Item	Section
Portland Cement Concrete	1000
Reinforcing Steel	1070
Curing Agents	1026
Joint Fillers	1028-1
Joint Sealers	1028
Deck Drains	1054-3
Expansion Anchors	1074-2
Metal Stay-in-Place Forms	1074-12
Calcium Nitrite Corrosion Inhibitor	1000-4(K)
Epoxy Protective Coating	1081

420-3 FALSEWORK AND FORMS

(A) General

Submit 8 sets of detailed drawings for falsework or forms for bridge superstructure and other components as required by the contract for review, comments and acceptance before beginning construction of the falsework or forms. This review does not relieve the Contractor of full responsibility for the safety, alignment, quality, or finish of the work.

Design falsework and forms to carry the full loads upon them, including a dead load of 23.5 kN/m³ for concrete, loads caused by equipment and personnel, and for lateral pressures resulting from rate of pours, setting times, and effects of vibration on the concrete, so that the finished concrete surface conforms to the proper dimensions and contours and has an even appearance.

Use lumber and other material for forms and falsework that is sound and in good condition.

Set falsework and forms to give the correct elevation shown on the drawings making proper allowance for shrinkage, deflections, and settlement, and maintain true to lines and grades designated until the concrete sufficiently hardens.

Where falsework or forms appear to be unsatisfactorily built in any respect either before or during placing of concrete, the Engineer will order the work stopped until the defects are acceptably corrected.

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Keep the falsework and forms in place after placing of concrete for the periods specified in Article 420-16. Remove falsework and forms in an acceptable manner. Do not leave forms or falsework permanently in place without written approval.

Provide a means, satisfactory to the Engineer, to check any settlement or deflection that may occur during the placing of concrete in the various portions of the work.

(B) Falsework

Build falsework on foundations of sufficient strength to carry the applied loads without appreciable settlement. Support falsework that cannot be founded on solid footings on ample falsework piling.

Use an acceptable method to compensate for shrinkage, deflection, and settlement. Use jacks in order to readily effect adjustment, if necessary, before or during placing of concrete, if required by the Engineer.

(C) Forms

(1) General

Use forms made of wood or steel except where other materials are specified by the contract or accepted by the Engineer.

(2) Wood Forms

Build forms mortar-tight of material sufficient in strength with ample studding, walling, and bracing to effectively prevent any appreciable horizontal and/or vertical deflection.

Provide forms with interior dimensions such that the finished concrete is of the form and dimensions shown on the plans.

Line forms, except for surfaces permanently in contact with earth fill, with plywood or other approved material. Provide a lining with a smooth and uniform texture and of such thickness and rigidity that a concrete surface of uniform texture and even appearance results. Provide joints between form liners that are mortar tight and even and maintain to prevent the opening of joints due to the shrinkage of the lumber.

Fillet forms at all sharp corners unless otherwise noted on the plans. Mill wood chamfer strips from straight grained lumber and surface on all sides.

Give forms for all projections a bevel or draft to insure easy removal.

At all times, maintain the shape, strength, rigidity, watertightness, and surface smoothness of reused forms. Resize any warped or bulged lumber before reusing. Do not reuse any forms that are unsatisfactory in any respect. Do not use plywood sheets showing torn grain, worn edges, patches or holes from previous use, or other defects that impair the texture of concrete surfaces exposed to view.

Maintain an acceptable alignment and no broken edges on all chamfer strips.

Thoroughly clean forms previously used of all dirt, mortar, and foreign material before reusing. Before placing concrete in forms to be removed, thoroughly coat all inside surfaces of the forms with commercial quality form oil or other equivalent coating which permits the ready release of the forms and does not discolor the concrete.

Construct or install metal spacers or anchorages, required within the forms for their support or to hold them in correct alignment and location, in such a way that the metal work can be removed to a depth of at least 25 mm from the exposed surface of the concrete without injury to such surface by

spalling or otherwise. Limit the diameter to not greater than 1½ times its depth for the recess formed in the concrete. Cut back all such metal devices in exposed surfaces, upon removal of the forms, to a depth of at least 25 mm from the face of the concrete. Carefully fill cavities produced by the removal of metal devices with cement mortar of the same mix used in the body of the work immediately upon removal of the forms, and leave the surface smooth, even, and as nearly uniform in color as possible. As an option, break off flush with the concrete surface those metal devices with cross sectional area not exceeding 32 mm² on surfaces permanently in contact with earth fill.

Do not weld metal devices to either reinforcing steel or structural steel that is a permanent part of the structure without written approval.

(3) Steel Forms

Apply the requirements of Subarticle 420-3(C)(2) in regards to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, texture and evenness of appearance of the resulting concrete surface, removal, re-use, and oiling to steel forms. Use steel for forms of such thickness that the forms remain true to shape. Counter-sink bolt and rivet heads. Design clamps, pins, or other connecting devices to hold the forms rigidly together and allow removal without injury to the concrete. Do not use steel forms that do not present a smooth surface or line up properly. Exercise care to keep steel forms free from rust, grease, or other foreign matter that will tend to discolor the concrete.

(D) Forms for Concrete Bridge Decks

In addition to the requirements of Subarticles 420-3(C)(1) through 420-3(C)(3), the following requirements apply to falsework and forms used to construct reinforced concrete bridge decks on girders. Furnish all materials, labor, equipment and incidentals necessary for the proper installation of falsework and forms for concrete bridge deck slabs.

For prestressed girder spans, the plans for the concrete deck slab are detailed for the use of a cast-in-place slab using either precast prestressed concrete panels or fabricated metal stay-in-place forms; however, as an option, construct a cast-in-place slab using removable forms. If noted on the plans, the option is available to use metal stay-in-place forms in lieu of precast prestressed concrete panels.

For structural steel spans, plans for the concrete deck slab are detailed for the use of metal stay-in-place forms; however, as an option, construct a cast-in-place slab using removable forms. Do not use precast prestressed concrete panels on structural steel spans.

If using a form system other than that detailed on the plans, do so at no additional cost to the Department. Changes in slab design to accommodate the use of optional forms are the responsibility of the Contractor. Submit these changes for review and approval. Prior to using optional forms, submit two sets of prints of detailed checked plans of the system and checked design calculations for the composite slab complying to the latest *AASHTO Standard Specifications* and *Highway Design Branch Structure Design Manual*. After the drawings are reviewed and, if necessary, the corrections made, submit reproducible drawings of the deck system to become the revised plans. Ensure that the size of the sheets used for the drawings is 560 x 864 mm. Ensure that the plans and design calculations are checked and sealed by a North Carolina Licensed Professional Engineer.

Where reinforced concrete deck slab with sand lightweight concrete is required by the contract, do not use precast prestressed concrete panels.

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Unless otherwise shown on the plans, use the same forming system for all of the same type superstructure spans within the bridge. Construct the slab overhang from the exterior girder to the outside edge of superstructure using removable forms.

(1) Precast Prestressed Concrete Panels

Prestressed concrete panels are subject to the requirements for prestressed concrete members as specified in Section 1078, the plans, and these Specifications.

Design prestressed panels subject to review by the Engineer. Prior to using prestressed panels, submit 7 sets, including one reproducible set, of detailed plans of the panels for review. Submit with the checked plans 1 set of checked design calculations for the panels complying with the latest *AASHTO Standard Specifications*, requirements detailed herein, and the plans. Have the plans and design calculations checked and sealed by a North Carolina Licensed Professional Engineer. If corrections to the drawings are necessary, submit 1 set of corrected reproducible drawings. Use a plan sheet size of 560 x 864 mm. The drawings become part of the plans.

Design the prestressed concrete panels in accordance with the following criteria:

- (a) Design details to provide a mating surface joint or a draft not exceeding 3.0 mm resulting in a joint that is closed at the top and a maximum of 6.0 mm open at bottom of panel. Detail the joints filled with grout or other methods approved by the Engineer to prevent leakage of the concrete. Place a chamfer or fillet, with a 19.0 mm horizontal width, along the top edges of the panel parallel with the prestressed girder.
- (b) Design panels to support the dead load of the panel, reinforcement, plastic concrete and a 2.4 kPa construction load. Design the panel and slab acting compositely to support design live loads and dead loads acting on the composite section. Include in the design dead load acting on the composite section an additional load of 1.0 kPa for a future asphalt wearing surface. For bridges up to 13.5 m in width distribute equally to all deck panels superimposed dead loads for such permanent bridge items as barrier rails, medians or any dead load which is applied after the deck is cast. In the case of bridges over 13.5 m wide, distribute these loads equally to the first 2 1/2 panels adjacent to each side of the load.
- (c) The design span of the prestressed concrete panel is the clear distance between edges of girders plus 50 mm measured parallel to the panel edges.
- (d) Limit tension in the precompressed tensile zone to 2.92 MPa unless the plans require 0-MPa tension.

(2) Fabricated Metal Stay-In-Place Forms

Furnish metal stay-in-place forms with closed tapered ends to form the concrete deck slabs as shown on the plans. Submit 8 copies of complete fabrication and erection drawings for review, comments and acceptance. When required by the design plans, detail SIP forms with excluder plates to exclude concrete from the valleys in the forms. Styrofoam void fillers may be used in SIP metal forms with the following stipulations:

Adhesive shall be used on all three contacting sides of the styrofoam void fillers rather than on the bottom only.

The adhesive shall be compatible with the styrofoam material so as not to cause the styrofoam to decompose.

Duct tape shall not be used to hold the styrofoam in place.

Styrofoam shall be placed in one piece across each bay, and be trimmed so as not to extend over the girder.

Styrofoam damaged during placement of reinforcing steel shall be replaced.

Indicate on these plans the grade of steel, the physical and section properties for all permanent steel bridge deck form sheets and a clear indication of locations of form supports. Do not fabricate the forming material until drawings are accepted.

Design metal stay-in-place forms in accordance with the following criteria:

- (a) Accommodate the dead load of the form, reinforcement and the plastic concrete, including the additional weight of concrete due to the deflection of the metal forms, plus 2.4 kPa for construction loads. Do not allow the unit working stress in the steel sheet to exceed 72.5% of the specified minimum yield strength of the material furnished or 250 MPa.
- (b) Limit the horizontal leg of the support angle to 75 mm. Design the support angle as a cantilever.
- (c) Limit the deflection under the weight of the forms, the plastic concrete and reinforcement to 1/180 of the form span or 13 mm whichever is less; however, do not design for a total loading less than 5.7 kPa.
- (d) Base the permissible form camber on the actual dead load condition. Do not use camber to compensate for deflection in excess of the foregoing limits.
- (e) The design span of the form sheets is the clear distance between edges of beam or girder flanges minus 50 mm measured parallel to the form flutes. Design and provide form sheets with a length at least the design span of the forms.
- (f) Compute physical design properties in accordance with requirements of the American Iron and Steel Institute "Specification for the Design of Cold-Formed Steel Structural Members" latest published edition.
- (g) Provide a minimum concrete cover of 30 mm clear above metal stay-in-place form to the bottom mat of reinforcement.
- (h) Maintain the plan dimensions of both layers of primary deck reinforcement from the top of the concrete deck.
- (i) Do not weld to flanges in tension or to structural steel bridge elements fabricated from non-weldable grades of steel.
- (j) Weld metal stay-in-place forms for prestressed concrete girders to embedded clips in the girder flanges. The embedded clips shall be a minimum of 50 mm x 75 mm and 50 mm long. The clips shall be galvanized, 12 gauge ASTM A653 steel and have a 19 mm or 25 mm diameter hole in the 50 mm leg. The spacing of the clips shall be 300 mm. All submitted metal stay-in-place form designs shall be able to utilize the standard size and spacing of the clip described above.

Do not unload or handle fabricated metal stay-in-place forming materials in such a manner as to damage or alter the configuration of the forms. Replace damaged materials at no additional cost to the Department.

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Store fabricated metal stay-in-place forms that are stored at the project site at least 100 mm above the ground on platforms, skids or other suitable supports and protect against corrosion and damage from any source.

Install all forms in accordance with detailed fabrication plans submitted to the Engineer for review. Clearly indicate on the fabrication plans the locations where the forms are supported by steel beam flanges subject to tensile stresses. Do not weld to the flanges within these locations. Do not allow form sheets to rest directly on the top of the beam or girder. Securely fasten sheets to form supports with a minimum bearing length of 25 mm at each end. Center sheets between the form supports. Place form supports in direct contact with the flange of girder or beam. Make all attachments by permissible welds, bolts, clips or other approved means. Weld in accordance with Article 1072-20 of the *Standard Specifications*, except 3.0 mm fillet welds are permitted.

In the areas where the form sheets lap, securely fasten the form sheets to one another by screws at a maximum spacing of 450 mm. Securely attach the ends of the form sheets to support angles with screws at a maximum spacing of 450 mm.

Where the galvanized coating is damaged on any exposed form metal, thoroughly clean, wire brush, then paint with two coats of zinc oxide zinc dust primer, Federal Specification TT-P-641d, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds is not considered damage and does not require the above repair.

Locate transverse construction joints at the bottom of a flute and field drill 6 mm weep holes at not more than 300 mm on center along the line of the joint.

Use a saw for all cuts. Do not flame cut forms.

(E) Falsework and Forms Over or Adjacent to Traffic

In addition to the applicable sections in 420-3(A) through 420-3(D), the following requirements apply to falsework and forms including metal stay-in-place forms and precast concrete deck panels erected over vehicular, pedestrian or railroad traffic, or vessel traffic on navigable waterways. It also covers falsework and forms for those parts of a substructure unit constructed within 6.1 m of the edge of a travelway or railroad track and more than 7.6 m above the ground line at the time of substructure construction.

(1) Submittals

Submit detailed drawings as required by the contract and one set of design calculations for falsework and forms for review and acceptance before beginning construction of the falsework or forms. Have the drawings and design calculations prepared, signed and sealed by a North Carolina Licensed Professional Engineer. These submittal requirements apply to all falsework and form systems covered by this section.

(2) Design

Design falsework and forms for the combined effects of dead load and live load and with appropriate safety factors in accordance with this section and the respective design codes of the materials used. Include the weight of concrete, reinforcing steel, forms and falsework in the dead load. Live load includes the actual weight of any equipment the falsework supports, applied as concentrated loads at the points of contact, and a uniform load of not less than 1.0 kPa applied over the supported area. In addition, apply a line load of 1 kN/m along the outside edge of deck overhangs.

(3) Inspection

Before the form or falsework system is loaded, inspect the erected falsework and forms and submit a written statement certifying that the erected falsework system complies with the accepted detailed drawings prepared by the Licensed Professional Engineer. Submit a separate certification for each span, unit, or bridge component. Any condition that does not comply with the accepted drawings, or any other condition deemed unsatisfactory by the Engineer, is cause for rejection until corrections are made.

420-4 PLACING CONCRETE

Do not place concrete until the depth of the excavation, character of the foundation material, adequacy of the forms and falsework, placement of reinforcement and other embedded items are inspected and approved. Do not place concrete without an Inspector present.

Place concrete in daylight or obtain approval for an adequate lighting system for construction and inspection of the work.

In preparation for the placing of concrete, remove all sawdust, chips, and other construction debris and extraneous matter from the interior of forms. Remove hardened concrete and foreign matter from tools, screeds, and conveying equipment.

Make sure that the concrete temperature at the time of placing in the forms is not less than 10° C nor more than 35° C, except where other temperatures are required by Articles 420-7, and 420-14.

Do not use concrete that does not reach its final position in the forms within the time stipulated in Subarticle 1000-4(E).

Thoroughly clean and wet surfaces, other than foundation surfaces, immediately before placing concrete to facilitate bonding to those surfaces.

Regulate the placement of concrete so that the pressures caused by the wet concrete do not exceed those used in the design of the forms.

Thoroughly work the external surface of all concrete during the placing by means of approved tools. During the placing of concrete, take care to use methods of compaction that result in a surface of even texture free from voids, water, or air pockets, and that force the coarse aggregate away from the forms in order to leave a mortar surface.

Place concrete so as to avoid segregation of the materials and the displacement of the reinforcement.

Equip chutes on steep slopes with baffle boards or provide chutes in short lengths that reverse the direction of movement.

Use all chutes, troughs, and pipes made from suitable materials other than aluminum and keep them clean and free from coating of hardened concrete by thoroughly flushing with water after each run. Discharge the water used for flushing clear of the structure.

Confine concrete dropped more than 1.5 m by closed chutes or pipes, except in walls of box culverts or retaining walls unless otherwise directed.

Take care to fill each part of the form by depositing the concrete as near to its final position as possible. Work the coarse aggregate back from the forms and around the reinforcement without displacing the bars. After initial set of the concrete, do not jar the forms and do not place strain on the projecting reinforcement or other items embedded in the concrete.

Compact all concrete required to be vibrated by means of approved high frequency internal vibrators or other approved type of vibrators immediately after depositing concrete in the forms. In all cases, have available at least 2 vibrators in good operating condition and 2 sources of power at the site of any structure in which more than 19 cubic meters of concrete is required. Do not attach or hold the vibrators against the forms or

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the reinforcing steel. When vibrating concrete containing epoxy coated reinforcing steel, use a vibrator with a protective rubber head as approved by the Engineer. Vibrate with care and in such a manner to avoid displacement of reinforcement, ducts, or other embedded elements. Vibrate in the appropriate location, manner, and duration to secure maximum consolidation of the concrete without causing segregation of the mortar and coarse aggregate, and without causing water to flush to the surface. When placing concrete to a depth in excess of 300 mm and containing one or more horizontal layers of reinforcing steel, place the concrete in horizontal layers not more than 300 mm thick. Place and compact each layer before the preceding layer takes initial set such that there is no surface of separation between layers. Do not taper layers of concrete in wedge-shaped slopes but instead place them with reasonably square ends and level tops.

If placing additional concrete against hardened concrete, take care to remove all laitance and to roughen the surfaces of the concrete to ensure that fresh concrete is deposited upon sound concrete surfaces and an acceptable bond is obtained. Thoroughly wet the existing concrete for a minimum of 2 hours before placing additional concrete.

Deposit and compact so as to form a compact, dense, impervious concrete of uniform texture which shows smooth faces on exposed surfaces. Repair, remove, and replace in whole or in part as directed and at no additional cost to the Department, any section of concrete found to be porous, cracked, plastered, or otherwise defective.

Protect beams and girders during concreting operations. Remove any concrete that gets on beams or girders immediately by an approved method to restore the surface to the specified condition.

420-5 PUMPING CONCRETE

Placement of concrete by pumping is permitted only when approved. Use and locate suitable pumping equipment that is adequate in capacity for the work and so that no vibrations result which might damage freshly placed concrete. Do not use pumping equipment, including the conduit system, which contains any aluminum or aluminum alloy that comes in contact with the concrete.

Waste all grout used to lubricate the inner surfaces of the conduit system.

Pump so that a continuous stream of concrete without air pockets is delivered. For test purposes, take concrete from the discharge end of the pump.

420-6 SLUMP TESTS

The slump of the concrete is determined in accordance with AASHTO T119.

When a slump test is made and the results of the test exceed the specified maximum, a check test is made immediately from the same batch or truck load of concrete. If the average of the 2 test results exceeds the specified maximum slump, the batch or truck load that contains the batch is rejected.

420-7 PLACING CONCRETE IN COLD WEATHER

(A) General

Do not place concrete when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is below 2°C without permission. When such permission is granted, uniformly heat the aggregates and/or water to a temperature not higher than 65°C. Place the concrete when the temperature of the heated concrete is not less than 12°C and not more than 27°C.

Use aggregates that are free of ice, frost, and frozen particles. Do not place concrete on frozen foundation material.

Protect all concrete by means of heated enclosures or by insulation whenever any of the following conditions occur:

- (a) The concrete is placed when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is below 2°C.

- (b) The air temperature, measured at the location of the freshly placed concrete in the shade away from artificial heat, is below 2°C and the concrete has not yet attained an age of 72 hours or an age of 48 hours when using high-early strength portland cement concrete. If the mix contains fly ash or ground granulated blast furnace slag, protect the concrete for 7 days.

Provide and place at directed locations a sufficient number of maximum-minimum recording thermometers to provide an accurate record of the temperature surrounding the concrete during the entire protection period.

Assume all risks connected with the placing of concrete under the cold weather conditions referred to herein. Permission given to place concrete when the temperature is below 2°C and the subsequent protection of the concrete as required herein does not relieve the Contractor in any way of the responsibility for obtaining the required results.

(B) Heated Enclosures

Immediately enclose portland cement concrete that is placed when the air temperature is below 2°C, and portland cement concrete that has not yet attained an age of 72 hours before the air temperature falls below 2°C, with a housing consisting of canvas or other approved material supported by an open framework or with an equally satisfactory housing. Maintain the air surrounding the concrete at a temperature of not less than 10°C nor more than 32°C for the remainder of the 72-hour period. Apply these same requirements to high-early-strength portland cement concrete except reduce the 72-hour period to 48 hours. Do not begin these time periods until completing manipulation of each separate mass of concrete.

Provide such heating apparatus as stoves, salamanders, or steam equipment, and the necessary fuel. When using dry heat, provide means of preventing loss of moisture from the concrete.

(C) Insulation

As an alternate to the heated enclosure specified in Subarticle 420-7(B), use insulated forms or insulation meeting all requirements of this subarticle to protect concrete. Use insulation under the same conditions that require heated enclosures. Place the insulation on the concrete as soon as initial set permits.

When using insulation for cold weather protection, batch concrete for sections 300 mm or less in thickness or diameter as outlined below. Use Type III portland cement without any increase in cement content, or use Type I or II portland cement with the cement content increased to 2.4 barrels per cubic meter. When the mix includes fly ash, use a mix containing 340 kg/m³ of cement and a minimum of 102 kg/m³ of fly ash. When the mix includes ground granulated blast furnace slag, use a mix containing 276 kg/m³ of cement and 148 kg/m³ of ground granulated blast furnace slag.

Use insulated materials with a minimum thickness of 25 mm. Insulate overhang forms both on the outside vertical faces and on the underside with a 25 mm minimum thickness of either rigid or blanket type insulation. Use insulating materials which provide a minimum system R value of 4.0 in the up mode as determined by ASTM C-236 with a 24.1 km/h wind over the cold side of the material and a minimum differential of 10°C. Furnish results of tests conducted in accordance with ASTM C-236 by an acceptable commercial testing laboratory for review, comments and acceptance. Obtain such acceptance prior to use of the material. Face or cover insulating blankets, top and bottom, with polyethylene or similar waterproofing material meeting the test requirements of Article 1026-3 except for the length and color requirements. Place blankets on the concrete in such a manner that they form a waterproof surface for the protected concrete. Do not use blankets with rips and tears in the waterproofing material unless acceptably repaired. When the anticipated low temperature expected during the

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protection period is less than -12°C , provide 50 mm of insulation. Overlap blanket insulation mats at the edges by at least 150 mm. Tightly butt rigid type insulation sheets together and seal. Take particular care to provide effective protection of curbs, corners, and around protruding reinforcing steel.

Should the air under the insulation fall below 10°C during the protection period, immediately cover the concrete with canvas and framework or other satisfactory housing and apply heat uniformly at a rate such that the air surrounding the concrete is not less than 10°C for the remainder of the protection period.

In the event that insulating materials are removed from the concrete prior to the expiration of the curing period, cure the concrete for the remainder of the period in accordance with Article 420-15.

420-8 CONSTRUCTION JOINTS

Provide construction joints only where located on the plans or shown in the placing schedule, unless otherwise approved in writing.

Place the concrete in each integral part of the structure continuously. Do not commence work on any such part unless the concrete supply, forces, and equipment are sufficient to complete the part without interruption in the placing of the concrete.

In case of emergency, make construction joints or remove the concrete as directed.

Make construction joints without keys, except when required on the plans. Rough float surfaces of fresh concrete at horizontal construction joints sufficiently to thoroughly consolidate the concrete at the surface.

After placing concrete to the construction joint and before placing fresh concrete, thoroughly clean the entire surface of horizontal construction joints of surface laitance, curing compound, and other materials foreign to the concrete. Clean vertical construction joints of curing compound and other materials foreign to the concrete.

Thoroughly clean and wet concrete surfaces for a minimum of 2 hours before placing additional concrete in order to facilitate bonding.

420-9 WIDENING EXISTING STRUCTURES

Where plans call for widening existing concrete structures, or otherwise require bonding new concrete to old, remove portions of the existing structures as indicated on the plans.

When extending an existing culvert, remove the following portions of the existing culvert: the portions that interfere with the proposed extension, headwalls only as necessary to clear proposed subgrade by a minimum of 450 mm, and wingwalls in such a manner that square surfaces the full thickness of the new sidewalls are provided for bonding new concrete to old. Cut existing wingwall reinforcing steel off flush with the concrete surface.

Thoroughly roughen, clean of loose material, and wet connecting surfaces of the old concrete for a minimum of 2 hours before placing new concrete.

420-10 EXPANSION JOINTS

(A) General

Locate and construct all joints as shown on the plans.

Chamfer or edge the edges of joints as shown on the plans or as directed.

Immediately after removing the forms, inspect the expansion joint carefully. Neatly remove any concrete or mortar in the joint.

(B) Filled Joints

Use cork, bituminous fiber, neoprene, or rubber meeting the requirements of Article 1028-1 in all expansion joint material. Use an optional second layer to obtain the required thickness, when a thickness of more than 25 mm is required.

Cut the joint filler to the same shape and size as the area to be covered except cut it 13 mm below any surface that is exposed to view in the finished work. As an option, cut the joint filler the same size and shape as that of the adjoining surfaces, and neatly cut back the material 13 mm on the surfaces that are exposed to view after the concrete hardens. Cut the joint filler out of as few pieces as practicable and, except as noted above, completely fill the space provided. Fasten the pieces in any one joint together in an approved manner. Do not use loose fitting or open joints between sections of filler or between filler and forms. Do not use joints made up with small strips. Place two-ply roofing felt over all joints in the filler material in vertical expansion joints below top of curbs. Place the felt on the side of the joint adjacent to the new pour.

Seal all expansion joints with a low modulus silicone sealant in accordance with Article 1028-4.

420-11 DRAINS IN WALLS AND CULVERTS

Construct drain holes and weep holes in abutment walls, wing walls, retaining walls, and the exterior walls of culverts as shown on the plans unless otherwise directed, and backfill in accordance with the requirements of Articles 410-8 and 410-9.

Cover drain holes and weep holes at the back face of the wall with hardware cloth of commercial quality, approximately 4.75 mm mesh, of aluminum or galvanized steel wire.

420-12 ANCHOR BOLTS AND BEARING AREAS

(A) Anchor Bolts

Accurately set all necessary anchor bolts in piers, abutments, or pedestals either while placing concrete, in formed holes, or in holes cored or drilled after the concrete sets.

If set in the concrete, position the bolts by means of templates and rigidly hold in position while placing the concrete.

Form holes by inserting in the fresh concrete oiled wooden plugs, metal pipe sleeves, or other approved devices, and withdrawing them after the concrete partially sets. Provide holes formed in this manner that are at least 100 mm in diameter.

Core holes at least 25 mm larger in diameter than the bolt used. Use approved equipment for coring concrete. Do not use impact tools. Place reinforcing steel to provide adequate space to core bolt holes without cutting the reinforcing steel.

During freezing conditions, protect anchor bolt holes from water accumulation at all times.

Bond the anchors with a non-shrink portland cement grout or a grout made with epoxy resin. Completely fill the holes with grout. Use any pre-approved non-shrink composition compatible with the concrete.

(B) Bearing Areas

Finish bridge seat bearing areas to a true level plane to not vary perceptibly from a straightedge placed in any direction across the area.

Place bearing plates in accordance with the requirements of Article 440-4.

420-13 ADHESIVELY ANCHORED ANCHOR BOLTS OR DOWELS

(A) Description

The work covered by this section consists of furnishing all necessary labor, equipment, and materials and performing all operations necessary for installing anchor bolts/dowels in concrete using an adhesive bonding system in accordance with the details shown on the plans and with the requirements of Section 1082 unless otherwise directed.

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Submit a description of the proposed adhesive bonding system to the Engineer for review, comments and acceptance. Include in the description the bolt type and its deformations, equipment, manufacturer's recommended hole diameter, embedment depth, material specifications, and any other material, equipment or procedure not covered by the contract. List the properties of the adhesive, including density, minimum and maximum temperature application, setting time, shelf life, pot life, shear strength and compressive strength. If bars/dowels containing a corrosion protective coating are required, provide an adhesive that does not contain any chemical elements that are detrimental to the coating and include a statement to this effect in the submittal concerning the contents as required by State or Federal Laws and Regulations.

(B) Procedure

(1) Drilling of Holes into Concrete

When directed, use a jig or fixture to ensure the holes are positioned and aligned correctly during the drilling process. Upon approval, adjusting hole locations to avoid reinforcing steel is permitted.

Drill the holes with a pneumatic drill unless another drilling method is approved. Follow the manufacturer's recommendations regarding the diameter of the drilled hole.

Immediately after completion of drilling, blow all dust and debris out of the holes with oil-free compressed air using a wand extending to the bottom of the hole. Remove all dust from the sides of the holes by brushing the holes with a stiff-bristled brush of a sufficient size and then blow the hole free of dust. Repeat this procedure until the hole is completely clean. Check each hole with a depth gauge to ensure proper embedment depth.

Repair spalled or otherwise damaged concrete using approved methods.

(2) Inspection of Holes

Inspect each hole immediately prior to placing the adhesive and the anchor bolts/dowels. Ensure all holes are dry and free of dust, dirt, oil, and grease. Rework any hole that does not meet the requirements of the contract.

(3) Mixing of Adhesive

Mix the adhesive in strict conformance with the manufacturer's instructions.

(4) Embedment of Anchor Bolt/Dowel

Clean each anchor bolt/dowel so that it is free of all rust, grease, oil, and other contaminants.

Unless otherwise shown on the plans, the minimum anchor bolt/dowel embedment depth is such that the adhesive develops at least 125% of the anchor bolt/dowel yield load as determined by the manufacturer.

Insert the anchor bolt/dowel the specified depth into the hole and slightly agitate it to ensure wetting and complete encapsulation. After insertion of the anchor bolt/dowel, strike off any excessive adhesive flush with the concrete face. Should the adhesive fail to fill the hole, add additional adhesive to the hole to allow a flush strike-off. Do not disturb the anchor bolts/dowels while adhesive is hardening.

(C) Field Testing

When specified on the plans, test the installed anchor bolts/dowels for adequate adhesive as specified below. Inform the Engineer when the tests will be performed at least 2 days prior to testing. Conduct the tests in the presence of the Engineer.

Use a calibrated hydraulic centerhole jack system for testing. Place the jack on a plate washer that has a hole at least 3 mm larger than the hole drilled into the concrete. Position the plate washer on center to allow an unobstructed pull. Position the anchor bolts/dowels and the jack on the same axis. Have an approved testing agency calibrate the jack within 6 months prior to testing. Supply the Engineer with a certificate of calibration.

In the presence of the Engineer, field test 10% of the first 50 anchor bolts/dowels prior to installing any additional anchors. For testing, apply and hold briefly 90% of the anchor bolt/dowel yield load shown on the plans. No visible signs of movement of the anchor bolts/dowels is permitted under this load. Upon receiving satisfactory results from these tests, install the remaining anchors. Test a minimum of 2% of the remaining anchors as previously described.

Record data for each anchor bolt/dowel tested on the report form entitled Installation Test Report of Adhesively Anchored Anchor Bolts or Dowels. Obtain this form from the North Carolina Department of Transportation Materials and Tests Engineer. Submit a copy of the completed report forms to the Engineer.

Final acceptance of the adhesively anchored system is based on the conformance of the pull test to the requirements of this specification. Failure to meet the criteria of this specification is grounds for rejection.

420-14 PLACING AND FINISHING BRIDGE DECKS

(A) Placing Concrete

Unless otherwise noted on the plans, use Class AA cast-in-place concrete conforming to the requirements of Section 1000.

When noted on the plans, use sand lightweight concrete conforming to the requirements of Section 1000.

Place concrete in accordance with these Specifications. Properly vibrate concrete to avoid honeycomb and voids. Have pouring sequences, procedures and mixes approved by the Engineer.

For metal stay-in-place forms, do not place concrete on the forms to a depth greater than 300 mm above the top of the forms. Do not drop concrete more than 1.0 m above the top of the forms, beams or girder. Keep the top surface of prestressed concrete panels clean. Thoroughly inspect panels prior to placement of the concrete cast-in-place slab. Remove any foreign matter, oil, grease or other contaminants either with a high pressure water blast or sand blast. Saturate the top surface of the prestressed concrete panels by thoroughly wetting the top surface with water for a minimum of 2 hours before placing the cast-in-place concrete slab. Do not allow the wetted panel surface to dry before cast-in-place concrete slab placement. Remove all puddles and ponds of water from the surface of the panels and top of girder flanges before placing the cast-in-place concrete slab.

Obtain a smooth riding surface of uniform texture, true to the required grade and cross section, on all bridge decks.

Do not place bridge deck concrete until the Engineer is satisfied that adequate personnel and equipment are present to deliver, place, spread, finish, and cure the concrete within the scheduled time; that experienced finishing machine operators and concrete finishers are employed to finish the deck; and that weather protective equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. During the period between April 15 and October 15, begin placing the bridge deck concrete as early as practical to allow the work to be accomplished during the cooler hours when forms, beams, and reinforcing steel are at ambient air temperatures.

Unless otherwise permitted, set the rate of concrete placement and use a set retarder such that the concrete remains workable until the entire operation of

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placing, screeding, rescreeding, surface testing, and corrective measures where necessary are complete. Use of a set retarder is waived when conditions clearly indicate it is not needed.

Place concrete in the deck when the concrete temperature at the time of placement is not less than 10°C, nor more than 32°C, except where other temperatures are required by Article 420-7.

Place concrete at a minimum rate of 25 m³ per hour.

Place and firmly secure supports for screeds or finishing machines before beginning placement of concrete. Set supports to elevations necessary to obtain a bridge roadway floor true to the required grade and cross section, and make allowance for anticipated settlement. Use supports of a type that upon installation, no springing or deflection occurs under the weight of the finishing equipment. Locate the supports such that finishing equipment operates without interruption over the entire bridge deck.

Immediately prior to placing bridge deck concrete, check all falsework and make all necessary adjustments. Provide suitable means such as telltales to permit ready measurement by the Engineer of deflection as it occurs. Do not adjust the profile grade-line for any of the forming types used, unless permitted.

On continuous steel beam or girder spans, cast the concrete in the order shown on the plans. Place concrete in a continuous manner between headers. Use approved screeds, screed supports, and screeding methods.

(B) Finishing

Unless otherwise specified or permitted, use mechanically operated longitudinal or transverse screeds for finishing bridge deck concrete. Do not use vibratory screeds unless specifically approved. Use readily adjustable screeds with sufficient rigidity and width to strike-off the concrete surface at the required grade. Do not use aluminum strike-off elements of screeds and hand tools used for finishing concrete.

Furnish personnel and equipment necessary to verify the screed adjustment and operation prior to beginning concrete placement.

Unless otherwise permitted, do not use longitudinal screeds for pours greater than 26 meters in length. Place sufficient concrete ahead of the screeded area to assure all dead load deflection occurs before final screeding.

When using a transverse screed on a span with a skew angle less than 75 degrees or more than 105 degrees, orient and operate the truss or beam supporting the strike-off mechanism parallel to the skew. Position the strike-off parallel to the centerline of bridge, and make the leading edge of concrete placement parallel to the skew. If approved, operate at a reduced skew angle on very wide or heavily skewed spans where the distance between screed supports exceeds 30 meters.

Orient and operate transverse screeds used on spans with skew angles between 75 degrees and 105 degrees parallel to the skew or perpendicular to the centerline of bridge.

Prior to placing concrete, verify the adjustment and operation of the screed as directed by operating the screed over the entire area and across all end bulkheads. Check the floor thickness and cover over reinforcing steel shown on the plans, and make adjustments as necessary.

During the screeding operation, keep an adequate supply of concrete ahead of the screed and maintain a slight excess immediately in front of the screed. Operate the screed to obtain a substantially uniform surface finish over the entire bridge deck. Do not allow workmen to walk on the concrete after screeding. Use a minimum of 2 approved work bridges to provide adequate access to the work for the purpose of finishing, testing, straightedging, making corrections, fogging,

applying curing medium, and for other operations requiring access to the bridge deck. Support the work bridges outside the limits of concrete placement.

The Engineer makes random depth checks of deck thickness and cover over reinforcing steel over the entire placement area and directly behind the screed in the fresh concrete. If depth checks indicate variations from plan dimensions in excess of 13 mm, take corrective action immediately.

Immediately following the screed and while the concrete is still workable, test the floor surface for irregularities with a 3 m straightedge. Test by holding the straightedge in successive positions parallel to the centerline of bridge and in contact with the floor surface. Test the surface approximately 450 mm from the curb line, at the centerline of each lane, and at the centerline of 2 lane bridges. Advance along the bridge in stages of not more than 1/2 the length of straightedge. Test the surface transversely at the ends, quarter points, and center of the span as well as other locations as directed.

Immediately correct areas showing depressions or high spots of more than 3 mm in 3.0 m by filling depressions with fresh concrete or by striking off high spots. Make corrections with hand tools or a combination of hand tools and rescreeding. Do not use the straightedge as a finishing tool. Give surfaces adjacent to expansion joints special attention to assure they meet the required smoothness.

Provide on the site fogging equipment which is capable of applying water to the concrete in the form of a fine fog mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the bridge deck resulting from wind, high temperature, or low humidity, or a combination of these factors. Do not apply the moisture from the nozzle under pressure directly upon the concrete and do not allow it to accumulate on the surface in a quantity sufficient to cause a flow or wash the surface. Maintain responsibility for determining when to apply the fog mist; however, also apply it when directed.

Keep readily available on site an adequate supply of suitable coverings that will protect the surface of the freshly placed bridge deck from rain. After the water sheen disappears from the surface and before the concrete becomes non-plastic, finish the surface of the floor further by burlap dragging, fine bristle brooming, belting, or other acceptable method which produces an acceptable uniform texture.

Do not use membrane curing compound unless approved. Cure the concrete using the water method in accordance with Article 420-15(B), with the following exceptions. Prior to reaching initial set, place a curing medium consisting of burlap under polyethylene sheets or another approved material on the deck and keep moist for a minimum of 7 curing days. Wet the burlap or other approved curing medium prior to placing on the deck. Apply water to the curing medium through soaker hoses or another approved method. Apply water in amounts to keep the medium moist but do not allow the water to flow or pond on the deck.

After curing the concrete, test the finished surface by means of an approved rolling straightedge designed, constructed, and adjusted to accurately indicate or mark all floor areas which deviate from a plane surface by more than 3.0 mm in 3.0 m. Remove all high areas in the hardened surface in excess of 3.0 mm in 3.0 m with an approved grinding or cutting machine. Where variations are such that the corrections will extend below the limits of the top layer of grout, seal the corrected surface with an approved sealing agent as required. If approved, correct low areas in an acceptable manner. Produce corrected areas that have a rough, uniform texture and present neat patterns. In all cases, maintain a minimum of 50 mm of concrete cover over reinforcement.

Unless otherwise indicated on the plans, groove bridge decks. Produce grooves that are perpendicular to the centerline of bridge. Do not start grooving until final straightedging and, when necessary, acceptable corrective measures are complete. Cut grooves into the hardened concrete using a mechanical saw device, which

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leaves rectangular grooves 3 mm wide and 5 mm deep. Produce grooves that have a center to center spacing of 19 mm. Do not groove the deck surface within 450 mm of the gutter lines and 50 mm of expansion joints or elastomeric concrete in expansion joint blockouts. On skewed bridges, ungrooved triangular areas adjacent to the joint are permitted, provided the distance from the centerline joint to the nearest groove, as measured parallel to the centerline of roadway, does not exceed 450 mm. Between expansion joints on horizontally curved bridges, periodically adjust the grooving operation such that adjacent grooves are separated by no more than 75 mm along the outer radius of the bridge deck.

Continuously remove all slurry or other residue resulting from the grooving operation from the bridge deck by vacuum pick-up or other approved methods. Prevent slurry from flowing into deck drains or onto the ground or body of water under the bridge. Dispose of all residue off the project.

(C) Inspection

The Engineer observes all phases of the construction of the bridge deck slab. These phases include installation of the metal forms; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete placement and vibration; and finishing of the bridge deck.

After the deck concrete is in place for a minimum period of 2 days, test the concrete for soundness and bonding of the metal stay-in-place forms by sounding with a hammer as directed. For a minimum of 50% of the individual form panels, as selected by the Engineer, hammer test over the entire area of the panel. If areas of doubtful soundness are disclosed by this procedure, remove the forms from such areas for visual inspection after the pour attains a minimum compressive strength of 16.5 MPa. Remove the stay-in-place forms at no additional cost to the Department.

At locations where sections of the forms are removed, do not replace the forms, but repair the adjacent metal forms and supports to present a neat appearance and assure their satisfactory retention. As soon as the forms are removed, allow the Engineer to examine for cavities, honeycombing and other defects. If irregularities are found, and in the opinion of the Engineer these irregularities do not justify rejection of the work, repair the concrete as directed. If the concrete where the forms are removed is unsatisfactory, remove additional forms, as necessary, to inspect and repair the slab. Modify the methods of construction as required to obtain satisfactory concrete in the slabs. Remove and repair all unsatisfactory concrete as directed.

Provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedures.

420-15 CURING CONCRETE

(A) General

Unless otherwise specified in the contract, use any of the following methods except for membrane curing compounds on bridge deck unless permitted in conjunction with the polyethylene sheeting method or on concrete which is to receive epoxy protective coating in accordance with 420-18. Advise the Engineer in advance of the proposed method. Have all material, equipment, and labor necessary to promptly apply the curing on the site before placing any concrete. Cure all patches in accordance with this article. Improperly cured concrete is considered defective.

When used in this article, curing temperature is defined as the atmospheric temperature taken in the shade away from artificial heat, with the exception that it is the temperature surrounding the concrete where the concrete is protected in accordance with Article 420-7.

A curing day is defined as any consecutive 24-hour period, beginning when the manipulation of each separate mass is complete, during which the air temperature adjacent to the mass does not fall below 4°C.

After placing the concrete, cure it for a period of 7 full curing days.

Take all reasonable precautions to prevent plastic shrinkage cracking of the concrete, including the provision of wind screens, fogging, application of an approved temporary liquid moisture barrier, or the early application of temporary wet coverings to minimize moisture loss.

Repair, remove, or replace as directed concrete containing plastic shrinkage cracks at no cost to the Department.

(B) Water Method

Keep the concrete continuously wet by the application of water for a minimum period of 7 curing days after placing the concrete.

When using cotton mats, rugs, carpets, or earth or sand blankets to retain the moisture, keep the entire surface of the concrete damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. Do not apply the moisture from the nozzle under pressure directly upon the concrete and do not allow it to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period, clear the concrete surfaces of all curing mediums.

(C) Membrane Curing Compound Method

Spray the entire surface of the concrete uniformly with a wax-free, resin-base curing compound conforming to the requirements of Article 1026-2. Use clear curing compound to which a fugitive dye is added for color contrast on bridge superstructures and substructures, and on retaining walls. Use either white pigmented or clear curing compound on culverts.

Apply the membrane curing compound after the surface finishing is complete, and immediately after the free surface moisture disappears. During the finishing period, protect the concrete by applying water with the fogging equipment specified in Subarticle 420-15(B).

Seal the surface with a single uniform coating of the specified type of curing compound applied at the rate of coverage recommended by the manufacturer or as directed, but not less than 1 liter per 3.7 square meters of area on surfaces other than bridge approach slabs. On bridge approach slabs, apply the curing compound at a minimum rate of 1 liter per 2.5 square meters of area.

At the time of use, thoroughly mix the compound with the pigment uniformly dispersed throughout the vehicle. If the application of the compound does not result in satisfactory coverage, stop the method and begin water curing, as set out above, until the cause of the defective work is corrected.

At locations where the coating shows discontinuities, pinholes, or other defects, or if rain falls on the newly coated surface before the film dries sufficiently to resist damage, apply an additional coat of the compound at the same rate specified herein immediately after the rain stops.

Completely remove any curing compound adhering to a surface to which new concrete is to be bonded by sandblasting, steel wire brushes, bush hammers, or other approved means.

Protect the concrete surfaces to which the compound is applied from abrasion or other damage that results in perforation of the membrane film for 7 curing days after placing the concrete. If the film of membrane compound is damaged or removed before the expiration of 7 curing days, immediately cure the exposed

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concrete by the water method until the expiration of the 7 curing days or until applying additional curing compound.

In the event that the application of curing compound is delayed, immediately start applying water as provided in Subarticle 420-15(B) and continue until resuming or starting application of the compound.

(D) Polyethylene Sheeting Method

Wet the exposed finished surface of concrete with water, using a nozzle that so atomizes the flow to form a mist and not a spray, until the concrete sets, after which place the white opaque polyethylene sheeting. Continue curing for 7 curing days after the concrete is placed. If the sheeting is damaged or removed before the expiration of 7 curing days, immediately cure the exposed concrete by the water method until placing additional sheeting or until after 7 curing days.

Use sheeting which provides a complete continuous cover of the entire concrete surface. Lap the sheets a minimum of 300 mm and securely weigh down or cement them together in such a manner as to provide a waterproof joint.

If any portion of the sheets is broken or damaged before the expiration of the curing period, immediately repair the broken or damaged portions with new sheets properly secured in place.

Do not use sections of sheeting damaged to such an extent as to render them unfit for curing the concrete.

(E) Forms-in-Place Method

As an option, cure surfaces of concrete by retaining the forms in place for a minimum period of 7 curing days after placing the concrete.

If electing to leave forms in place for a part of the curing period and using one of the other methods of curing included in this article for the remainder of the curing period, keep the concrete surfaces wet during transition between curing methods.

420-16 REMOVAL OF FORMS AND FALSEWORK

Do not remove forms and falsework for the portions of structures listed in Table 420-1 until the concrete attains the compressive strength shown, as evidenced by nondestructive test methods approved in writing or by conducting compressive strength tests in accordance with AASHTO T22 and T23. Furnish approved equipment used for nondestructive tests.

**TABLE 420-1
MINIMUM CONCRETE STRENGTH FOR
REMOVAL OF FORMS AND FALSEWORK**

Portion of Structure	Minimum Compressive Strength, MPa
Bridge Deck Slabs and overhangs for beam and girder bridges	20.7
Arch culverts, top slabs of box culverts, walls of box culverts when cast monolithically with the top slab or when the wall is 3 m or more in height, caps and struts of sub-Structures, diaphragms, and other members subject to dead load bending	16.5

Remove forms for ornamental work, railing, parapets, walls less than 3 m in height, curb faces on bridge superstructures, and vertical surfaces that do not carry loads, any time after 3 hours if the concrete is set sufficiently to permit form removal without damage to the member.

Do not remove forms used for insulation before the expiration of the minimum protective period required in Article 420-7.

Do not remove formwork for bent diaphragms until after casting deck concrete and allowing the concrete to attain a strength of 16.5 MPa. As an option, to remove support from bent diaphragms prior to casting deck concrete, submit for approval a method to prevent the possibility of bent diaphragms slipping downward.

When removing forms prior to the end of the required curing period, use other curing methods to complete the required curing. When removing forms from underneath slabs prior to the end of the curing period, complete the curing in accordance with the requirements of Subarticle 420-15(C).

420-17 SURFACE FINISH

(A) General

Finish all concrete as required by this article except for bridge decks. Use the type of finish called for in Subarticles 420-17(B) through 420-17(D), except where the contract requires a Class 1 or Class 2 surface finish. Apply epoxy protective coating as required by 420-18.

(B) Ordinary Surface Finish

Apply ordinary surface finish to all formed concrete surfaces either as a final finish or preparatory to a higher class finish. On surfaces backfilled or otherwise covered, or enclosed surfaces, the removal of fins and form marks, the rubbing of grouted areas to a uniform color, and the removal of stains and discoloration, is not required. Use an ordinary surface finish, unless otherwise required, as final finish on all surfaces.

During the placing of concrete, take care to use methods of compaction that result in a surface of even texture free from voids, water, or air pockets, and that the coarse aggregate is forced away from the forms in order to leave a mortar surface.

Immediately after removing the forms, clean and fill with grout all pockets, depressions, honeycombs and other defects as directed. Remove all form ties or metal spacers to a depth of at least 25 mm below the surface of the concrete then clean and fill the resulting holes or depressions with grout. As an option, break off flush with the concrete surface those metal devices with exposed cross sectional area not exceeding 32 mm² on surfaces permanently in contact with earth fill. Unless otherwise required, remove fins and other projections flush with the concrete surface. Remove stains and discoloration.

Use grout for patching which contains cement and fine aggregate from the same sources and in the same proportions as used in the concrete. Cure the grout in accordance with Article 420-15. After the grout has thoroughly hardened, rub the surface with a carborundum stone as required to match the texture and color of the adjacent concrete.

(C) Unformed Surfaces Not Subjected to Wear

Finish all unformed surfaces not subjected to wear by placing an excess of material in the forms and removing or striking off such excess with a wooden template, forcing the coarse aggregate below the mortar surface. Do not use mortar topping for concrete railing caps and other surfaces falling under this classification.

Obtain the final finish for caps and railing in one of the following ways:

- (1) **Brush Finish:** After striking off the concrete as described above, have skilled and experienced concrete finishers thoroughly work and float the surface with a wooden, canvas, or cork float. Before this last finish sets, lightly stroke the surface with a fine brush to remove the surface cement film, leaving a fine grained, smooth, but sanded texture.
- (2) **Float Finish:** Finish the surface with a rough carpet float or other suitable device leaving the surface even, but distinctly sandy or pebbled in texture.

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(D) Sidewalk, Islands, or Stairways on Bridges

Strike off and compact fresh concrete until a layer of mortar is brought to the surface. Finish the surface to grade and cross section with a float, trowel smooth, and finish with a broom. If water is necessary, apply it to the surface immediately in advance of brooming. Broom transverse to the line of traffic.

(E) Class 1 Surface Finish

In addition to the requirements of Subarticle 420-18(B), as soon as the pointing sets sufficiently to permit, thoroughly wet the entire surface with a brush and rub with a coarse carborundum stone or other equally good abrasive, bringing the surface to a paste. Continue rubbing to remove all form marks and projections, producing a smooth dense surface without pits or irregularities.

Carefully spread or brush uniformly over the entire surface the material ground to a paste by rubbing and allowing it to take a reset. After rubbing, cure the surface for a period of 7 curing days. Obtain the final finish by thoroughly rubbing with a fine carborundum stone or other equally good abrasive. Continue this rubbing until the entire surface is of a smooth texture and uniform color.

(F) Class 2 Surface Finish

In addition to the requirements of Subarticle 420-17(B), after the pointing sets sufficiently to permit, thoroughly wet and rub the entire surface with a coarse carborundum stone or other equally good abrasive to bring the surface to a smooth texture and remove all form marks. Finish the paste formed by rubbing as described above by carefully stroking with a clean brush, or spread it uniformly over the surface and allow it to take a "reset", then finish it by floating with a canvas, carpet-faced, or cork float; or rub down with dry burlap.

420-18 EPOXY COATING

(A) General

Use an epoxy coating meeting the requirements of Section 1081, Type 4A Flexible and moisture insensitive. Provide a certification showing the proposed epoxy meets Type 4A requirements.

(B) Surfaces

With the exception of cored slab bridges, apply the epoxy protective coating to the top surface area, including chamfer area of bent caps under expansion joints and of end bent caps, excluding areas under elastomeric bearings. For cored slab bridges, do not apply the epoxy protective coating to the bent or end bent caps.

Use extreme care to keep the area under the elastomeric bearings free of the epoxy protective coating. Do not apply the epoxy protective coating in the notch at the ends of the prestressed concrete girders.

Thoroughly clean all dust, dirt, grease, oil, laitance and other objectionable material from the concrete surfaces to be coated. Air blast all surfaces immediately prior to applying the protective coating.

Use only cleaning agents preapproved by the Engineer.

(C) Application

Apply epoxy protective coating only when the air temperature is at least 4°C and rising, but less than 35°C and the surface temperature of the area to be coated is at least 4°C. Remove any excess or free standing water from the surfaces before applying the coating. Apply one coat of epoxy protective coating at a rate such that it covers between 2.45 and 4.9 m²/L.

Under certain combinations of circumstances, the cured epoxy protective coating may develop an oily condition on the surface due to amine blush. This condition is not detrimental to the applied system.

Apply the coating so that the entire designated surface of the concrete is covered and all pores are filled. To provide a uniform appearance, use the exact same material on all visible surfaces.

420-19 PROTECTION OF SUBSTRUCTURE CONCRETE FROM RUST STAINS

In order to prevent unpainted structural steel from staining substructure concrete, protect all final exposed areas of the concrete from rust stains until casting the bridge deck and sealing the expansion joints. Use an approved method for protecting the concrete.

In lieu of the above, remove the stains by approved methods and cleaning agents.

420-20 PLACING LOAD ON STRUCTURE MEMBERS

Do not place beams or girders on concrete substructures until the concrete in the substructure develops a minimum compressive strength of 16.5 MPa.

In addition to the requirements of Article 410-8, do not place backfill or fill for retaining walls, abutments, piers, wing walls, or other structures that will retain material to an elevation higher on one side than the other until the concrete develops the minimum specified strength for the class of concrete required for the structure.

Do not carry backfill for arch culverts and box culverts to an elevation higher than 0.3 m above the top of footing or bottom slab until the concrete develops the minimum specified strength for the class of concrete required for the culvert.

Adhere to the following time and strength requirements for erection of forms and construction of superimposed bridge substructure elements:

- (A) Wait a minimum of 12 hours between placing footing or drilled pier concrete and erecting column forms.
- (B) Wait a minimum of 24 hours between placing footing or drilled pier concrete and placing column concrete.
- (C) Wait a minimum of 72 hours between placing column concrete and beginning erection of cap forms or until column concrete attains a compressive strength of at least 10.3 MPa.
- (D) Wait a minimum of 96 hours between placing column concrete and placing cap concrete or until column concrete attains a compressive strength of at least 13.8 MPa.

Do not place vehicles or construction equipment on a bridge deck until the deck concrete develops the minimum specified 28 day compressive strength and attains an age of at least 14 curing days. Construction equipment is allowed on bridge approach slabs after the slab concrete develops a compressive strength of at least 20.7 MPa and attains an age of at least 7 curing days. A curing day is defined in Subarticle 420-15(A).

Provide evidence that the minimum compressive strengths referred to above are satisfied by nondestructive test methods approved in writing or by compressive strength tests made in accordance with AASHTO T22 and T23. Furnish approved equipment for use in nondestructive tests.

Do not place construction equipment, materials, or other construction loads on any part of the structure without permission. Submit 7 copies of the proposed plans for placing construction loads on the structure for review, comments and acceptance.

Do not abruptly start or stop concrete trucks on bridge deck. Do not mix concrete in the truck while on the deck. While machine forming concrete barrier rail or parapet, do not place any equipment on the deck except one concrete truck and the equipment necessary to place the concrete. Allow concrete barrier rail and parapet to attain a compressive strength of 20.7 MPa prior to placing any traffic on the deck other than equipment referenced above necessary to construct any remaining barrier rail or parapet.

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Do not operate heavy equipment over any box culvert until properly backfilling with a minimum cover of 1 m.

420-21 MEASUREMENT AND PAYMENT

Class _____ Concrete will be measured and paid as the number of cubic meters of each class that is incorporated into the completed and accepted structure except as indicated below. The number of cubic meters of concrete is computed from the dimensions shown on the plans or from revised dimensions authorized by the Engineer. When the foundation material is rock, the number of cubic meters of footing concrete is computed by the average end area method using the lower limits established for foundation excavation. The volume of concrete displaced by piles other than steel piles is not included in the quantity to be paid for.

Grooving Bridge Floors will be measured and be paid as the actual number of square meters shown on the plans. Where the plans are revised, the quantity to be paid for is the quantity shown on the revised plans.

Reinforced Concrete Deck Slab and Reinforced Concrete Deck Slab (sand lightweight concrete) will be measured and paid as the number of square meters shown on the plans. No separate payment will be made for furnishing and incorporating calcium nitrite corrosion inhibitor when required by the plans.

The plan quantity is determined from the horizontal surface area using the nominal dimensions and configuration shown in the Layout Sketch for computing surface area as shown on the plans. The transverse dimension is out to out of slab including raised median and/or sidewalk sections. Diaphragms are considered as a portion of the slab. When required by the plans, curtain walls, raised medians, sidewalks, pavement brackets, end posts, sign mounts, luminaire brackets and any other concrete appurtenances, expansion joint material, etc. are also considered a part of this item. Concrete Barrier Rail (including curved end blocks for the concrete barrier rail, when used) is not considered a part of this item.

For structural steel spans, the quantities of concrete and reinforcing steel shown on the plans are based on a metal stay-in-place forming method. These quantities include amounts for 25 mm additional concrete due to the corrugation of the metal forms, concrete diaphragms and, when required by the plans, curtain walls, pavement brackets, end posts, raised medians, sidewalks and other required attachments based on the profile grade and plan camber of the girders.

For prestressed concrete girder spans, the quantities of concrete and reinforcing steel shown on the plans are based on the forming method detailed on the plans. These quantities include concrete diaphragms, and, when required by the plans, curtain walls, pavement brackets, end posts, raised medians, sidewalks, and other required attachments based on the profile grade and plan camber of girders. The quantities also include either cast-in-place slab concrete when the plans are detailed for the prestressed concrete panel forming method or amounts for 25 mm additional concrete due to the corrugation of the metal forms when the plans are detailed for the fabricated metal stay-in-place form forming method and based on the profile grade and plan camber of the girders.

No measurement is made for concrete or reinforcing steel due to a variation in camber of the girders from the plan camber or for additional quantities required by optional methods of forming.

No separate measurement or payment will be made for furnishing, installing, and testing anchor bolts/dowels. Payment at the contract unit prices for the various pay items will be full compensation for all materials, equipment, tools, labor, and incidentals necessary to complete the work.

These prices and payments will be full compensation for all items required to construct concrete structures.

Payment will be made under:

Pay Item	Pay Unit
Class _____ Concrete	Cubic Meter
Grooving Bridge Floors	Square Meter
Reinforced Concrete Deck Slab	Square Meter
Reinforced Concrete Deck Slab (Sand Lightweight Concrete)	Square Meter

SECTION 422 BRIDGE APPROACH SLABS

422-1 DESCRIPTION

Construct reinforced concrete slabs at bridge approaches, including subgrade, base course, curbs and sidewalks; furnish and place temporary slope drainage systems and subsurface drainage systems; remove existing pavement or approach slab; furnish and place concrete, reinforcing steel, joint filler, sealer and other materials; finish and cure concrete.

Construct the approach slabs before constructing concrete barrier rails or sidewalks.

422-2 MATERIALS

Refer to Division 10.

Item	Section
Portland Cement Concrete	1000
Curing Agents	1026
Joint Filler	1028-1
Joint Sealer	1028-4
Reinforcing Steel	1070
Subdrain Fine Aggregate	1044-1
Stone, No. 78M	1005
Aggregate Base Course	1010-1 through 1010-4
Corrugated Aluminum Alloy Pipe	1032-2
Corrugated Steel Pipe	1032-3
Corrugated Polyethylene (PE) Pipe	1044-6

422-3 CONSTRUCTION METHODS

When weep drains are shown on the plans, place a stone drain consisting of .03 m³ of No. 78M stone contained in a porous fabric bag at each pipe drain located in the end bent cap or abutment and tie it securely. Place subdrain fine aggregate in conjunction with the stone drain as shown on the plans.

Place and compact the subdrain fine aggregate in accordance with Article 410-10.

Construct the subgrade in accordance with Section 500.

Construct the aggregate base course in accordance with Section 520.

Construct the asphalt concrete base course in accordance with Section 610.

Apply the requirements of Section 420 to all concrete except as otherwise provided herein. Use class AA concrete.

Finish and groove the reinforced concrete bridge approach slabs in accordance with the requirements of Article 420-14, except do not groove the approach slabs when grooving the bridge deck is not required.

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When grooving is not required, apply a broomed texture to the approach slabs before the concrete becomes non-plastic. Cure bridge approach slabs in the same manner as specified for bridge decks in Article 420-15(B).

Temporarily cover or fill the opening in the joint at the end bent until installation of the joint seal. Make sure that the covering or filler provides for drainage off the bridge deck and keeps debris out of the joint and off the end bent cap.

Shape the concrete curb to match the face of the barrier rail. Do not place the curb within the limits shown on the plans until after sawing the joint at the end bent. Give the concrete a light broom finish with brush marks parallel to the curb.

When shown on the plans, construct sidewalks on bridge approach slabs in accordance with plan details. Do not construct sidewalks until sawing the joint at the end bent. Finish the concrete in accordance with Subarticle 420-17(D).

Include in the temporary slope drainage system the earth ditch block, erosion resistant surface material, Class B stone for erosion control, and the pipe. Locate it as shown on the plans.

Use either corrugated polyethylene (PE), corrugated steel, or corrugated aluminum alloy for the temporary drainage pipe. Do not use perforated pipe. Provide temporary pipe of sufficient length for complete drainage away from the roadway embankment.

Backfill the approach slabs as soon as practical to prevent erosion adjacent to the slab.

422-4 MEASUREMENT AND PAYMENT

The price and payment below will be full compensation for all items required to construct bridge approach slabs including but not limited to those items contained in Article 422-1.

Bridge Approach Slabs, Sta. _____ will be paid for at the contract lump sum price.

Grooving bridge approach slabs will be paid for at the contract unit price per square meter for Grooving Bridge Decks as provided in Article 420-21.

Payment will be made under:

Pay Item	Pay Unit
Bridge Approach Slabs, Sta. _____	Lump Sum

**SECTION 425
FABRICATING AND PLACING
REINFORCEMENT**

425-1 DESCRIPTION

Furnish, fabricate, and place steel reinforcement other than wire mesh reinforcement, including all related materials such as tie wire, separators, wire bar supports, mechanical butt splices for reinforcing steel, and other material for fastening the reinforcing steel in place; galvanize and/or coat where required; and fabricate, cut, bend, place, and splice the reinforcement in conformity with the shape and dimensions shown on the plans and as specified in these Specifications. Provide epoxy coated reinforcing steel where indicated on the plans.

425-2 MATERIALS

Refer to Division 10.

Item	Section
Steel Bar Reinforcement	1070-2
Wire Mesh Reinforcement	1070-3
Reinforcing Wire	1070-3

Wire Bar Supports	1070-4
Epoxy Coated Reinforcing Steel	1070-8
Spiral Column Reinforcing Steel	1070-9
Epoxy Coated Spiral Column Reinforcing Steel	1070-9
Mechanical Butt Splices for Reinforcing Steel	1070-10

425-3 PROTECTION OF MATERIALS

Protect steel reinforcement at all times from damage and make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil, or other foreign materials at the time of placement in the work.

Store epoxy coated reinforcing steel bars at the project site a minimum of 0.3 m above the ground on wooden or padded supports placed 3 m apart, and completely cover with an opaque cloth, canvas, or woven fiber reinforced polyethylene white tarp. Do not use solid plastic sheeting. Cover the bars such that adequate ventilation is provided to prevent condensation from forming on the material during storage, and completely protect the bars from direct sunlight. Do not allow water to pond under the epoxy coated reinforcing steel.

Store epoxy coated bars as close as possible to their final location in the structure to prevent coating damage from unnecessary handling.

Do not store epoxy coated bars at the project site from one construction season until the following construction season unless stored in a waterproof enclosure.

425-4 PLACING AND FASTENING

Accurately place reinforcement as shown on the plans and secure firmly in position by wiring at intersections and using metal bar supports, precast mortar blocks, or other approved devices of sufficient strength and location to resist distortion.

Tie reinforcing bars at all intersections except where spacing is less than 0.3 m in both the longitudinal and transverse directions, in which case tie at alternate intersections, as an option. Securely tie each intersection of vertical reinforcing steel and spiral reinforcement for drilled piers. Use plastic or epoxy coated spiral spacers with epoxy coated spiral column reinforcing steel.

Provide wire bar supports for reinforcing steel in accordance with Article 1070-4 of the proper height to provide the distance from the forms and the proper spacing between rows of steel as indicated on the plans. When required by the plans, epoxy coat bar supports in accordance with Article 1070-8. Provide rust-proofed supporting legs for wire bar supports that rest on the forms as provided in Article 1070-4. When providing rust proofing by plastic protection, make sure that the dipped plastic coating or premolded plastic tips are intact on each bar support leg while concrete is placed.

Precast blocks, of approved shape and dimensions, for holding vertical reinforcement in position from 1:2 mortar or concrete of the same mix used in the member being cast. Cure precast blocks in accordance with the requirements of Article 420-15 for the water method or the polyethylene sheeting method. To hold vertical bars in position, use precast blocks which have embedded wires extending from the block a sufficient distance to tie to the bar.

Roll mesh reinforcement flat before placing concrete, unless otherwise shown on the plans. Hold mesh reinforcement firmly in place against vertical and transverse movement by acceptable means.

Weld reinforcing steel in accordance with the American Welding Society's "Reinforcing Steel Welding Code AWS D1.4" and only where required in the contract. Obtain written approval for additional welding. Do not use tack welds unless approved.

Exercise extreme care when transporting, handling, placing and tying epoxy coated reinforcing steel to prevent damage to the coating.

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Immediately before placing epoxy coated reinforcing steel bars in the forms, visually inspect each bar for coating damage. Ensure that all coating damaged by any cause is satisfactorily repaired, including hairline cracks and that each bar, including bar ends, is completely encapsulated in epoxy coating or patching material at the time of concrete placement. Make coating repairs as described in Section 1070-8(K) with material specified in Section 1070-8(C). Do not coat more than 5 percent of surface area on each bar with patching material including patching due to damage to the coating by the coater, fabricator, transporter, or contractor. The patching limits do not include holiday repairs, overspray and coated ends of bars.

Do not expose epoxy coated reinforcing steel to the weather for more than 30 days after placing in the forms. If the concrete is not placed within 30 days, cover the epoxy coated reinforcing steel as required by Article 425-3.

Do not place reinforcement while placing concrete in the member involved.

Place, allow inspection, and obtain approval for reinforcement in any member before placing concrete.

425-5 SPLICING

(A) General

Furnish all reinforcement in the full lengths indicated on the plans.

Do not splice bars without written approval except where shown on the plans.

Provide splice lengths as shown on the plans.

Overlap sheets of mesh with each other sufficiently to maintain a uniform strength and securely fastened to each other at the ends and edges. Lap at least the dimension of 1 mesh.

(B) Mechanical Butt Splices

Provide mechanical butt slices for reinforcing steel in accordance with Section 1070-10 when called for on the plans.

When an exothermic connector is used, do not let the splice depend upon fusion of the filler metal with the bars. Select a temperature for heating the bars that is below the melting point of the bars and is sufficiently low so as not to significantly affect the original hardness nor decrease the structural properties of the bars. Visual inspection of the finished splices is sufficient; the splice is acceptable if sound filler metal is present at both ends of the splice sleeve and at the sleeve entry port.

Splice the bars in accordance with the manufacturer's recommendations using the manufacturer's required accessories as approved by the Engineer. Use mechanical butt splices only where specified on the plans. Any additional splices require approval.

If bars are epoxy coated, strip the epoxy coating within the limits of the sleeve prior to splicing. After making the splice, paint any unprotected areas of the reinforcing bar and the coupling sleeve with epoxy paint as described in the *Standard Specifications*.

425-6 MEASUREMENT AND PAYMENT

Reinforcing Steel or *Epoxy Coated Reinforcing Steel* will be measured and paid for as the number of kilograms of steel bar reinforcement, reinforcing wire, and plain rods shown on the plans as being necessary to complete the work. Where the plans are revised, the quantity to be paid for is the quantity shown on the revised plans. Where directed to deviate from the plans in such a manner to change the quantities of steel bar reinforcement, reinforcing wire, and plain rods necessary to complete the project, the quantity shown on the plans is increased or decreased by the theoretical computed weight of reinforcing steel added or subtracted by the change.

Spiral Column Reinforcing Steel or Epoxy Coated Spiral Column Reinforcing Steel will be measured and paid for as the number of kilograms of spiral column reinforcing shown on the plans as being necessary to complete the work. Where the plans are revised, the quantity to be paid for is the quantity shown on the revised plans. Where directed to deviate from the plans in such a manner to change the quantities of steel bar reinforcement, reinforcing wire, and plain rods necessary to complete the project, the quantity shown on the plans is increased or decreased by the theoretical computed weight of spiral column reinforcing steel added or subtracted by the change.

The quantity of reinforcing steel or spiral column reinforcing steel shown on the plans is an estimate based on the theoretical computed weight of the steel necessary to complete the work, and will be used for pay purposes. No revision in this pay quantity nor any adjustment in the contract unit price for Reinforcing Steel or Spiral Column Reinforcing Steel will be made except where revisions in the plans affect the quantity of reinforcing steel or spiral column reinforcing steel necessary to complete the work or where an error has been found in the estimate of steel shown on the plans.

In the event that the elevation of the top of a footing is raised by a distance not exceeding 1 meter, and the reinforcing steel or spiral column reinforcing steel for the substructure unit has been fabricated before the elevation was raised, no decrease in the quantity of steel to be paid for will be made from the theoretical weight of steel shown on the plans for the original substructure unit. Under the above circumstances the provisions of Article 109-6 will not apply as the steel not used in the work shall remain the property of the Contractor and payment for such steel will be made as provided above. No separate payment will be made for the cost of cutting off reinforcing steel or spiral column reinforcing steel as payment at the contract unit price per kilogram for the item of Reinforcing Steel or Spiral Column Reinforcing Steel will be full compensation for cutting the steel.

There will be no direct payment for reinforcing steel when the basis of payment or compensation clause applicable to a particular section of the Specifications states that payment at the contract unit or lump sum prices for the work covered by such section will be full compensation for furnishing and placing reinforcing steel.

No separate payment will be made for the work of furnishing and placing wire mesh reinforcement as payment at the contract unit price for the item or items covering the structure containing the mesh reinforcement will be full compensation for such work.

These prices and payments will be full compensation for all items required to fabricate and place reinforcement.

Payment will be made under:

Pay Item	Pay Unit
Reinforcing Steel	Kilogram
Epoxy Coated Reinforcing Steel	Kilogram
Spiral Column Reinforcing Steel	Kilogram
Epoxy Coated Spiral Column Reinforcing Steel	Kilogram

SECTION 430 ERECTING PRESTRESSED CONCRETE MEMBERS

430-1 DESCRIPTION

Furnish and erect precast-prestressed concrete bridge members other than piling. Furnish, galvanize, place, and paint, as applicable, bearing components, anchor bolts, diaphragm bars, washers, nuts, structural and reinforcing steel, miscellaneous hardware, paint, bearing assemblies, and all other materials; handle, transport, and store materials; furnish erection drawings; paint; set bearings and anchorage; grout, and erect and install

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the bridge members and all other items necessary to complete the erection in accordance with the requirements of the contract.

When used in this section, the term *prestressed concrete* refers to precast, pretensioned, prestressed concrete.

430-2 MATERIALS

Refer to Division 10.

Item	Section
Precast-Prestressed Members	1078
Plain Steel Bars, Threaded Ends	1074-3
Structural Steel	1072
Reinforcing Steel	1070
Organic Zinc Repair Paint	1080-9
Bearing Plate Assemblies	1072-5
Elastomeric Bearings	1079-2

430-3 HANDLING AND STORAGE

Take special care in handling, transporting, and storing prestressed members. Members damaged while handled or transported will be rejected unless repaired to the satisfaction of the Engineer.

Handle members at the bearings or at pick-up points designated on the plans unless using other methods approved in writing.

Transport prestressed concrete bridge girders in a horizontal upright position. Locate points of support and directions with respect to the girder approximately the same during transportation and storage as when the member is in the final position within the structure.

430-4 METHODS AND EQUIPMENT

Use methods and equipment to install prestressed members that result in satisfactory installation.

430-5 BEARINGS AND ANCHORAGES

Supply elastomeric bearings, when required by the plans, meeting the requirements of Section 1079.

Set steel sole plates level in exact position with full and even bearing on the bearing pad.

Accurately set anchor bolts in accordance with the requirements of Subarticle 420-12(A).

When welding the sole plate to the embedded plate in the girder, use temperature indicating wax pens, or other suitable means, to ensure that the temperature of the sole plate does not exceed 149°C. Temperatures above this may damage the elastomer.

Prior to welding, grind the galvanized surface of the portion of the embedded plate and sole plate that require welding. After welding, repair damaged galvanized surfaces in accordance with Article 1076-6.

430-6 ERECTION AND INSTALLATION

(A) General

Erect prestressed concrete members by methods that satisfy the handling requirements specified in Article 430-3.

Perform field welding in accordance with Article 1072-20 only when required on the plans.

When indicated on the plans, recess the ends of tie rods used in intermediate diaphragms of prestressed concrete girders. Fill these recesses with an approved non-metallic, non-shrink grout to match the neat lines of the girders.

When concrete is cast in contact with prestressed members, thoroughly clean and wet the surface of the member which contacts the fresh concrete for a minimum of 2 hours just prior to casting the fresh concrete.

After casting and finishing all concrete, thoroughly clean the prestressed members.

(B) Cored Slabs

When erecting prestressed cored slabs, place the 12.7 mm diameter transverse post tensioning strands and tension to 133 kN in each span. Grease the transverse strands and place in a non-corrosive 12.7 mm diameter, 1.6 mm minimum wall thickness black polyethylene pipe meeting the requirements of ASTM D2239. Do not apply grease or extend the pipe in the area of the recesses at the ends of the tensioning strands where grout is applied. After tensioning the 12.7 mm diameter transverse strand in a span and before placing any equipment, material or barrier rail on the span, fill the shear key, dowel holes, and recesses at the ends of transverse strands with an approved non-metallic, non-shrink grout and cure for 3 days minimum, and until the grout reaches a compressive strength of 20.7 MPa.

After tensioning and curing, obtain approval prior to placing material and equipment on the cored slab spans. Support cranes or other equipment exceeding the legal load limit on mats. Submit for review a detailed drawing for the mats that are intended for use on the cored slabs. Provide a complete description of the equipment that is intended for placement on the mats. Supply and construct mats at no additional cost to the Department.

(C) Box Beams

The post tensioning system shall use 15.2 mm diameter strands. Strands shall be tensioned to 196 kN. Strands shall be placed in a non-corrosive 15.2 mm diameter, 1.6 mm minimum wall thickness black polyethylene pipe meeting the requirements of ASTM D2239.

When erecting prestressed box beams, place the transverse post tensioning system in the diaphragms, place grout in the grout pockets located at the areas of the post tensioning strands, if provided, and tension to the required force. Grease the strands and place in the polyethylene pipe. Do not apply grease or extend the pipe in the area of the recesses at the ends of the tensioning strands where grout is applied. Tension the strands in the diaphragm nearest mid-span first. Proceed to tension strands in the adjacent diaphragms. Continue the tensioning operation in a symmetric manner along the length of the span. At each diaphragm location, maintain a symmetric tension force between each pair of strands in the diaphragm. After all tensioning in a span is completed and before placing any equipment, material or barrier rail on the span, fill the shear key, dowel holes, and recesses at the ends of the diaphragm with an approved non-metallic, non-shrink grout. Cure for 3 days minimum and until the grout reaches a compressive strength of 20.7 MPa.

After tensioning and curing, obtain approval prior to placing material and equipment on the box beam spans. Support cranes or other equipment exceeding the legal load limit on mats. Submit for review a detailed drawing for the mats that are intended for use on the box beams. Provide a complete description of the equipment that is intended for placement on the mats. Supply and construct mats at no additional cost to the Department.

430-7 PAINTING

Clean, by hand or with power tools, and paint with 2 coats of organic zinc repair paint all ungalvanized steel surfaces, such as tie rod ends, not encased in concrete in

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accordance with Section 442. Provide a minimum dry thickness of each coat of paint of 0.04 mm.

430-8 MEASUREMENT AND PAYMENT

__ mm Prestressed Concrete Girders will be measured and paid for as the number of linear meters of prestressed concrete girders estimated on the plans as being necessary to complete the project.

914 mm x ____ mm Prestressed Concrete Cored Slabs will be measured and paid for as the number of linear meters of prestressed concrete cored slabs estimated on the plans as being necessary to complete the project.

914 mm x ____ mm Prestressed Concrete Box Beams will be measured and paid for as the number of linear meters of prestressed concrete box beams estimated on the plans as being necessary to complete the project.

Concrete Box Beams will be measured and paid for as the number of linear meters of concrete box beams estimated on the plans as being necessary to complete the project.

Elastomeric Bearings will be paid at the contract lump sum price.

These prices and payments will be full compensation for all items required to erect prestressed concrete members, including but not limited to those items contained in Article 430-1.

Payment will be made under:

Pay Item	Pay Unit
<i>__ mm Prestressed Concrete Girders</i>	Linear Meter
<i>914 mm x ____ mm Prestressed Concrete Cored Slabs</i>	Linear Meter
<i>914 mm x ____ mm Prestressed Concrete Box Beams</i>	Linear Meter
Concrete Box Beams	Linear Meter
Elastomeric Bearings	Lump Sum

SECTION 440 STEEL STRUCTURES

440-1 DESCRIPTION

Construct steel structures and steel structure portions of composite structures in conformity with the lines, grades, and dimensions shown on the plans and as specified in these Specifications.

Furnish, fabricate, galvanize, deliver, place, erect, clean, shop paint, and field paint structural metals and all other materials; furnish, erect, and remove falsework; set bearings and anchorage; weld; and furnish all materials for and assemble all structural joints. Structural metals include structural steels, metallic electrodes, steel forgings and castings, gray iron and malleable iron castings, drain pipes, and any incidental metal construction. Perform the above in conformity with the contract.

Before starting work, inform the Engineer as to the proposed method of erection.

440-2 MATERIALS AND FABRICATION

Refer to Division 10.

Item	Section
Structural Steel	1072
Steel Pipe	1074-6
Welded Stud Shear Connectors	1072-8
High Strength Bolts, Nuts, Washers, and Direct Tension Indicators	1072-7
Preformed Bearing Pads.	1079-1
Anchor Bolts	1072-6
Bearing Plate Assemblies	1072-5
Organic Zinc Repair Paint	1080-9
Elastomeric Bearings	1079-2

440-3 HANDLING AND STORING MATERIALS

Move, handle, and store all structural steel, in the shop, field and while being transported in accordance with Article 1072-11.

440-4 BEARINGS AND ANCHORAGES

Supply preformed bearing pads and elastomeric bearings, as required by the plans, meeting the requirements of Section 1079.

Set steel masonry plates level in exact position with full and even bearing on the preformed bearing pad.

Accurately set anchor bolts in accordance with the requirements of Subarticle 420-12(A).

Make sure that the location of anchors and setting of bearings take into account any variation from mean temperature at time of setting and anticipated lengthening of bottom flange due to dead load after setting, so that at mean temperature and under dead load the bearings are in a vertical position and anchor bolts at expansion bearings center in their slots. Mean temperature is 16°C unless otherwise stipulated on the plans. Do not restrict full and free movement of the superstructure at the movable bearings by improperly setting or adjusting bearings or anchor bolts and nuts.

440-5 STRAIGHTENING BENT MATERIAL, HEAT CURVING AND HEAT CAMBERING

Straighten bent material, heat curve and heat camber as approved and in accordance with Article 1072-12.

440-6 FIELD ERECTION

Report immediately any error in the shop fabrication, or deformation resulting from handling and transporting, which prevents the proper assembling and fitting up of parts by more than the moderate use of drift pins or by more than a moderate amount of reaming, chipping, or cutting. Correct errors in the presence of the Engineer by approved methods.

Do not perform hammering which injures or distorts the members.

Limit the drifting during assembly to only that needed to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes require enlarging to admit the bolts, ream or correct them by approved methods. Do not enlarge the holes more than 1.6 mm over the nominal size hole called for without written approval.

Before assembling the members, clean and dry to touch all bearing surfaces and permanently contacting surfaces.

For bolted splices and field connections, fill one half of the holes with bolts and cylindrical erection pins (half bolts and half pins) before placing permanent fasteners. For continuous units, pin and bolt all beam and girder splices and bring the splices to the correct elevations before permanently fastening. For bolted connections use fit-up bolts and optional shipping bolts with the same nominal diameter as the permanent fasteners, and use cylindrical erection pins which are 1 mm larger. Use permanent bolts as fit-up bolts if desired.

Use temporary bolts, including but not limited to shipping and fit-up bolts, supplied with square or hexagon heads and square or hexagon nuts. The use of hexagon head temporary bolts and nuts is allowed, but paint both the head and nut with a durable yellow paint prior to installation.

Do not reuse permanent bolts for final installation unless the nut is easily turned onto the bolt for the full threaded length by hand and without use of tools.

The use of erection bolts for field welded joints is allowed. Use erection bolts that are galvanized when the finish paint is applied in the structural steel fabrication shop and meet the requirements of AASHTO M164M. Supplement these bolts with clamps as necessary to meet the AWS Specifications. Where unpainted AASHTO M270 Grade 50W structural steel is used, use erection bolts meeting the requirements of AASHTO M 164M for Type 3 bolts.

After field welding the connection, leave the erection bolt in place with at least the minimum bolt tension shown in Table 440-1. Use holes that are 5 mm larger than the nominal erection bolt diameter.

440-7 FIELD WELDING

Perform field welding only when called for on the plans and in accordance with Article 1072-20.

Remove paint or galvanizing at the location of field welds by blast cleaning (SSPC SP-6 finish), or hand (SSPC SP-2 finish) or power tool cleaning (SSPC SP-3 finish) just prior to welding. Clean sufficiently to prevent contamination of the weld by the paint.

440-8 CONNECTIONS USING HIGH STRENGTH BOLTS

(A) General

This article covers the assembly of structural joints using plain or galvanized high strength carbon steel bolts with suitable nuts and washers tightened to a high tension. Use bolt holes that conform to the requirements of Article 1072-18.

Protect bolts, nuts, and washers from moisture during storage and so that they show no signs of rust at the time of installation.

Make sure that plain bolts, nuts, and washers have a thin coat of lubricant at the time of installation.

Apply beeswax, stick paraffin or other approved lubricant to the threads of galvanized bolts just prior to installing the bolts.

Use bolt, nut and washer (when required) combinations from the same rotational-capacity lot.

Perform the rotational capacity test described in Section 1072-7(D)(4) on each rotational-capacity lot prior to the start of bolt installation. Use hardened steel washers as required by the test.

(B) Bolted Parts

Make sure that the slope of surfaces of bolted parts in contact with the bolt head and nut does not exceed 1:20 with respect to a plane normal to the bolt axis. Make sure bolted parts fit solidly together when assembled and are not separated by gaskets or any other interposed compressible material. Provide contact surfaces, including those adjacent to the bolt heads, nuts, or washers, that are free of scale, dirt, burrs, oil, lacquer, loose rust, rust inhibitor, other foreign material, and other defects that prevent solid seating of the parts.

(C) Installation

(1) Bolt Tensions

Tighten each fastener to provide at least the minimum bolt tension shown in Table 440-1. Tighten fasteners by the turn-of-nut tightening method, with direct tension indicators in accordance with Subarticle 440-8(C)(6), or if permitted, by the use of load indicating bolts as provided in Subarticle 440-8(C)(4).

**TABLE 440-1
REQUIRED BOLT TENSION**

Bolt Size, mm	Minimum Bolt Tension in kN
12.7 mm	53.6 kN
15.9 mm	85.4 kN
19.1 mm	126.3 kN
22.2 mm	174.6 kN
25.4 mm	229.1 kN
28.6 mm	251.1 kN
31.8 mm	318.9 kN
34.9 mm	380.1 kN
38.1 mm	462.6 kN

If necessary because of bolt entering and wrench operation clearances, tighten by turning the bolt while preventing the nut from rotating. Use impact wrenches, if necessary, with adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

(2) Washers

Make sure all fasteners have a hardened washer under the element (nut or bolt head) turned in tightening. Use galvanized washers when galvanized nuts and bolts are required. As an exception to the above, use special washers for oversize, short-slotted, and long-slotted holes in accordance with Subarticle 1072-18(H).

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

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(3) Turn-of-Nut Tightening

When using the turn-of-nut method to provide the required bolt tension, first provide enough bolts in a "snug tight" condition to bring the parts of the joint into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, place bolts in any remaining holes in the connection and bring to snug tightness. After bringing all bolts in a connection to snug tightness, match mark each nut, bolt shank, and the structural base metal with a line of white ink or paint that is not water soluble. Additionally, mark the structural base metal to indicate the applicable amount of nut rotation specified in Table 440-2. Tighten all bolts in the joint additionally by the applicable amount of nut rotation specified in Table 440-2, progressing systematically from the most rigid part of the joint to its free edges. During this operation do not allow rotation of the part not turned by the wrench. To ensure compliance with this article, keep the match mark on the bolt shank and the initial mark on the structural base metal aligned. Additionally, tighten to align the match mark on the nut and the mark representing the specified amount of nut rotation.

**TABLE 440-2
NUT ROTATION ^a FROM SNUG TIGHT CONDITION**

Bolt Length (As measured from Underside of head to extreme end of point)	Disposition of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis and Other Face Sloped Not More Than 1:20 (bevel washer not used)	Both Faces Sloped Not More Than 1:20 From Normal to Bolt Axis (bevel washers not used)
Up to and Including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 Diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 Diameters but not exceeding 12 diameters ^b	2/3 turn	5/6 turn	1 turn

^a Applicable to coarse thread heavy hex structural bolts of all sizes and lengths up to 12 diameters, and heavy hex semi-finished nuts. Nut rotation is relative to the bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance should be plus or minus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance should be plus or minus 45 degrees.

^b When bolt lengths exceed 12 diameters, the required rotation shall be determined by actual tests in a suitable tension device simulating the actual conditions.

(4) Load Indicating Bolts

Tightening by use of a load indicating bolt system is permitted provided it can be demonstrated by an accurate direct measurement procedure that the bolt is tightened in accordance with Table 440-1. Tighten by approved methods and procedures.

(5) Galvanized High Strength Bolts

Use mechanically galvanized high strength bolts in all bolted connections for painted structural steel.

Install galvanized high strength bolts carefully so that shop painted surfaces are not scarred or otherwise damaged.

Repair galvanized surfaces that are abraded or damaged by thoroughly wire brushing the damaged area and removing all loose and cracked coating, after which give the cleaned area 2 coats of organic zinc repair paint.

(6) Direct Tension Indicators

Supply direct tension indicators in accordance with the requirements of ASTM F959, Article 1072-7, and the manufacturer's recommendations.

Install the direct tension indicators in strict compliance with the manufacturer's written instructions.

Furnish to the Engineer a copy of the manufacturer's instructions for installing the direct tension indicators along with at least one metal feeler gage for each container of direct tension indicators shipped before beginning installation.

Make sure that the lot number on the containers of direct tension indicators is for the same lot number tested as indicated on the test documents.

Furnish to the Engineer three samples of load indicating washers from each lot number, each size and type for tests and two each of the metal feeler gages required for performing the tests.

Install the direct tension indicator under the bolt head. If it is necessary to install the direct tension indicator under the nut, or if the bolt head shall be turned, install additional hardened washers in accordance with the manufacturer's instructions.

Provide a tension indicating device on the project for determining the tension imposed on a fastener when the protrusions on direct tension indicator are properly compressed.

Test 3 samples from each lot of direct tension indicators in the presence of the Engineer. Achieve a minimum bolt tension of 5% greater than that required by Table 440-1 of Article 440-8.

Do not substitute direct tension indicators for hardened steel washers required with short slotted or oversized holes. If desired, use direct tension indicators in conjunction with hardened steel washers.

Install direct tension indicators initially to a snug tight condition as specified in Subarticle 440-8(C)(3). After initial tightening, fully tighten as recommended by the manufacturer, beginning at the most rigid part of the joint and continuing toward its free edges.

For tightening fasteners containing direct tension indicators, use a clean and lubricated wrench of type and capacity recommended by the manufacturer. Maintain air supply and hoses in good condition and provide air pressure of at least 690 kPa at the wrench.

When tightening the fasteners, ensure that the part of the fastener being restrained from turning does not rotate during the tightening process.

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Ensure that no portion of the direct tension indicator protrusions is accidentally partially flattened before installing in the structural steel joints.

Do not reuse direct tension indicators. If it is necessary to loosen a bolt previously tensioned, discard and replace the direct tension indicator.

(D) Inspection

Allow the Engineer the opportunity to observe installation of bolts to determine that the selected tightening procedure is properly used. The Engineer determines when bolts are properly tightened and in the case of direct tension indicator bolts that the correct indication of tension is achieved. Where the turn-of-nut method is used, each bolt is inspected visually for the correct relationship between the match marks on the nut and the bolt shank. Bolts installed by the turn-of-nut method may reach tensions above the value given in Table 440-1 but this is not a cause for rejection. After properly tightening bolts, make sure that the end of the bolt is flush with or extended beyond the outer face of the nut.

Do not begin painting in the area of tightened bolts until after bolt inspection is complete.

In addition to inspecting the match mark relationship with the turn-of-nut method, use the following inspection procedure unless the contract requires a more extensive or different inspection procedure.

As directed, furnish and use, in the presence of the Engineer, or allow the Engineer to use an inspection torque wrench, calibrated as follows:

At least once each working day, place 3 calibration sample bolts of the same grade, size, representative length, and conditions as those under inspection in a tension indicating calibration device. Furnish a tension indicating calibration device certified by an approved independent testing lab within 6 calendar months prior to testing the bolts under inspection, to be in good working order and to provide accuracy within plus or minus 10 percent for the range of loads between 110 kN and 180 kN. Place a washer under the part turned in tightening for each bolt if washers are so used in the structure. If no washer is used make sure that the material abutting the part turned is the same as that used in the structure.

Tighten each calibration sample bolt in the calibration device by any convenient means to an initial condition equal to 15 percent of the required tension and then to the minimum tension specified in Table 440-1. Then apply the inspecting wrench to the tightened bolt and determine the torque necessary to turn the nut or head 5 degrees (approximately 25 mm at 300 mm radius) in the tightening direction. Use the average torque measured in the tests of 3 bolts as the job inspecting torque.

Use the inspection wrench to inspect bolts, represented by the calibration sample bolts, which are tightened in the structure by applying in the tightening direction the job inspecting torque to 10 percent of the bolts, but not less than 2 bolts, selected at random in each connection. If no nut or bolt head turns by this application of the job inspecting torque, the connection is acceptable as properly tightened. If any nut or bolt head turns by the application of the job inspecting torque, apply this torque to all bolts in the connection. Tighten and reinspect all bolts whose nut or head turns by the job inspecting torque. Alternatively, retighten all the bolts in the connection and resubmit the connection for the specified inspection.

When using direct tension indicators, proper tension of bolts is inspected by the Engineer by inserting a .125 mm thickness feeler gage into the openings between adjacent flattened protrusions of the direct tension indicator. Proper tension is obtained when the number of spaces for which the gage is refused is equal to or greater than the value shown in Table 440-3.

**TABLE 440-3
Direct Tension Indicator Gap Refusal**

Number of Spaces in Washer	Number of Spaces Gage is Refused*
4	2
5	3
6	3
7	4
* The gage shall be refused in all spaces when the direct tension indicator is used under the turned element.	

When using direct tension indicators, do not tighten bolts to a no visible gap condition.

Inspections of direct tension indicator installations are made by the Engineer by the use of the metal feeler gauges provided by the Contractor. At least 10%, but no less than two of the bolts in each connection are inspected with feeler gauges. Additionally, all remaining bolts in each connection are visually inspected for proper tightening.

440-9 SURFACE PREPARATION AND PROTECTION OF WEATHERING STEEL

After fabrication, shop clean all weathering steel remaining in the unpainted condition in the completed structure to a SSPC SP-6 finish. Provide a contact surface condition in accordance with Subarticle 442-8(B) at the time of bolt installation.

Protect the structural steel during concreting and any other operations that are particularly hazardous with respect to soiling the steel. Remove any foreign matter which gets on the steel as soon as possible by either solvent cleaning, hand tool cleaning, power tool cleaning, blast cleaning, or a combination thereof, as necessary to restore the surfaces to the specified condition.

440-10 MEASUREMENT AND PAYMENT

Approximately _____ Kilograms Structural Steel will be measured and paid for at the contract lump sum price. The approximate quantity shown in the contract pay item is an estimate based on the computed weight of the structural steel necessary to complete the work. No measurement for payment will be made for this pay item, and no adjustment in the contract lump sum price will be made for any variation from the approximate quantity shown except for revisions in the plans which affect the quantity of structural steel necessary to complete the work.

When revisions in the plans have been made which affect the quantities of structural steel, adjustments in compensation will be made by supplemental agreement.

When the contract includes the item of Painting of Structural Steel, all work of painting except for shop painting will be paid for as provided in Article 442-14 and payment for shop painting will be included in the contract lump sum price for *Approximately _____ Kilograms Structural Steel*. When the contract does not include the item of Painting of Structural Steel, payment at the contract lump sum price for *Approximately _____ Kilograms Structural Steel* will be full compensation for both shop and field painting.

Elastomeric Bearings will be paid for as provided in Article 430-8.

The price and payment will be full compensation for all items required to construct steel structures including but not limited to those items contained in Article 440-1.

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Payment will be made under:

Pay Item	Pay Unit
Approximately _____ Kilograms Structural Steel	Lump Sum

**SECTION 442
PAINTING STEEL STRUCTURES**

442-1 DESCRIPTION

Paint steel structures and properly prepare metal surfaces; apply, protect, and dry paint coatings; protect pedestrian, vehicular, water, or other traffic upon or underneath the structure; protect all portions of the structure and adjacent work against disfigurement by splatters, splashes, overspray, and smirches of paint or of paint materials; apply paint in the shop and field; and furnish blast cleaning equipment, paint spraying equipment, brushes, rollers, paint cleaning abrasives, cleaning solvents, tools, tackle, scaffolding, labor, and any other materials, hand or power tools, inspection equipment, and personal protective and safety equipment necessary for the entire work.

442-2 MATERIALS

Refer to Division 10.

Item	Section
Paint and Paint Materials	1080

442-3 PROTECTION OF WORK

Protect all parts of the structure against disfigurement by splatters, splashes, overspray, and smirches of paint or of paint materials. Assume responsibility for any damage or disfigurement caused by operations to vehicles, persons, or property, including plants and animals; and provide protective measures to prevent such damage.

Thoroughly clean and restore any surface or surfaces disfigured by splatter, overspray, splashes, smirches, etc., to its original condition.

Restore any damaged structure or surface to its original condition.

If traffic causes dust considered by the Engineer to be detrimental to the work, sprinkle dust producing areas with water or dust palliative and take any other necessary precautions to prevent the accumulation of dust and dirt on freshly painted surfaces.

442-4 ACCESS TO THE WORK

Provide safe and convenient access to all parts of the work in accordance with Section 105-11.

442-5 APPLICATION CONDITIONS

Unless the paint manufacturer's application instructions are more restrictive, obtain written permission to apply paint when the temperature of the air or metal is below 10°C, when freezing weather is forecast during the drying period, or when the metal is hot enough to cause the paint to blister or produce a porous paint film. Also, do not apply paint or perform any surface preparation when the air is misty; in the rain, snow, or fog, or when the steel surface temperature is less than 3°C above the dew point, or as directed.

Provide adequate and safe storage for all paint and equipment. Do not expose paint materials to rain, excessive condensation, long periods of direct sunlight, or temperatures above 43°C or below 4°C. Follow the manufacturer's storage requirements if more restrictive than the above requirements.

Replace paint damaged by any cause at no cost to the Department.

442-6 MIXING PAINT

Mix paint in accordance with the manufacturer's instructions and Article 1080-1.

442-7 PAINT SYSTEMS

Include in the system surface preparation, shop painting, and/or field painting. Use all paints and solvents for shop and field applications that are produced by the same manufacturer.

Use approved/qualified paint products found in Section 1080. Apply the paint system required by the plans and at the film thickness indicated below. Coating thickness in excess of the maximum dry film thickness is acceptable as long as the coating is free of visible defects (runs, sags, cracking, lifting).

SYSTEM 1 INORGANIC ZINC (IOZ) PRIMER AND ACRYLIC TOP COATS

Coat	Material	mm Dry/Wet Film Thickness	
		Min	Max
Primer	1080-7 IOZ	.075 DFT	.125 DFT
Intermediate	1080-12 Brown	.050 DFT	.100 DFT
Stripe	1080-12 White	.100 WFT	.175 WFT
Topcoat	1080-12 Gray	.075 DFT	.125 DFT
Total		.200 DFT	.350 DFT

Apply System 1 to non-weathering steel surfaces cleaned to an SSPC SP-10 finish. Shop apply the IOZ primer, two coats of acrylic paint, and one strip coat of acrylic paint over all structural steel surfaces except as otherwise specified. As an option, acrylic paint may be applied in the field. Apply the primer to the shear connectors and all surfaces of the top flange. Completely cure the inorganic zinc primer to meet the requirements of ASTM D4752 before top coating. Ensure that the Elcometer Adhesion of the zinc primer is no less than 2.75 MPa when tested in accordance with ASTM D4541. If bubbling occurs during the application of the first field coat, apply a mist coat of brown paint to prevent further bubbling. Ensure that the Tape Adhesion of the cured system is no less than 3A when tested in accordance with ASTM D3359.

SYSTEM 2 INORGANIC ZINC (IOZ) PRIMER AND COAL TAR EPOXY TOP COATS

Coat	Material	mm Dry/Wet Film Thickness	
		Min	Max
Primer	1080-7 IOZ	.075 DFT	.125 DFT
Intermediate	1080-8 Red	.200 DFT	.300 DFT
Topcoat	1080-8 Black	.200 DFT	.300 DFT
Total		.475 DFT	NA

Apply System 2 on non-weathering steel surfaces cleaned to an SSPC SP-10 finish. Shop painting consists of painting with a primer, and two coats of coal tar epoxy paint over all structural steel surfaces except as otherwise specified. Completely cure the inorganic zinc primer to meet the requirements of the ASTM D4752 solvent rub test before top coating. Ensure that the Elcometer Adhesion of the zinc primer is no less than 2.75 MPa before top coating when tested in accordance with ASTM D4541. Apply the finish coat when the first coat of coal tar epoxy is still tacky. Ensure that the Elcometer Adhesion of the cured system is no less than 2.75 MPa when tested in accordance with ASTM D4541.

SYSTEM 3 ACRYLIC PRIMER AND TOP COATS

Coat	Material	mm Dry/Wet Film Thickness	
		Min	Max
Primer	1080-12 Brown	.050DFT	.100 DFT
Intermediate	1080-12 White	.050 DFT	.100 DFT
Stripe	1080-12 Brown	.100 WFT	.175 WFT
Topcoat	1080-12 Green	.050 DFT	.100 DFT
Topcoat	1080-12 Gray	.050 DFT	.100 DFT
Total		.200 DFT	.400 DFT

Apply System 3 in the field or shop to non-weathering steel surfaces cleaned to an SSPC SP-6 finish. Painting consists of painting with two primer coats, a stripe coat and two finish coats over all structural steel surfaces except as otherwise specified. Provide a curing period for the first primer coat of paint of at least 24 hours. Ensure that the Tape Adhesion of the cured system is no less than 3A when tested in accordance with ASTM D3359.

SYSTEM 4 ACRYLIC PRIMER AND TOP COATS FOR WEATHERING STEEL

Coat	Material	mm Dry/Wet Film Thickness	
		Min	Max
Primer	1080-12 Brown	.050 DFT	.100 DFT
Intermediate	1080-12 White	.075DFT	.125 DFT
Stripe	1080-12 Brown	.100 WFT	.175 WFT
Topcoat	1080-12 Brown	.050 DFT	.100 DFT
Total		.175 DFT	.325 DFT

Apply System 4 to weathering steel surfaces cleaned to an SSPC SP-6 finish. Shop painting consists of applying all primer and finish paints at the ends of beams or girders within a distance of 1 1/2 times the depth of the beam or girder at the bearing except as otherwise specified. Provide a curing period for the first primer coat of paint of at least 24 hours. Ensure that the Tape Adhesion of the cured system is no less than 3A when tested in accordance with ASTM D3359.

SYSTEM 5 OIL/ALKYD PRIMER AND ALKYD TOP COATS

Coat	Material	mm Dry/Wet Film Thickness	
		Min	Max
Spot Primer	1080-5 Red +	.038 DFT	.075 DFT
Primer	1080-5 Red	.038DFT	.075 DFT
Stripe	1080-5 Red +	.075 WFT	.125 WFT
Topcoat	1080-6 Gray +	.050 DFT	.100 DFT
Topcoat	1080-6 Gray	.050 DFT	.100 DFT
Total		.175 DFT	.350 DFT

Apply System 5 in the field overcoating old oil/alkyd paint systems. Painting consists of two primer coats (one on spots which have been cleaned to an SSPC SP-3 finish) and the other over the repairs and the old paint. If applying System 5 to new structural steel, apply the first prime coat in the shop and apply the remaining coats after erecting the steel and placing all concrete. Apply a stripe coat of primer and two finish coats over all structural steel surfaces except as otherwise specified. Provide a curing period for the

first primer coat of at least 24 hours. The “+” indicates the addition of an approved tinting pigment to achieve a color difference. Ensure that the Tape Adhesion of the cured system in the areas of spot repairs, is no less than 3A when tested in accordance with ASTM D3359.

442-8 SURFACE PREPARATION

(A) Blast Cleaning

Use a blast profile which is .025 to .075 mm and angular. The degree of cleaning required is indicated under the specified paint system. Unless otherwise specified, clean all other steel surfaces to be coated or metallized to meet SSPC SP-10. Clean weathering steel surfaces to be painted to achieve a SSPC SP-6 finish.

Blast clean by centrifugal or forced air blasters. When using forced air blasters, use blast nozzles with a minimum 8 mm orifice and operate at no less than 690 kPa when measured with a needle gage at the nozzle. Use dry blasting for all blast cleaning. Select a size or grade of abrasive that provides the specified finish and profile meeting the requirements of Article 1080-15.

Perform blast cleaning operations in such a manner that no damage is done to partially or entirely completed portions of the work

After blasting, brush the surface with clean brushes made of hair, bristle, or fiber; blow off with compressed air, or clean by vacuum so that any traces of blast products from the surface and any abrasive from pockets and corners are removed.

Use compressed air for nozzle blasting that is free of detrimental amounts of water or oil. Provide adequate separators and traps.

Examine the blast cleaned surface for any traces of oil, grease, or smudges deposited in the cleaning operations. If present, remove them by an approved method. Have the degree of cleanliness and profile approved prior to painting.

When blast cleaning structures open to traffic, provide suitable protective enclosures to prevent damage to public and private property. Do not blast directly over traffic without prior approval of the Engineer.

When blast cleaning near bridge machinery, seal all journals, bearings, motors, and moving parts against entry of abrasive dust before blast cleaning.

Unless otherwise authorized, prime or treat blast cleaned surfaces to be painted no later than 8 hours after blast cleaning is complete. Reclean the cleaned surfaces that contain rust or are contaminated with foreign material before painting or bolting.

(B) Hand or Power Tool Cleaning

Thoroughly remove loose paint, rust, scale, dirt, oil, grease, and other detrimental substances by hand cleaning (SSPC-SP2), power tool cleaning (SSPC-SP3), or any combination of these methods. Hand cleaning includes the use of metal brushes, grinders, sanders, or any approved combination of these tools. Use bristle or wood fiber brushes to remove loose dust.

442-9 APPLICATION OF PAINT

(A) General

Unless otherwise permitted, apply all paint by spraying, except apply the stripe coat by brush or roller. The use of a brush or roller is permitted to make minor repairs to the primer.

Make sure that the applicator has a current copy of the paint manufacturer's application instructions, along with Material Safety Data Sheets for each paint; and furnish 2 copies to the Engineer. Unless otherwise required herein, apply in accordance with the manufacturer's instructions.

Do not start applying paint until the paint materials are approved.

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Both Shop and Field applicators are required to conduct and document quality control inspection of the painting, including measurements of temperature, dew point, surface profile, and paint thickness. Make sure that the paint applicator has the Engineer's pre-approved procedure for repair of all damage and defects.

The Engineer approves all paint thinning activities. The paint products specified in Section 1080 do not require thinning when applied under normal conditions. Obtain written approval for any thinning necessitated by weather conditions or other causes. Only those thinners approved by the paint manufacturer as described in the application instructions are permitted.

Paint in a neat and workmanlike manner. Apply the paint so as to provide a tight film of the specified thickness, well bonded to the metal or previously applied paint, and free of laps, streaks, sags, or other defects.

Make sure each coat of paint is in a proper state of cure or dryness before applying the succeeding coat. Where necessary, clean each coat of paint in accordance with Subarticle 442-8(B).

When a stripe coat is required, apply a 50 mm stripe by brush or roller to all exposed edges of steel before applying the finish coat. Locate the edge or corner in the approximate center of the paint stripe.

(B) Spray Application

Use equipment for spray application of paint that is suitable for the intended purpose, capable of properly atomizing the paint, and equipped with suitable pressure regulators and gages. Use air caps, nozzles, and needles recommended by the manufacturer of the equipment for the material being sprayed. Keep the equipment in satisfactory condition to permit proper paint application. In closed or recirculating paint spray systems where gas under pressure is used over the liquid, use an inert gas, such as nitrogen.

Provide and drain periodically during operations, adequately sized traps or separators to remove oil and water from the compressed air. Make sure that the air from the spray gun impinging against the surface shows no water or oil.

Use an agitated spray pot. Adjust the agitator or stirring rod to reach within 50 mm of the bottom of the spray pot and be in motion at all times during paint application. Provide sufficient motion to keep the paint well mixed.

Apply paint in a uniform layer, with overlapping at the edge of the spray pattern. Adjust the spray pattern so that the paint is deposited uniformly.

442-10 SHOP PAINTING

(A) General

Shop painting is the painting of structural steel in an enclosed shop or plant before shipment to the site of erection. The work in this section applies to previously uncoated steel and includes the proper preparation of the metal surfaces and the application, protection, and cure/drying of coatings. Complete all shop fabrication, including welding and attachment of shear connectors, before painting is started.

(B) Painted Areas

(1) Do not paint the following surfaces:

Bearing assemblies, plates, etc. called for as galvanized or metallized.

Areas where field welding is to be performed.

Outside surfaces of splice plates (Systems 3 and 5 only).

Plate surfaces contacting elastomeric bearing pads

Contact surfaces with blockouts for bolted connections on curved girder bridges and beam and girder splices (Systems 3 and 5 only). In the areas of

these blockouts, extend the finish paint no closer than 50 mm nor more than 75 mm from the edges of contact surfaces in bolted connections. Ensure that the primer paint is clearly visible around these areas when the structural steel is assembled. The same offset dimensions are required for finish paint at field welds, measured from the proposed location of the field weld.

- (2) Areas where paint is not required and overspray is permitted include:
 - Bolt holes.
 - Shear connectors and top surface of top flange.
- (3) Clean and paint stiffener clips and other inaccessible areas on a best effort basis. Such areas are those that contain enclosed surfaces, the majority of which are not visible.
- (4) Apply a stripe coat on all corners and raised welds.
- (5) Provide a shop certification by American Institute Steel Construction (AISC) Sophisticated Paint Endorsement (SPE) or Society of Protective Coatings (SSPC) Qualification Procedure Three (QP3) when the quantity is greater than 140 m² of painted steel.
- (6) Provide a repair procedure for all damage and defects for approval before painting.
- (7) Paint erection marks for the field identification of members and weight marks upon surface areas previously painted with a shop coat. Do not load material for shipment until the paint is thoroughly dry, and in any case not less than 24 hours after applying the paint.

(C) Definitions

A **Corner** is defined as the intersection of two surfaces that are not in the same plane.

Inaccessible areas are partially or completely enclosed surfaces, the majority of which are not visible without the use of special devices such as mirrors.

A **Sharp Edge** is a corner on a steel section that terminates in a point or edge and appears able to cut human flesh.

A **Stripe Coat** is an additional coat of paint applied to the edges, outside corners, and areas difficult to coat by spray before or after a full coat is applied to the surface. The stripe coat is intended to give those areas sufficient film build and coverage to resist corrosion.

(D) Surface Preparation

The requirements of Article 442-8 apply to surface preparation of steel surfaces in the shop. Abrasive Cleanliness: Check abrasives daily for contaminants or as otherwise directed by the Engineer. Verify that abrasive material meets the cleanliness requirements of SSPC AB1 or SSPC AB2 depending on the abrasive material used.

The following items are required as a part of preparation and cleaning:

- (1) Corner Condition: Bevel corners to an approximate 2 mm chamfer if the included angle is less than 90 degrees.
- (2) Surface Irregularities: Remove slivers, hackles, tears and projection of blast cleaned steel. Restore the profile in areas larger than one square meter.
- (3) Weld Spatter: Remove excessive weld spatter and all loose weld spatter. Tightly adherent weld spatter is allowed unless it is sharp. Flatten sharp weld spatter.

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- (4) Bolts: Shop installed galvanized bolts on which the coating is disturbed or distressed during shop cleaning is of no concern as long as the coating system is applied over them. If necessary, after installation, clean shop installed black bolts in accordance with SSPC Surface Preparation 1 Solvent Cleaning. Blast clean or otherwise clean by an approved alternative method the bolts before shop priming.

442-11 FIELD PAINTING

Field painting is conducted after erection, or when damage to a shop applied coating system is repaired, or when steel is otherwise painted outside an enclosed shop environment. A SSPC QP1 certified contractor shall perform work.

Obtain written permission from the Engineer to apply field coats of paint between December 1 of one year and May 1 of the following year inclusive. Do not apply any coating below 0°C or when a temperature of 0°C or below is predicted during the drying and curing period of the paint. Do not apply any coating above or below the manufacturers recommended application temperatures or during a period when an ambient temperature outside the recommended range is predicted during the drying and curing period of the paint. Obtain written approval for suitable enclosures if wishing to use such enclosures during adverse weather conditions. Use enclosures that control atmospheric conditions artificially inside within limits suitable for painting during the painting operation and until the paint is dry/cured or until weather conditions permit its exposure in the open.

Do not apply paint in rain, fog or when wind velocity is continuously greater than 16 km per hour. Harsh environments may necessitate re-cleaning during or between paint applications.

Do not apply paint over traffic without prior written approval from the Engineer.

Touch-up of shop painted non-weathering steel consists of painting with primer and finish paint over all the previously uncoated exposed metal surfaces. When the repair area exceeds 93,000 mm², clean, prime, and topcoat damaged areas in accordance with Subarticle 442-8(A). Otherwise clean, prime, and topcoat damaged areas in accordance with Subarticle 442-8(B). For systems with shop applied topcoats, apply an additional field appearance coat of finish paint to the outside surface of all exterior beams on non-weathering steel bridges over highways and navigable waterways.

When an appearance coat of finish paint is required, paint the portion of galvanized high strength bolts on the outside face of exterior beams or girders with primer and appearance coat of the finish paint. Apply the primer to the galvanized high strength bolts by brush so that the primer is not applied to the adjacent finish paint.

At the location of field welds, satisfactorily remove all paint or galvanizing by blast cleaning, or hand or power tool cleaning just prior to welding. Clean sufficiently to prevent contamination of the weld by the paint.

Final acceptance by the Engineer will be after erection of the structure, when the final coat has been applied, and all repairs effected.

Clean all contaminants such as soil, concrete, weld splatter, grease, or any other deleterious material from the steel or shop coated surfaces before any painting operations begin. Harsh environments may necessitate re-cleaning during or between paint applications.

442-12 INSPECTION

Only NCDOT Certified Coating Level 1 inspectors shall inspect the field-coating application.

Ensure that the coating applicator maintains a daily quality control record. The information required in the record is listed on Materials and Tests Form M&T-610. Maintain quality control data in a log and format approved by the Engineer. Enter data

on a daily or immediate basis as coating activities are conducted. Ensure that the applicator's quality control representative signs and dates each entry.

Apply all coatings in accordance with SSPC PA1. Repair all coating defects or nonconformities in accordance with SSPC PA1. Make repairs to the topcoat with a uniform gloss and color on visible surfaces. The Engineer makes the final decision concerning uniformity and appearance.

442-13 REPAINTING OF EXISTING STEEL STRUCTURES

Repaint existing steel structures in accordance with Article 442-1 through 442-12 and the requirements of this section.

(A) Pollution Control

During field painting operations, utilize all necessary precautions to prevent dispersion of surface preparation debris, paint, or any other material outside the work area due to wind or any other reason.

(B) Hazardous Paint Removal

Should the existing paint system include toxic substances such as red lead oxide which is considered hazardous if improperly removed, furnish a containment and spill control plan for surface preparation and painting operations and await review and approval of said plan before beginning work. This plan shall meet or exceed the requirements of Class 2A in accordance with SSPC Guide 6. This work shall be performed by a SSPC QP2 certified contractor.

Monitor air quality. Any visible emissions outside the containment structure or air quality monitoring results exceeding the permissible OSHA action level is justification for suspension of the work. Monitor air quality at random locations within 0.3 to 1.5 meters from the enclosure in accordance with NIOSH Method 7082.

Immediately collect and retain any spilled dust or paint debris in approved containers. Should a spill result in soil or water contamination, take all necessary actions to remediate the site to its original state.

Waste Handling

Treat and consider all paint debris generated during the work as hazardous waste.

Collect debris from surface preparation operations in bulk dumpsters or other suitable metal containers approved by the Waste Disposer and Engineer.

Permanently identify each container with a date and identification number. At the end of the work shift, collect all debris generated for that day in the container. No subsequent work is permitted until all debris is properly collected and stored. Store the containers in a fenced or otherwise secured area in an approved location to prevent damage or vandalism.

Clean and dispose of any incidental materials or equipment that are contaminated as the result of work activities on the project.

Waste Disposal: Dispose of waste in accordance with North Carolina's Hazardous Waste Rules 15A NCAC 13A.

(C) Health and Safety Responsibility

In addition to the requirements of Article 105-11 Inspection of Work, Section 106 Control of Material, and Section 107 Legal Relations and Responsibility to Public, provide effective engineering and work practice controls to insure adequate protection.

Prior to beginning work, certify to the Engineer that all personnel involved with lead paint removal operations (including rigging and material handling personnel) are properly trained and understand the applicable parts of EPA 40 CFR Part 745

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and OSHA Standards 29 CFR 1910 and 29 CFR 1926 including any amendments in force at the time of this contract.

442-14 MEASUREMENT AND PAYMENT

When the contract does not include the item of Painting of Structural Steel, there will be no direct payment for the work covered by this section.

When the contract includes the item of *Painting of Structural Steel*, all work covered by this section except for shop painting will be paid for at the contract lump sum price for this item. Payment at the contract lump sum price for approximately _____ kilograms Structural Steel will be full compensation for the work of shop painting.

These prices and payments will be full compensation for all items required to paint steel structures including but not limited to those items contained in Article 442-1.

Pollution Control will be paid for as the contract lump sum price.

When provided for in the contract, payment will be made under:

Pay Item	Pay Unit
Painting of Structural Steel	Lump Sum
Pollution Control	Lump Sum

SECTION 450 BEARING PILES

450-1 DESCRIPTION

Furnish and drive bearing piles as shown on the plans and as directed by the Engineer to the required bearing and penetration. Furnish, weld, and attach steel pile points, pipe pile plates, pile tips and splicers; provide collars, hardware, concrete, reinforcing steel, and all other materials; furnish all equipment, preauger through embankments, install piles vertically or on a batter; galvanize, cut off, splice, and build up piles; place concrete and reinforcing steel; construct pile trestles; furnish and place temporary bracing; remove any obstructions; wrap, bolt, or fasten timber fender piles; and abandon, remove, replace, and restrike or redrive piles as necessary.

450-2 MATERIALS

Refer to Division 10.

Item	Section
Timber Piles, Prestressed Concrete Piles, Steel Pipe and H Piles	1084
Portland Cement Concrete	1000

450-3 PREPARATION FOR DRIVING

If applicable, completely excavate for the cap and/or footing before installing piles. If applicable and unless noted otherwise on the plans, construct the embankment to the bottom of cap or footing elevation for a horizontal distance of 15 m from any pile except where fill slopes are within 15 m of a pile. If preaugering through an embankment is necessary before driving prestressed concrete piles, submit the preaugering and pile installation methods with the proposed pile driving methods and equipment for approval.

450-4 DETERMINATION OF PILE LENGTH

The estimated total pile lengths per structure shown on the plans are for bid purposes only. Determine pile lengths and furnish piling of sufficient length to obtain the required bearing and penetration and the required embedment into the cap or footing as shown on the plans. As an option and at no cost to the Department, make investigations as necessary to determine the required pile lengths.

450-5 DRIVING EQUIPMENT

Submit the proposed pile driving methods and equipment including the pile driving hammer, hammer cushion, pile helmet and cushion, if any. Do not submit more than two

pile driving hammers per pile type per submittal. Submit this information for approval at least 20 working days before driving piles. All equipment is subject to satisfactory field performance.

Drive bearing piles with approved driving equipment using steam, air, or diesel hammers. Use pile driving hammers with an energy that will not overstress the piles during driving and provide the required driving resistance at blows per 0.3 m ranging from 36 to 96, unless approved otherwise by the Engineer. Use a variable energy hammer to drive prestressed concrete piles.

Operate steam, air, or diesel hammers at the length of stroke and number of blows per minute required by the Engineer. Operate air and steam hammers within 10% of the manufacturer's rated speed in blows per minute or the rate approved by the Engineer.

Provide plant and equipment for air or steam hammers with sufficient capacity to maintain, under working conditions, the volume and pressure specified by the manufacturer. Equip the plant and equipment with accurate pressure gauges that are easily accessible. Use striking parts of air and steam hammers that weigh at least 1/3 the weight of the pile helmet and pile, with a minimum weight of 1250 kg.

Equip open-end (single acting) diesel hammers with a graduated scale (jump stick) extending above the ram cylinder, graduated rings or grooves on the ram, or an electric sound activated remote measuring instrument to allow the Engineer to visually determine hammer stroke at all times during pile driving operations.

Equip closed-end (double acting) diesel hammers with a calibrated bounce chamber pressure gauge, in good working order, mounted near ground level and easily read by the Engineer. Also, provide a current calibrated chart or graph equating bounce chamber pressure and gauge hose length to equivalent energy for the closed-end diesel hammer used. Submit this chart or graph with the proposed pile driving methods and equipment required above.

Protect and hold pile heads in position with an approved pile helmet. Make sure that the pile helmet closely fits the top of the pile and extends down the sides of the pile a sufficient distance to hold the pile in position. Protect the heads of concrete and timber piles from direct impact with an approved pile cushion. Provide collars or bands to protect timber piles against splitting or brooming where required.

450-6 ACCURACY OF DRIVING

Drive piles so that the axial alignment is within 20 mm per meter from the vertical or batter shown on the plans. Horizontally, keep the pile within 75 mm of the plan location longitudinally and transversely. Maintain pile embedment in the cap or footing to within 75 mm more or 50 mm less than that shown on the plans. No additional payment is made for increased cap or footing dimensions necessary due to piles driven out of position.

450-7 CONSTRUCTION REQUIREMENTS

(A) General

Unless otherwise approved or directed by the Engineer, do not drive piles within 15 m of cast-in-place concrete until the concrete attains an age of at least 3 curing days. When approved by the Engineer, the Contractor may use vibratory hammers to install the initial portions of steel piles. The Engineer will approve the depth of pile installation with the vibratory hammer. Do not use vibratory hammers to install prestressed concrete piles.

The Engineer will inspect the capblock before beginning each pile driving project and periodically throughout the duration of the project, depending on driving conditions as determined by the Engineer. Expose the hammer cushion for inspection as directed by the Engineer. Replace or repair any hammer cushion that is less than 25% of the original thickness.

Do not exceed the allowable pile driving stresses during the entire driving time. Allowable pile driving stresses are defined in the *AASHTO Standard*

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Specifications for Highway Bridges. Drive piles to the required tip elevation or penetration into natural ground, whichever is lower, in a continuous operation unless stopped due to exceeding the maximum blow count or the allowable pile driving stresses, insufficient pile length, or other reasons approved by the Engineer. Once the required embedment is achieved, the Engineer may require the Contractor to stop driving and wait before restriking to allow for soil setup.

Use a pile cushion made of pine plywood with a 100 mm minimum thickness for driving prestressed concrete piles. When using a pile cushion, provide a new cushion for each pile unless approved otherwise by the Engineer. Replace the pile cushion if, during the driving of any pile, the cushion is either compressed more than one-half the original thickness or begins to burn.

Redrive any pile raised or moved laterally by the driving of adjacent piles.

(B) Timber Piles

Store and handle timber piles by methods that do not damage the pile. Take care to avoid breaking the surface of treated piles. Do not use cant-hooks, dogs, or pike-poles. Treat cuts or breaks in the surface of treated piles in an approved manner.

Cut off the tops of all piles at the elevation shown on the plans. Except where a cast-in-place concrete cap or footing is constructed, cut off piles to a plane that provides true bearing on every pile without the use of shims. Withdraw any pile damaged during driving operations, driven out of its proper location or below the cut-off grade and replace with a new pile, or otherwise correct as directed by the Engineer.

Thoroughly brush-coat the sawn surface of all timber piles not encased in concrete with 3 applications of approved preservative treatment and then cover with a coat of hot roofing pitch or other approved hot bituminous material. Place a sheet of galvanized iron or aluminum upon each pile head, bend it down over the sides of the pile, neatly trim and firmly secure to the pile with large headed galvanized roofing nails. Use sheets of iron that are 0.635 mm and 600 mm x 600 mm in size. If using aluminum, use the same size as specified for galvanized iron sheets with a minimum thickness of 0.81 mm.

(C) Prestressed Concrete Piles

Handle, transport, and store prestressed concrete piles by methods that do not damage the pile and support the piles at the pick-up points shown on the plans or along their full length. Replace piles damaged in handling or driving unless they are repaired to an acceptable condition.

When driving or cutting off piles below the elevation shown on the plans, build up the pile section to the plan elevation as shown on the plans unless otherwise directed by the Engineer.

Cut off piles not driven to grade perpendicular to the axis of the pile by means that do not result in spalling or other damage to the pile. Use steel pile tips with prestressed concrete piles when shown on the plans. Use pile splicers for splicing steel pile tips. Contact the Materials and Tests Unit for a list of approved pile splicers. Submit pile splicer specifications with the manufacturer's attachment detail to the Engineer for approval before installation.

(D) Steel Piles

Handle and store steel piles by methods that do not damage the pile. Store the piles above ground upon platforms, blocks, or other supports and keep the piles free from dirt, grease, and other foreign matter, and protect insofar as is practicable from corrosion. Do not damage coatings on steel piles. Protect coatings when driving piles through templates in an approved manner.

When shown on the plans, galvanize steel piles in accordance with Section 1076. Prepare the pile surface and provide materials in accordance with the applicable portions of this section.

Use pile points for steel piles when shown on the plans or as directed by the Engineer. Contact the Materials and Tests Unit for a list of approved pile points. Weld pile points to piles in accordance with the manufacturers' details as approved by the Engineer. The minimum weld length is twice the width of the flange.

Furnish plates for pipe piles when shown on the plans or as directed by the Engineer. Weld plates to the bottom of pipe piles as shown on the plans. Use pipe pile plates with a thickness as shown on the plans and that meets the requirements of ASTM A709, Grade 50.

Cut off piles at the required elevations along a plane normal to the axis of the pile. Use approved methods for cutting off piles.

Use welded butt splices for steel piles as shown on the plans. Weld in accordance with the requirements of Article 1072-20. Do not use more than 3 pieces (2 splices) of steel pile in making up one full-length pile.

(E) Redriving Piles

Once the required pile embedment has been achieved, the Contractor may choose to or the Engineer may require restriking or redriving piles. If the Contractor chooses to stop driving and then restrike or redrive piles, no payment will be made for restrikes or redrives. If the Engineer requires the Contractor to stop driving and then restrike or redrive piles, the payment will be made in accordance with Article 450-9. When the Engineer requires restrikes or redrives, the Engineer will determine the time to wait after stopping driving and the number of restrikes or redrives. However, the maximum number of restrikes or redrives per pile during any 48 hour period will not exceed three. The minimum time separation between redrives required by the Engineer is 4 hours.

Use the same approved pile driving methods, equipment and compressed pile cushion from the previous drive to restrike or redrive the pile unless the cushion is unacceptable due to deterioration, in which case use another acceptable cushion. Do not use a cold diesel hammer for a restrike or redrive, unless in the opinion of the Engineer, it is impractical to do otherwise. In general, warm up the hammer by applying at least 20 blows to a previously driven pile or timber mats on the ground.

450-8 PENETRATION AND WAVE EQUATION

When no tip elevation is shown on the plans, drive piles to the required bearing capacity and a penetration of at least 3 m into natural ground unless otherwise directed by the Engineer. When a tip elevation is shown on the plans, drive piles to the required bearing capacity and the specified tip elevation. When noted on the plans, drive piles to additional capacity to account for downdrag or negative skin friction and scour.

Natural ground within an area of new embankment is defined as the bottom of the embankment or bottom of footing on piles, whichever is lower.

The Engineer will use the wave equation analysis to evaluate the suitability of the proposed pile driving methods and equipment to evaluate pile driving stresses and estimate the driving resistance in order to achieve the required bearing capacity. The required driving resistance in blows per meter or any equivalent set, is based upon the bearing capacity shown on the plans with a minimum safety factor of 2 plus any additional capacity to account for downdrag or negative skin friction and scour, when applicable. The Engineer will provide the required driving resistance based upon the wave equation analysis and pile driving analyzer results, if applicable, using the approved pile driving methods and equipment.

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Stop driving piles when practical refusal is reached, unless otherwise directed by the Engineer. Practical refusal is defined as 180 blows per 0.3 m or any equivalent set.

450-9 MEASUREMENT AND PAYMENT

Piles (Treated Timber Piles, _____ mm Prestressed Concrete Piles, _____ Steel Piles or _____ Galvanized Steel Piles) will be measured and paid as the actual number of linear meters of piles incorporated into the completed and accepted structure. This quantity is measured as the length of pile before driving minus any pile cut-offs. No payment will be made for pile cut-offs or cutting off piles. However, once the required bearing and penetration has been achieved, the Contractor may drive the remaining portion of a pile to grade in lieu of cutting off the pile provided the remaining portion does not exceed 1.5 m and the pile can be driven without damaging the pile or reaching the maximum blow count or practical refusal. When this occurs, the additional length of pile driven will be measured as described above.

For prestressed concrete piles that are built up, the quantity of piles to be paid for will also include the actual number of linear meters added to the original pile length by the build-up. Steel pile tips are not included in the quantity of prestressed concrete piles. No payment will be made for steel pile tips or pile splicers and any associated hardware or welding. The cost for these items will be considered incidental to the cost of the prestressed concrete pile.

Pile Points will be measured and paid for per each for the actual number of pile points incorporated into the completed and accepted structure.

Pipe Pile Plates will be measured and paid for per each for the actual number of plates incorporated into the completed and accepted structure.

Pile Redrives will be measured and paid for per each as the actual number of restrikes or redrives required by the Engineer. No payment will be made for restrikes or redrives when the Contractor chooses to restrike or redrive piles.

No payment will be made for any defective or rejected piles or any piles driven for falsework, bracing, or temporary work bridges.

The prices and payments will be full compensation for all items required to provide bearing piles including but not limited to those items contained in Article 450-1.

Payment will be made under:

Pay Item	Pay Unit
Treated Timber Piles	Linear Meter
_____ mm Prestressed Concrete Piles	Linear Meter
_____ Steel Piles	Linear Meter
_____ Galvanized Steel Piles	Linear Meter
Steel Pile Points	Each
Pipe Pile Plates	Each
Pile Redrives	Each

SECTION 452 SHEET PILE RETAINING WALLS

452-1 DESCRIPTION

Construct permanent sheet pile retaining walls of sheet piling and concrete coping, if required, as shown on the plans and as directed by the Engineer. This section only applies to sheet pile retaining walls that are left in place so that they become part of the completed work. Provide and drive sheet piles; furnish collars, hardware, and all other materials and equipment; cut off sheet piles as necessary; furnish and place temporary bracing and reinforcing steel; construct, form, and finish concrete coping; seal joints;

place and compact backfill; remove any obstructions; and remove, replace, and correct sheet piles as necessary.

452-2 MATERIALS

Refer to Division 10.

Item	Section
Steel and Prestressed Concrete Sheet Piles	1084
Portland Cement Concrete	1000
Curing Agents	1026
Joint Fillers	1028-1
Joint Sealers	1028-4
Reinforcing Steel	1070-1, 1070-2

452-3 DRIVING EQUIPMENT

Submit the proposed sheet pile driving methods and equipment to the Engineer. Submit this information for approval at least 20 working days before driving sheet piles. Drive sheet piles with approved driving equipment using steam, air, or diesel hammers. Use pile driving hammers that do not overstress the sheet piles during driving.

452-4 ACCURACY OF DRIVING

Drive sheet piles to a tolerance of not more than 10 mm per meter from the vertical. Horizontally, keep the sheet piles within 75 mm of the plan location longitudinally and transversely.

452-5 CONSTRUCTION REQUIREMENTS

(A) General

Unless otherwise approved or directed by the Engineer, do not drive sheet piles within 15 m of cast-in-place concrete until the concrete attains an age of at least 3 curing days. When approved by the Engineer, the Contractor may use vibratory hammers to install portions of steel sheet piles. The Engineer will determine the allowable depth of sheet pile installation with the vibratory hammer. Do not use vibratory hammers to install prestressed concrete sheet piles.

The Engineer will inspect the capblock before beginning each pile driving project and periodically throughout the duration of the project, depending on driving conditions, as determined by the Engineer. Expose the hammer cushion for inspection as directed by the Engineer. Replace or repair any hammer cushion that is less than 25% of the original thickness.

Do not exceed the allowable pile driving stresses during the entire driving time. Allowable pile driving stresses are defined in the *AASHTO Standard Specifications for Highway Bridges*. Drive piles to the required tip elevation or penetration into natural ground, whichever is lower, in a continuous operation unless stopped due to exceeding the maximum blow count or allowable pile driving stresses, insufficient sheet pile length, or other reasons approved by the Engineer.

Use a pile cushion made of pine plywood for driving prestressed concrete sheet piles. Replace the pile cushion if, during the driving of any sheet pile, the cushion is either compressed more than one-half the original thickness or begins to burn. When using a pile cushion, provide a new cushion for each sheet pile unless approved otherwise by the Engineer.

(B) Prestressed Concrete Sheet Piles

Handle, transport, and store prestressed concrete sheet piles by methods that do not damage the pile. Support the sheet piles while handling, transporting, and storing as shown on the plans or along their full length. Replace sheet piles damaged in handling or driving unless they are repaired to an acceptable condition.

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Cut off concrete sheet piles not driven to grade by means that do not result in spalling or other damage to the sheet pile.

(C) Steel Sheet Piles

Handle and store steel sheet piles by methods that do not damage the pile. Store the sheet piles above ground upon platforms, blocking, or other supports. Keep the sheet piles free from dirt, grease, and other foreign matter, and protect them insofar, as is practicable from corrosion.

Cut off sheet piles with approved methods at the required elevations.

(D) Sheet Pile Penetration

Install sheet piles such that the tips of the sheet piles penetrate to the tip elevations shown on the plans or as directed by the Engineer.

(E) Concrete Coping

When concrete coping is required as shown on the plans, place reinforcing steel and construct cast-in-place concrete coping in accordance with Section 825. Extend coping 150 mm above the elevation where the grade intersects the back of the wall unless otherwise required by the plans or as directed by the Engineer. If required, insert sleeves for fence posts in the top of coping in accordance with Section 866. Use Class A concrete and provide an ordinary surface finish. Grooved contraction joints are required every 3.0 m and expansion joints are required every 9.0 m along the coping. If the grade behind the wall slopes towards the wall, seal the joint between the coping and the asphalt or concrete with joint sealer.

Remove forms any time after 3 hours if the concrete is sufficiently set to permit form removal without damaging the coping.

(F) Backfilling

When concrete coping is required as shown on the plans, do not backfill behind sheet pile retaining walls until the concrete develops a minimum compressive strength of 20.7 MPa.

Use approved material for backfill that is free from large or frozen lumps, wood, or other undesirable material. Where it is necessary to provide backfill material from sources other than excavated areas or borrow sources in connection with this contract, payment for furnishing and hauling such backfill material will be made as provided in Article 104-7 for extra work. Placing and compacting such backfill is not considered extra work and will be considered incidental to the cost of the sheet pile retaining wall.

Compact backfill in accordance with Subarticle 235-4(C). Place backfill within 1 m of the back of the wall with hand operated compaction equipment. Do not operate heavy earth moving equipment within 3.0 m of the back of the wall.

452-6 MEASUREMENT AND PAYMENT

Sheet Pile Retaining Wall will be measured and paid as the actual number of square meters of exposed face area incorporated into the completed and accepted wall. The wall height is measured as the difference between the top and bottom of the wall. The bottom of the wall is defined as the point where the finished grade intersects the front of the wall. The top of the wall is defined as the top of coping or bottom of cap elevation.

The price and payment will be full compensation for all items required to provide sheet pile retaining walls including but not limited to those items contained in Article 452-1.

Payment will be made under:

Pay Item	Pay Unit
___ Sheet Pile Retaining Wall	Square Meter

SECTION 453 GRAVITY RETAINING WALLS

453-1 DESCRIPTION

Construct gravity retaining walls of cast-in-place reinforced concrete and a brick veneer, if required, in accordance with the Structure Standard Drawings for gravity retaining walls and as directed by the Engineer. Furnish and place concrete, reinforcing steel, brick masonry and ties, joint fillers and sealers, curing agents, and all other materials and equipment; erect and remove all falsework and forms; protect concrete in wind, rain, low humidity, high temperatures, or other unfavorable weather; construct joints and weep holes; finish and cure concrete; protect concrete from rust stains; place stone drains and subdrain fine aggregate; place and compact backfill; and excavate for walls.

453-2 MATERIALS

Refer to Division 10.

Item	Section
Portland Cement Concrete	1000
Curing Agents	1026
Joint Fillers	1028-1
Joint Sealers	1028-4
Reinforcing Steel	1070-1, & 1070-2
Subdrain Fine Aggregate	1044-1
Stone, #78M	1005
Brick	1040-1
Mortar	1040-8

453-3 CONSTRUCTION REQUIREMENTS

Excavate as necessary for gravity retaining walls. Notify the Engineer when foundation excavation is complete. Do not place any concrete until obtaining approval of the excavation depth and the character of the foundation material. Where foundation material is found to be unacceptable, undercut the foundation material and backfill with an approved select material as directed by the Engineer.

Place reinforcing steel and construct cast-in-place concrete in accordance with Section 420. Construct 75 mm diameter weep holes on 3 m centers along the wall. Exit weep holes just above finished grade and slope holes on a 75 mm per meter slope through the wall so that water drains out of the front of the wall. Extend the top of wall 150 mm above the elevation where the grade intersects the back of the wall unless otherwise required by the plans or as directed by the Engineer.

If required, insert sleeves for fence posts in the top of wall in accordance with Section 866. Use Class A concrete and provide a Class 1 surface finish for all exposed surfaces. Grooved contraction joints are required every 3 m and expansion joints are required every 9 m along the wall. Remove forms any time after 3 hours if the concrete is sufficiently set to permit form removal without damaging the wall.

If the grade behind the wall slopes towards the wall, seal the joint between the wall and the asphalt or concrete with joint sealer. If a concrete paved ditch is required behind the wall, the sloping backwall of the gravity retaining wall forms half the concrete paved ditch.

If a brick veneer is required as shown on the plans, construct brick masonry in accordance with Section 830. Anchor brick veneer with approved brick to concrete type anchors according to the manufacturers' specifications with a minimum vertical spacing

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of 400 mm and a minimum horizontal spacing of 800 mm with each row staggered 400 mm from the row of anchors above and below.

Place a stone drain consisting of .03 m³ of #78M stone contained in a bag of porous fabric at each weep hole. Place subdrain fine aggregate beneath, around, and over the stone drain so that the stone drain is covered by a layer of subdrain fine aggregate at least 300 mm thick. Place a horizontal drain of subdrain fine aggregate at least .09 m² in cross section to connect all stone drains.

Do not backfill behind gravity retaining walls until the concrete develops a minimum compressive strength of 20.7 MPa. Use approved material for backfill that is free from large or frozen lumps, wood or other undesirable material. Where it is necessary to provide backfill material from sources other than excavated areas or borrow sources in connection with this contract, payment for furnishing and hauling such backfill material will be made as provided in Article 104-7 for extra work. Placing and compacting such backfill is not considered extra work and will be considered incidental to the cost of the gravity retaining wall.

Compact granular backfill in accordance with Subarticle 235-4(C). Place backfill within 1 m of the back of the wall with hand operated compaction equipment. Do not operate heavy earth moving equipment within 3 m of the back of the wall.

453-4 MEASUREMENT AND PAYMENT

Gravity Retaining Walls will be measured and paid for as the actual number of square meters of exposed face area incorporated into the completed and accepted wall. The wall height is measured as the difference between the top and bottom of wall. The bottom of wall is defined as the point where the finished grade intersects the front of the wall. The top of wall is defined as the top elevation of the completed wall including any height from the brick veneer, if applicable. If a concrete paved ditch is required behind the wall, no payment will be made for the portion of the ditch formed by the sloping backwall of the gravity retaining wall.

The price and payment will be full compensation for all items required to provide gravity retaining walls including but not limited to those items contained in Article 453-1.

Payment will be made under:

Pay Item	Pay Unit
Gravity Retaining Walls	Square Meter

SECTION 454 WATERPROOFING AND DAMPPROOFING

454-1 DESCRIPTION

Waterproof or dampproof concrete surfaces in accordance with the requirements of these Specifications for the particular method of waterproofing or dampproofing called for on the plans. Furnish and apply all asphalt, tar, fabric, asphalt plank, and any other materials.

454-2 MATERIALS

Refer to Division 10.

Item	Section
Asphalt Primer	1020-9(A)
Asphalt Binder	1020-9(B)
Tar	1020-9(C)
Woven Cotton Fabric	1020-9(D)

454-3 METHOD A WATERPROOFING**(A) General**

Method A waterproofing consists of one coat of asphalt primer, and 3 mop coats of hot asphalt cement with 2 layers of cotton fabric alternating between the mop coats.

(B) Preparation of Surface

Ensure that concrete surfaces are dry, reasonably smooth, and free from projections or holes which are capable of puncturing the membrane. Immediately before applying the waterproofing, thoroughly clean the surface of dust and loose materials.

Make sure that the concrete is at least 14 days old for Class A concrete, at least 10 days old for Class AA Concrete, or at least 7 days old for high early strength concrete, before beginning waterproofing. Do not waterproof in wet weather nor when the temperature is below 2°C, without permission.

(C) Application

Give waterproofed surfaces a thorough coat of asphalt primer, and allow it to set thoroughly before applying the first mop coat. Heat the asphalt cement for the mop coat to a temperature of not less than 149°C and frequently stir to avoid local overheating. Equip the heating kettles with thermometers.

Begin the waterproofing at the low point of the surface.

Use a half width first strip of fabric; and a full width second strip. Lap the full width of the first strip. Make the third and each succeeding strip full width and lap so that there are 2 layers of fabric at all points with laps not less than 50 mm wide. Make sure that the end laps are at least 300 mm.

Beginning at the low point of the surface, mop a section about 500 mm wide and the full length of the surface with hot asphalt cement. Immediately roll the first strip of fabric into the asphalt cement and press into place to eliminate all air bubbles and to provide a firm bond to the surface. Mop this strip and an adjacent section of the surface of a width equal to slightly more than half the width of the fabric with hot asphalt binder and roll a full width of the fabric into this cement, completely covering the first strip, and press into place. Mop this second strip and an adjacent section of the concrete surface with hot asphalt cement and place the third strip of fabric to lap the first strip not less than 50 mm. Continue this process until the entire surface is covered, each strip of fabric lapping at least 50 mm over the second preceding strip. Give the entire surface a final mopping of hot asphalt cement.

Mop on concrete to completely cover the surface sufficiently heavy on cloth to completely conceal the weave. Use at least 45.4 liters of asphalt on horizontal surfaces for each 9.3 m² square meter of finished work, and at least 56.8 liters on vertical surfaces. Perform the work so that, at the close of a day's work, all laid cloth receives the final mopping of asphalt. Thoroughly seal down all laps.

(D) Special Requirements

At the edges of the membrane and at any points punctured by such appurtenances as drains or pipes, make suitable provisions to prevent water from getting between the waterproofing and the waterproofed surface.

Place all membrane flashing at curbs and against girders, spandrel walls, etc., with separate sheets of membrane lapping the main membrane not less than 300 mm. Closely seal flashing with either a metal counter-flashing or by embedding the upper edges of the flashing in a groove poured full of joint filler.

Provide expansion joints, both horizontal and vertical, with water stops and premolded joint filler as called for on the plans. Seal expansion joints in the face

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adjacent to the membrane bituminous material. Carry the membrane continuously across all expansion joints.

At the ends of the structure carry the membrane well down on the abutments and make suitable provisions for all movement.

(E) Repairs

Repair any damage that occurs as directed. Repair by patching when permitted. Extend the first ply of the patch at least 300 mm beyond the outermost damaged portion of the membrane and extend the second ply at least 75 mm beyond the first.

(F) Backfilling

Do not backfill without permission and until the final mop coat thoroughly hardens. Place backfill in such a manner that the waterproofing is not damaged.

454-4 METHOD B DAMPPROOFING

(A) General

Method B dampproofing consists of 2 coats of tar, Grade RT-6.

(B) Preparation of Surface

Make sure the surfaces are dry. Immediately before applying the first dampproofing coat, thoroughly clean the surfaces of dust and loose materials. Permit the concrete to cure for a period of at least 14 days for Class A concrete, at least 10 days for Class AA concrete, or 7 days for high early strength concrete, before dampproofing.

(C) Application

Give the concrete surfaces 2 applications tar, Grade RT-6. Apply the tar by means of suitable brushes to secure uniform and thorough applications. Do not apply the second coat of tar until the first coat thoroughly sets. Do not apply dampproofing during any time that the surface is exposed to any moisture. Make sure that the temperature of the tar is such that uniform and thorough application is obtained. Do not backfill until the second coat thoroughly sets.

454-5 MEASUREMENT AND PAYMENT

Method ___ Waterproofing will be measured and paid as the actual number of square meters of surface that is waterproofed. In measuring this quantity, measurement is made along the actual surface that is to be waterproofed before the waterproofing is applied.

Method ___ Dampproofing will be measured and paid as the actual number of square meters of surface that is dampproofed. In measuring this quantity, measurement is made along the actual surface that is to be dampproofed before the dampproofing is applied.

These prices and payments will be full compensation for all items required to waterproof and dampproof including but not limited to those items contained in Article 454-1.

Payment will be made under:

Pay Item	Pay Unit
Method _____ Waterproofing	Square Meter
Method _____ Dampproofing	Square Meter

SECTION 460 BRIDGE RAILING

460-1 DESCRIPTION

Furnish and place metal, pipe, or concrete barrier bridge railing in accordance with the requirements of these Specifications and as shown on the plans. Furnish posts, rail bars, pipe fittings, hardware, paint, barrier delineators, concrete, reinforcing steel,

admixtures, forms, falsework and all other materials; galvanize; paint; fabricate and erect rail; and place, finish, and cure concrete.

460-2 MATERIALS

Refer to Division 10.

Item	Section
Portland Cement Concrete	1000
Retroreflective Sheeting	1070-2
Aluminum Rail	1074-5
Galvanized Steel Rail	1074-5
Pipe Rail	1074-6
Paint	1080
Barrier Delineators	1088-2
Epoxy Coated Reinforcing Steel	1070-8

460-3 CONSTRUCTION METHODS

Adhere to the construction load limitations of Article 420-20 while placing concrete for all bridge rails.

(A) Metal Rail

Use either aluminum or galvanized steel rail, but use the same material on all structures on the project on which metal rail is required.

Use shims if necessary to obtain correct post alignment.

Drive aluminum rivets cold. Thoroughly coat the base of aluminum rail post, closure plates, shims, or any other aluminum surface in contact with concrete with an approved aluminum impregnated caulking compound.

(B) Pipe Rail

Give galvanized pipe rail one field coat of organic zinc repair paint, of minimum wet thickness of .038 mm, after erection in accordance with the requirements of Section 442 unless otherwise required in the contract.

(C) Concrete Barrier Rails

This Subarticle applies to the construction of concrete barrier rail, median barrier rail and concrete parapet, referred to collectively as concrete barrier rails.

Plans for the concrete barrier rails are detailed for slip-formed cast-in-place concrete. Unless otherwise noted, construct concrete barrier rails detailed on the plans using conventional forms or by slip-forming using an approved self-propelled extrusion machine. Except as noted herein, construct in accordance with the requirements of Section 420.

Construct joints in the barrier rails at the locations and of the type shown on the plans.

Construct concrete barrier rails to the shape, line, grade, and dimensions shown on the plans except that when slip-forming rails, either radius or chamfer the corners. Check slip-formed rail concrete directly behind the extrusion machine using successive overlapping applications of the 3 m straightedge. Correct high and low areas while the concrete is still workable. Limit horizontal and vertical deviation from plan line and grade to no more than 6 mm in 3 meters.

Provide sufficient internal vibrators to consolidate the concrete along the faces of forms and adjacent to joints. Consolidate the concrete by internal vibration in one pass of the extrusion machine. Produce a dense and homogeneous barrier free of voids and honeycomb with minimum hand finishing. Coordinate concrete

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delivery and placement to provide uniform progress while minimizing stopping and starting of the extrusion machine.

When plans require horizontal deck drains through the barrier rails, use drain couplings with slip-formed rails.

Correct all exposed surfaces that are not satisfactory to the Engineer as to uniformity of color and texture or because of excessive patching as required. Give the roadway face of barrier rails constructed using conventional forms a Class 2 surface finish in accordance with Subarticle 420-17(F). Use a broom finish on the roadway face of slip-formed barrier rails.

Provide barrier rail delineators in accordance with Section 854.

460-4 MEASUREMENT AND PAYMENT

_____ *Bar Metal Rail* will be measured and paid for as the actual number of linear meters of metal rail, measured along the top bar of the rail, that is completed and accepted.

_____ *mm Galvanized Steel Pipe Rail* will be measured and paid for as the actual number of linear meters of pipe rail, measured along the top pipe of the installed pipe rail, that is completed and accepted.

Concrete Barrier Rail will be measured and paid for as the number of linear meters of concrete barrier rail provided on the plans.

Concrete Median Barrier will be measured and paid for as the number of linear meters provided on the plans.

_____ x _____ *Concrete Parapet* will be measured and paid for as the number of linear meters of concrete parapet provided on the plans.

Construct slope protection under the ends of bridges or at other locations in accordance with details shown in the contract. Excavate and backfill; and furnish and place concrete, reinforcement, and other materials. Unless otherwise noted on the plans, use cast-in-place reinforced concrete.

There will be no direct payment for bridge rail delineators as they are incidental to other pay items in this Specifications.

These prices and payments will be full compensation for all items required to provide bridge railing including but not limited to those items contained in Article 460-1.

Payment will be made under:

Pay Item	Pay Unit
_____ Bar Metal Rail	Linear Meter
_____ mm Galvanized Steel Pipe Rail	Linear Meter
Concrete Barrier Rail	Linear Meter
Concrete Median Barrier	Linear Meter
_____ x _____ Concrete Parapet	Linear Meter

**SECTION 462
SLOPE PROTECTION**

462-1 DESCRIPTION

Construct slope protection under the ends of bridges or at other locations in accordance with details shown in the contract. Excavate and backfill; and furnish and place concrete, reinforcement, and other materials. Unless otherwise noted on the plans, use cast-in-place reinforced concrete.

462-2 MATERIALS

Refer to Division 10.

Item	Section
Portland Cement Concrete	1000
Curing Agents	1026
Joint Fillers	1028-1
Wire Mesh Reinforcement	1070-3
Grout	1040-9

462-3 CONSTRUCTION METHODS

Immediately before placing the paving, properly shape and firmly compact the slope so that it conforms to the required lines and grades.

Construct cast-in-place concrete slope protection in accordance with Section 420, except as otherwise provided herein. Use Class B concrete. Furnish and place reinforcement as shown on the plans and in accordance with the requirements of Section 425. After placing the concrete for one section, strike it off to plan grade and finish to a dense and uniform surface.

Provide a reasonably smooth and uniform surface for the finished slope protection that does not vary more than 13 mm in a distance of 3 m.

Do not place backfill adjacent to cast-in-place slope protection at any one end bent until each individual section of paving at the end bent cures for 3 or more curing days as defined in Subarticle 420-15(A). However, place backfill no later than 5 calendar days after the last section of concrete paving placed at the end bent cures for 3 curing days. Compact all backfill to a degree comparable to the adjacent undisturbed material.

462-4 MEASUREMENT AND PAYMENT

___ mm *Slope Protection* will be measured and paid for as the actual number of square meters of slope protection, measured along the top surface of the paving, which is completed and accepted.

The price and payment will be full compensation for all items required to provide slope protection including but not limited to those items contained in Article 462-1.

Payment will be made under:

Pay Item	Pay Unit
___ mm Slope Protection	Square Meter