# SECTION 701 – DRIVEN PILING

**701.01 Description.** This work shall consist of furnishing and driving foundation piles of the type and dimensions designated including cutting off or building up foundation piles when required. Piling shall conform to and be installed at the location, tip elevation, penetration, or bearing in accordance with 105.03.

## MATERIALS

**701.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Epoxy Coating for Piles | 915.01(d) |
| Reinforcing Steel | 910.01 |
| Steel Encased Concrete Piles | 915.01 |
| Steel H Piles | 915.02 |
| Structural Concrete | 702 |
| Timber Piling, Treated | 911.02(c) |
| Timber Piling, Untreated | 911.01(e) |

Reinforcing steel within steel shell piles and in the reinforced concrete pile encasement shall not be epoxy coated.

Powdered epoxy resin shall be used to coat the epoxy coated portion of the steel shell encased concrete piles.

The Contractor may furnish and drive thicker walled steel shells than specified.

**701.03 Handling of Epoxy Coated Piles.** Piles shall be shipped using dunnage and padding shall be used with chains or steel bands.

Damage to epoxy coated piles shall be repaired in accordance with 915.01(d). Epoxy coated piles will be rejected if the total area of repair to the coating exceeds 2% of the total coated surface area.

## CONSTRUCTION REQUIREMENTS

**701.04 Equipment for Driving Piles.**

**(a) Approval of Pile Driving Equipment**. All pile driving equipment furnished by the Contractor shall be in working condition and subject to approval. All pile driving equipment shall be sized such that the piles can be driven with reasonable effort to the ordered lengths without damage. The pile driving equipment shall not be used until approval is received in writing. The Contractor shall submit to the Geotechnical Engineer, Materials and Tests Division, with a copy to the Engineer, a

completed Pile and Driving Equipment Data Form at least 15 calendar days prior to driving piles. The form will be included in the Proposal book. Pile driving equipment will be subject to satisfactory performance during production.

The Engineer will use the information provided by the Contractor to run the wave equation analysis or the alternate method, from which the acceptance of the pile driving equipment will be founded. Approval criteria of pile driving systems will consist of both the required number of hammer blows per meter (foot) and the pile stresses at the required pile capacity. The required number of hammer blows indicated by the wave equation at the ultimate pile load shall be less than 600 blows per meter (180 blows per foot) for the pile driving equipment to be acceptable.

1. Wave Equation Analysis Method. For the pile driving equipment to be acceptable, the driving stresses predicted by the wave equation analysis shall not exceed the values where pile damage impends. These limiting values may be calculated as follows:

a. The maximum allowable compressive and tensile stress for steel piles = 0.9Fy.

b. The maximum allowable compressive stress for prestressed concrete piles = $0.85f_c'$ - effective prestress.

c. The maximum allowable tensile stress, MPa (psi), for prestressed concrete piles = $0.25\sqrt{f_c'}$+ effective prestress, where $f_c'$ is expressed in MPa ($3\sqrt{f_c'}$+ effective prestress, where $f_c'$ is expressed in psi).

d. The effective prestress may be obtained from the approved shop drawings.

The Contractor will be notified of the acceptance of the proposed pile driving system within 15 calendar days of the receipt of the Pile and Driving Equipment Data Form. If the wave equation analysis shows that either pile damage or inability to reasonably drive a pile with respect to allowable blow counts will result from the proposed equipment, the Contractor shall modify or replace the proposed equipment until subsequent wave equation analyses indicate the piles can be reasonably driven to the desired ultimate capacity, without damage. The Engineer will notify the Contractor of the acceptance of the revised driving system within seven calendar days of receipt of a revised data form.

No variation in the pile driving system will be permitted without written approval, with the exception of increasing concrete pile cushion thickness to control driving stresses. Changes in the driving system will only be considered after the Contractor has submitted the necessary information for a revised wave equation analysis. The Contractor will be notified of the acceptance of the pile driving system changes within three work days of the receipt of the requested change.

**2. Alternate Method.** If the alternate method is used, the energy of the pile driving equipment shall be rated by the manufacturer at or above the appropriate minimum manufacturer's rated hammer energy for the corresponding ultimate pile capacity as shown in the table below. The ultimate pile capacity as shown on the plans is equal to the design load times the factor of safety.

ALTERNATE METHOD
MINIMUM PILE HAMMER REQUIREMENTS

| Ultimate Pile Capacity, Kilonewtons | (Kips) | Minimum Manufacturer's Rated Hammer Energy, Joules | (Foot-pounds) |
|---|---|---|---|
| 450 and under | (100 and under) | 9 830 | (7,250) |
| 451 to 800 | (101 to 180) | 12 200 | (9,000) |
| 801 to 1330 | (181 to 300) | 20 340 | (15,000) |
| 1331 and over | (301 and over) | wave equation required | |

The Contractor shall use the approved system and no variations in the driving system will be permitted without the Engineer's approval. All changes in the pile driving system will only be considered after the Contractor has submitted a new Pile and Driving Equipment Data Form. The Contractor will be notified of the acceptance of the proposed change in driving equipment within three work days of receipt of the data form. If the Engineer determines the Contractor's hammer is not functioning properly and is unable to drive the pile to the required depth, the hammer shall be removed from service.

**(b) Pile Hammers.** Concrete piles of 500 mm (20 in.) diameter or width and larger shall be driven by means of air, steam, diesel, or hydraulic hammers, unless otherwise approved. Steel piles shall be driven with air, steam, diesel, or hydraulic hammers. Gravity hammers shall only be used if specifically permitted in the contract or approved in writing.

**1. Gravity Hammers.** When gravity hammers are permitted, the ram shall have a mass (weight) of between 1360 and 1590 kg (3,000 and 3,500 lbs). The height of drop shall not exceed 4.5 m (15 ft). The mass (weight) of gravity hammers shall not be less than the combined mass (weight) of the drive head and pile. All gravity hammers shall be equipped with hammer guides to ensure concentric impact on the drive head.

**2. Steam and Air Hammers.** The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the volume and pressure specified by the manufacturer of the hammer. The plant and equipment shall be equipped with accurate chamber pressure gauges which are accessible to the Engineer. When wave equation analysis is not used for

pre-approval, the weight of the striking parts of air and steam hammers shall not be less than one third the weight of the drive head and pile being driven. The striking parts shall not weigh less than 1250 kg (2,750 lbs).

**3. Diesel Hammers.** Open-end or single acting diesel hammers shall be equipped with a device such as rings on the ram, a scale, or a jump stick, extending above the ram cylinder, to permit the Engineer to visually determine hammer stroke at all times during pile driving operations. The Contractor shall provide the Engineer a chart from the hammer manufacturer equating stroke, blows per minute, and potential energy for the open-end diesel hammer. Closed-end double acting diesel hammers shall be equipped with a bounce chamber pressure gauge, in working order, mounted near ground level so as to be read by the Engineer.

The Contractor shall provide the Engineer a chart equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used. This calibration to actual hammer performance shall be performed within 90 days before the beginning of the work.

**4. Pile Driving Aids.** Pile driving aids such as jets, followers, and prebored holes shall not be used unless specified. If specified, pile driving aids shall be used for installing production piles only after the pile tip elevation for safe support of the pile load is established by means of load testing or test piles conventionally driven. The Contractor shall perform all extra load tests or extra work required to drive test piles as determined by the Engineer.

**(c) Pile Driving Appurtenance.**

**1. Hammer Cushion.** All impact pile driving equipment, except gravity hammers, shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniform driving behavior. Hammer cushions shall be made of durable, manufactured materials, provided in accordance with the hammer manufacturer's guidelines. All wood, wire rope, and asbestos hammer cushions will not be permitted. A striker plate as recommended by the hammer manufacturer shall be placed on the hammer cushion to ensure uniform compression of the cushion material. The condition of the hammer cushion shall be checked with the Engineer at the beginning of pile driving and after each 100 h of pile driving. A hammer cushion whose thickness has been reduced to less than 75% of the original thickness shall be replaced.

**2. Pile Drive Head.** Piles driven with impact hammers shall have an adequate drive head to distribute the hammer blow to the pile head, be axially aligned with the hammer and the pile, be guided by the leads, and not be free-swinging. The drive head shall fit around the pile head and prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

For steel and timber piling, the pile heads shall be cut squarely.

A drive head as recommended by the manufacturer shall be provided to hold the axis of the pile in line with the axis of the hammer. The pile head shall be plane and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the drive head.

**3. Pile Cushion.** The heads of concrete piles shall be protected with a pile cushion made of plywood. The minimum plywood thickness placed on the pile head prior to driving shall not be less than 100 mm (4 in.). A new pile cushion shall be provided for each pile. The pile cushion shall be replaced if, during the driving of the pile, the cushion is either compressed more than one-half the original thickness or begins to burn. The pile cushion dimensions shall equal or exceed the cross sectional area of the pile top, and shall be sized to fit the dimensions of the pile cap.

**4. Leads.** Piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed in a manner that affords freedom of movement of the hammer while maintaining alignment of the hammer and the pile to ensure concentric impact for each blow. Leads may be either fixed or swinging type. Swinging leads, when used, shall be fitted with a pile gate at the bottom of the leads. The leads shall be adequately embedded in the ground, or the pile shall be constrained in a structural frame such as a template to maintain alignment.

**5. Followers.** Followers shall only be used when approved in writing by the Engineer. If a follower is permitted, the first pile in each bent and every tenth pile driven thereafter shall be driven full length without a follower, to verify that adequate pile length is being attained to develop the desired pile capacity. The follower and pile shall be held and maintained in equal and proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full length piles. The final position and alignment of the first two piles installed with followers in each substructure unit shall not exceed more than 75 mm (3 in.) from the locations shown on the plans before additional piles are installed.

**6. Jets.** Jetting will not be permitted for concrete piles unless otherwise specified. The Contractor shall determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile without affecting the lateral stability of the final in-place pile. The Contractor shall be responsible for all damage to the site caused by improper jetting operations. If jetting is specified, the jetting plant shall have sufficient capacity to permit installation to the required elevation, location, and alignment in accordance with 701.09(b). Unless otherwise directed, external jet pipes shall be removed when the pile tip is 3.0 m (10 ft) above the prescribed tip elevation, depending on soil conditions. The pile shall then be driven to the required bearing capacity with an impact hammer. The Contractor shall control, treat if necessary, and dispose of all jet water in accordance with 108.03.

Upon completion of driving a jetted pile, all voids around the pile shall be filled with B borrow and saturated with water.

**701.05 Test Piles.** Test piles shall be driven when shown on the plans at the locations and to the lengths specified or as directed by the Engineer. Unless otherwise directed, test piles shall be driven at such locations to permit their use in the finished structure. Test piles shall not be driven outside of permanent pile locations and be pulled and redriven as production piles. Test piles specified to be used as permanent piles in a structure shall have sufficient length to be cut off at the plan grade for top of pile. The length of test piles shall be greater than the estimated length of production piles in order to provide for variation in soil conditions. Precast concrete and treated timber test piles shall be a minimum of 3.0 m (10 ft) longer than the estimated length of piling shown on the plans. Steel piles shall be provided such that additional 3.0 m (10 ft) of driving will not require an additional splice.

The driving equipment used for driving test piles shall be identical to that proposed for use on the production piling and shall be subject to approval. The Contractor shall excavate the ground at each test pile to the elevation of the bottom of the footing before the pile is driven, unless shown on the plans or otherwise directed.

Test piles shall be driven to the required pile capacity or as directed. Each test pile shall be restruck after a 24 to 72 h waiting period to assess the effects of setup and relaxation unless otherwise approved. The hammer shall be warmed up before driving begins by applying at least 20 blows to another fixed object. If the test pile does attain the specified capacity upon restriking, the blow count attained during initial driving shall be used to establish the adequacy of production piles. If the specified capacity is not attained on restriking, the Contractor shall redrive the test pile till it achieves the required capacity and repeat the restrike procedure. Test piles driven full length without attaining the required capacity shall be spliced and driven until the required bearing is obtained. Splices for test piles shall be in accordance with 701.11.

A record of driving of test piles which includes the number of hammer blows per 0.3 m (1 ft) for the entire driven length, the as-driven length, cutoff elevation, penetration, and all other pertinent information will be kept by the Engineer. The test pile shall be redriven when it has been determined from a load test that the test pile does not have adequate capacity. If a redrive is necessary, the Engineer will record the number of hammer blows per 25 mm (1 in.) of pile movement for the first 0.3 m (1 ft) of redrive.

**701.06 Driven Pile Capacity.** The Engineer will use the following methods in determining driven pile capacity as shown in the Contract Information book.

**(a) Wave Equation Analysis Program, or WEAP.** The pile capacity will be determined based on the pile capacity versus blow count relationship obtained from the wave equation analysis. Piles shall be driven with the approved driving equipment to the length necessary to obtain the required blow count. Jetting or other methods to facilitate pile penetration shall not be used unless specified or approved in writing after a revised driving resistance is established from the wave equation analysis. Adequate pile penetration shall be considered to be obtained when the specified wave equation resistance criteria is achieved within 1.5 m (5 ft) of the estimated tip elevation, when

provided, based on ordered length. Piles not achieving the specified resistance within these limits, or those requiring a minimum tip elevation, shall be driven to capacities determined by the Engineer.

**(b) Dynamic Formula.** The ultimate pile capacity will be determined by means of dynamic formula. Piles shall be driven to the length necessary to obtain the ultimate pile capacity which is equal to the factor of safety times the design load. The ultimate pile capacity, as shown on the plans, can be calculated from the formula as follows:

Metric: $Ru = 7 \sqrt{E} (\log 10N) - 550$

English: $Ru = 0.5[1.75 \sqrt{E} (\log 10N) - 100]$

where Ru = The ultimate pile capacity in kilonewtons (tons)

E = The manufacturer's rated energy in joules (foot pounds) at the ram stroke observed in the field and not reduced for efficiency

log 10N = Logarithm to the base 10 of the quantity 10 multiplied by N, where N is the number of hammer blows per 25 mm (1 in.) at final penetration.

**(c) Dynamic Pile Load Test**. Dynamic measurements will be used to evaluate hammer and driving system performance, pile driving stresses, pile structural integrity, and pile bearing capacity. Dynamic monitoring will be conducted by the pile driving analysis, or PDA, consultant in accordance with ASTM D 4945. The PDA consultant will be acquired by the Department. The Contractor may require approximately 1 h per pile to install the dynamic monitoring equipment. The number of piles to be monitored may be increased if so directed.

For piles to be dynamically monitored, the Contractor shall predrill the required instrument attachment holes prior to placing the pile in the leads. The Contractor shall furnish the equipment, materials, and labor necessary for drilling holes in each pile and mounting the instruments near the head of the pile with bolts through the drilled holes. Each pile to be tested shall be instrumented with force and acceleration transducers provided by the PDA consultant, installed by the Contractor, before striking.

The Contractor shall provide access to the pile for attaching instruments after the pile is placed in the leads.

Upon determination by the Engineer that valid data have been secured, the PDA consultant, with the assistance of the Contractor, shall remove the instrumentation from the piles.

The Contractor shall furnish electric power for the dynamic test equipment. The power supply at the outlet shall be 10 A, 115 V, 55-60 cycles, AC only. If a field generator is used as the power source, it shall be equipped with functioning meters for monitoring voltage and frequency levels.

The Contractor shall drive the test pile to the depth at which the dynamic test equipment indicates that the ultimate pile capacity shown on the plans has been achieved, unless otherwise directed. The Contractor shall drive test piles to the minimum tip elevation and a depth that satisfies the required bearing. The stress in the piles will be monitored during driving with the dynamic testing equipment to ensure that the values developed do not exceed the values shown in 701.04(a). The Contractor may reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer in order to maintain stresses below the values shown in 701.04(a). If non-axial driving is indicated by the dynamic test equipment measurements, the Contractor shall immediately realign the hammer system.

The Contractor shall wait a minimum of 24 h, or up to 72 h, depending on the soil conditions, and after the instruments are reattached, restrike the test pile. It is estimated that the Contractor will require approximately 1 h to reattach the instruments. The hammer shall be warmed up before restriking begins by applying at least 20 blows to another pile or other fixed object. The maximum amount of penetration required during redrive shall be 150 mm (6 in.) or the total number of hammer blows shall be 50, whichever occurs first. After restriking, the Engineer will either accept the tip elevation or specify additional pile penetration and testing.

**(d) Static Load Test.** The test pile capacity shall be verified by performing actual loading tests of designated piles in the structure in accordance with ASTM D 1143, Quick Load Test Method, with loads applied by hydraulic jack. Such tests shall consist of the incremental application and removal of static pressure exerted on the pile through approved rigging, together with suitable apparatus for accurately determining the superimposed weight of pressure and pile settlement under each increment of load. The safe allowable load will be determined from the settlement versus load curve generated by the incremental loading in accordance with 701.06(d)1.

The top elevation of all test piles shall be determined immediately after driving and again just before load testing to check for heave. A pile which heaves more than 6 mm (1/4 in.) shall be redriven, or jacked, to the original elevation prior to testing. A minimum 36 h waiting period shall be observed between the driving of a load test pile and the commencement of the load testing unless otherwise specified or authorized.

The Contractor shall provide complete protection at all times for the pile, supports, and reference beam from wind, direct sunlight, frost action, or other disturbances. The Contractor shall maintain an air temperature in the immediate vicinity of the test pile and reference beam of not less than 10°C (50°F) and shall provide adequate lighting for the duration of the test.

No production piles shall be driven until completion of the static pile load test unless approved by the Engineer.

**1. Load Test Procedure.** The Contractor shall furnish and construct a suitable reaction frame or load platform to provide a load on the pile having a capacity of 8900 kN (1000 t) or 300% of the design load, whichever is less. A minimum of five calendar days prior to construction of the reaction frame or load platform, the Contractor shall submit, for review and approval, plans for the reaction frame or load platform. The reaction frame shall be designed by a professional engineer. The primary method of determining the applied load shall be from a calibrated load cell. Incremental loads of 10% of the design load shall be placed on the pile at 2 1/2 min intervals until continuous jacking is required to maintain the incremental load or the capacity of the load frame is reached.

The Contractor shall furnish the hydraulic pump, load cell, spherical bearing plate, and two reference beams. Each reference beam shall be a W or M section, of minimum length of 6 m (20 ft), and a mass (weight) of 7.5 to 30 kg/m (5 to 20 lb/ft) unless otherwise approved. The Engineer will conduct the static load test and will provide the gauges to measure movement of the test pile. The Contractor shall assist in performing the static load test by operating the pump, reading the gauges, etc. The Contractor shall furnish and install telltale rods encased in a lubricated pipe in the test pile prior to the static load test.

If the ultimate capacity of a pile from the load settlement curve does not equal or exceed the ultimate pile capacity shown on the plans, the Contractor shall redrive the pile to an adequate bearing capacity. The increase in bearing capacity shall be determined by the PDA. The pile shall be load tested again after the appropriate waiting period. Load tests shall be repeated as many times as necessary until the pile carries the required load.

**2. Hydraulic Jacks and Load Gages.** Hydraulic jacks and gages shall be used for the superimposed load. The jacks, gages, and hydraulic pumps shall be calibrated with each other within the last six months by an independent laboratory. All calibration checks shall be within 5% of the applied load. When a jack, gage, and hydraulic pump are calibrated, they shall be used as a unit. Changing one of the three components shall require a recalibration. Gages shall be of the size that provides ease of reading: approximately 110 mm (4 1/2 in.) diameter with gradations for 8.9 kN (2 t) or less for loads under 890 kN (100 t), and gradations of 44.5 kN (5 t) or less for loads over 890 kN (100 t).

**3. General Requirements**. On completion of the load testing, a test pile or anchor pile which is not a part of the finished structure shall be removed or cut off at least 0.3 m (1 ft) below either the bottom of footing or the finished ground elevation if not located within the footing area.

**701.07 Piling Length.** The estimated length of piles shown on the plans and in the Schedule of Pay Items are for bidding purposes only. The Contractor shall provide the lengths of such piles necessary to obtain the bearing and penetration required as determined from results obtained in driving representative test piles or other pertinent data. There will be expected variations in final tip elevations due to differences in driving resistance. The final tip elevation of each pile will be determined during the driving operation. When minimum tip elevations are specified, the Contractor shall drive piles to a depth that satisfies this requirement in addition to required bearing. The Contractor shall furnish the proposed pile length for use in each bent of a structure before driving the piles. There shall not be more than two splices exposed to view in each length of piling after driving is completed. The Contractor shall also furnish satisfactory evidence as to the identification, such as heat numbers for steel piles, of all portions of a built-up pile.

The limits of the epoxy coated steel shell portion of the pile, and the limits of the reinforced concrete shall be as shown on the plans.

**701.08 Required Bearing Capacity.** Piles shall be driven to the penetration necessary to obtain the required ultimate pile capacity, which shall be the factor of safety times design load, as shown on the plans. A blow count/ultimate pile capacity relationship will be determined based on the driving of representative, test piles.

Jetting or other methods shall not be used to facilitate pile penetration unless shown on the plans. The ultimate pile capacity of jetted piles shall be based on impact driving blow count after the jet pipes have been removed. Jetted piles not attaining the required ultimate pile capacity at the ordered length shall be spliced and driven with an impact hammer until the required ultimate pile capacity is achieved in accordance with the driving criteria in 701.06.

The required ultimate capacity of piles driven with followers will only be considered acceptable when the piles with followers attain the same tip elevation as the full length piles driven without followers, installed in accordance with 701.04(c)5.

**701.09 Preparation and Driving.** The heads of all piles shall be plane and perpendicular to the longitudinal axis of the pile before the drive head is attached. The heads of all concrete piles shall be protected with a pile cushion as described in 701.04(c)3.

Approval of a pile hammer relative to driving stress damage will not relieve the Contractor of responsibility for piles damaged due to misalignment of the leads, failure of hammer cushion or cushion material, failure of splices, malfunctioning of the pile hammer, improper construction methods, etc. Piles damaged for such reasons will be rejected and shall be replaced if the Engineer determines that the damage impairs the strength of the pile.

**(a) Pilot Holes.** Augering, wet-rotary drilling, or other methods of boring pilot holes shall be used only when specified or approved. The procedures shall be carried out so as not to impair the carrying capacity of the piles already in place or the safety of existing adjacent structures. Prebored holes shall not be of a size smaller than the diameter or diagonal of the pile cross section. If subsurface obstructions, such as boulders or rock layers are encountered, the hole diameter may be increased to the least dimension which is adequate for pile installation. The use of spuds or a short strong driven member which is removed to make a hole for inserting a pile, will not be permitted in lieu of preboring.

If new embankment through which H-piles are to be driven is 6.0 m (20 feet) or more in height, holes to receive the piles shall be prebored.

Before driving piles for the end bents, holes to receive the piling shall be prebored through the embankment elevation to the original ground. After the piles have been driven, the space between the pile and the prebored hole shall be backfilled with B borrow as directed. If the embankment in the area of the end bents is to be constructed of sand, gravel, or other permeable material in which a prebored hole would not remain open, the piling shall be driven before the embankment is constructed.

After a pile is driven, the voids around the pile shall be filled with B borrow. Water shall be added to the hole to saturate the final placement of B borrow.

Except for end bearing piles, preboring shall be stopped at least 1.5 m (5 ft) above the pile tip elevation determined from the ordered length. The pile shall be driven with an impact hammer to the specified blow count. Where piles are to be end-bearing on rock or hardpan, preboring may be carried to the surface of the rock or hardpan. The piles shall then be driven with an impact hammer to ensure proper seating.

If the Engineer determines that pre-excavation has disturbed the load bearing capacities of previously installed piles, those piles that have been disturbed shall be restored by means of redriving or other approved remedial measures. Redriving or other remedial measures shall be instituted after the preboring operations in the area have been completed.

Holes may be required to be cored into rock to accommodate pile placement. The approach grade shall be completed before coring is begun. Holes of the diameter shown on the plans shall then be cored through the embankment into solid rock to the elevations shown on the plans or as otherwise directed. The piles shall be driven to approximate refusal at the bottoms of the cored holes. Approximate refusal will be considered as 600 blows per meter (180 blows per foot). The holes in cored rock shall then be filled with concrete. Holes through embankment shall be filled with B borrow as described above.

**(b) Location and Alignment Tolerance.** Piles shall not be spaced closer than 760 mm (30 in.) center to center. A maximum deviation of 38 mm (1 1/2 in.) in any direction from exact position will be permissible in pile trestle bents and pile bents. A maximum deviation of 150 mm (6 in.) in any direction will be permitted for a foundation pile in footings for piers or abutments. The tendency of concrete or steel piles to twist or rotate shall be prevented and corrected. Piles to be swaybraced shall be aligned as necessary so that the swaybracing may be properly welded to the piles. After all piles in a bent are aligned, the bent cap shall be placed on the piles.

If the location or alignment tolerances are exceeded, the extent of overloading shall be investigated. If the Engineer determines that corrective measures are necessary, such corrective measures shall be designed and constructed. Proposed corrective measures shall be subject to approval.

**(c) Heaved Piles.** Level readings for checking on pile heave after driving shall be made at the start of pile driving operations and shall continue until the Engineer determines that such checking is no longer required. Level readings shall be taken immediately after the pile has been driven and again after piles within a radius of 4.5 m (15 ft) have been driven. If pile heave of 6 mm (1/4 in.) is observed, accurate level readings referenced to a fixed datum shall be taken on all piles immediately after installation and periodically thereafter as adjacent piles are driven to determine the pile heave range. All piles which have been heaved more than 6 mm (1/4 in.) shall be redriven to the required resistance or penetration. Concrete shall not be placed in pile casings until pile driving has progressed beyond a radius of 4.5 m (15 ft) from the pile to be concreted. If pile heave is detected for pipe or shell piles which have been filled with concrete, the piles shall be redriven to original position. The previously approved hammer-pile cushion system shall be used.

**(d) Installation Sequence.** The order of placing individual piles in pile groups shall be starting from the center of the group and proceeding outward in both directions, unless an alternate installation sequence is approved.

**(e) Inspection.** The Engineer shall be given 24 h notice before the driving of each pile, test or production. No pile shall be driven except in the presence of the Engineer.

Prior to placing concrete in cast-in-place pipe or shell concrete piles in driven shells, the Contractor shall supply a suitable light for the inspection of each shell throughout its entire length.

**(f) Pouring Concrete.** After all water and other foreign substances have been removed from the shells and the final approval given, the reinforcing steel, if specified, shall be placed, and the shells shall be filled with class A concrete in the presence of the Engineer. Concrete shall be deposited into pile shells in a stream with a cross-sectional area that is no more than approximately 50% of the area of the pile shell

to prevent air pockets from forming. Concrete shall be vibrated in the upper 7.5 to 9.0 m (25 to 30 ft) of the piles. Epoxy coated piles shall be protected during riprap placement. All damaged epoxy coating shall be repaired in accordance with 915.01(d).

**701.10 Unsatisfactory Piles.** The method used in driving piles shall not subject the piles to excessive or undue abuse which produces crushing and spalling of concrete, injurious splitting, splintering, brooming of the wood, or deformation of the steel. Misaligned piles shall not be forced into proper position. All piles damaged during driving by reason of internal defects, or by improper driving, or driven out of its proper location, or driven below the designated cutoff elevation shall be corrected as directed.

Piles which have been bent, or otherwise damaged, during installation shall be considered unsatisfactory unless the bearing capacity is proven by load tests performed by the Contractor. If such tests indicate inadequate capacity, corrective measures as determined by the Engineer shall be taken such as use of bent piles at reduced capacity, installation of additional piles, strengthening of bent piles, or replacement of bent piles.

A concrete pile will be considered defective if a visible crack, or cracks, appears around the entire periphery of the pile, or if a defect is observed, as determined by the Engineer.

**701.11 Splicing Piles.** Full length piles should be placed in leads when practical, however, when splicing is necessary, the following methods shall be used.

Splicing of steel piles and steel shells for cast-in-place concrete piles shall be made as shown on the plans. Welded connections for splices shall be used. All work shall be done with approved methods, and materials, and by welders qualified in accordance with 711.32.

**701.12 Steel H Pile Tips.** Steel H pile tips shall be cast-in-one-piece steel in accordance with ASTM A 27 Grade 450-240 (ASTM A 27 Grade 65-35). The tips shall have sufficient flange and continuous web vertical back-ups to ensure proper alignment and fitting to the pile. They shall provide full bearing for the piles. The soil or rock bearing surfaces of the tips shall be sloped downward toward the web with a minimum of 15 degrees, but not to exceed 30 degrees to the horizontal under the flanges. The sloped surfaces of the points shall terminate so as to form a flat surface which does not exceed one fourth of the flange width. The surfaces may have individual or continuous cutting teeth. The minimum weight of the pile tips shall be in accordance with the schedule as follows:

| PILE TIP SIZE | MIN. WEIGHT OF TIP, kg (lb) |
|---|---|
| HP 254 (HP 10) | 10 (22) |
| HP 305 (HP 12) | 13 (28) |
| HP 356 (HP 14) | 21 (46) |

The welds for the attachment of a pile tip shall be partial penetration single bevel groove welds placed full flange width along the outside of each pile flange.

Either the pile tip or the outside of each flange of the pile shall be beveled 45 degrees. The depth of the bevel shall be a minimum of 10 mm (3/8 in.) for HP 250 x 62 and HP 310 x 79 (HP 10 x 42 and HP 12 x 53) piles; and a minimum of 11 mm (7/16 in.) for HP 330 x 109, HP 360 x 108, and HP 360 x 132 (HP 13 x 73, HP 14 x 73, and HP 14 x 89) piles. The width of weld at the outside face of the pile flange shall be the same as the beveled depth. E60XX welding rods shall be used. All welds shall be made in the flat position.

The ends of the piles shall be prepared and welded to the pile tips in accordance with the manufacturer's recommendations.

Steel H pile tips furnished shall be covered by a type C certification in accordance with 916. The Engineer will randomly select one pile tip of each size to verify the minimum weight requirement, prior to use.

**701.13 Cut-Off Lengths.** The tops of all permanent piles and pile casings shall be cut off at the elevation shown on the plans. All cut-off lengths shall become the property of the Contractor and shall be removed from the project site.

**701.14 Method of Measurement.** Piles, epoxy coated piles, and cored holes in rock will be measured by the meter (linear foot) complete in place. Timber piles will be measured by the meter (linear foot) furnished and by the meter (linear foot) driven. Test pile, dynamic pile load test, static pile load test, test pile restriking, and pile tip will be measured per each. Encasement, class A concrete filling, reinforcing steel, and epoxy coating will not be measured for payment.

**701.15 Basis of Payment.** The accepted quantities of steel shell encased concrete piles, epoxy coated steel shell encased reinforced concrete piles, steel H piles, epoxy coated steel H piles, reinforced concrete encased steel H piles and cored holes in rock will be paid for at the contract unit price per meter (linear foot) for the thickness and diameter, or size specified, complete in place. The accepted quantities of furnished timber piles will be paid for at the contract unit price per meter (linear foot). The accepted quantities of driven timber piles will be paid for at the contract unit price per meter (linear foot). Test piles; dynamic pile load test; static pile load test; test pile, restrike; and pile tip will be paid for at the contract unit price per each for the pile size or designation specified.

**(a) Timber Piles Furnished.** Timber foundation piles, including piles used as test piles, but not including test piles driven outside the limits of the structure, will be paid for at the contract unit price per meter (linear foot) for pile, timber, furnished, for the length of accepted piles actually placed in the leads, except as follows.

For all timber piles delivered to the site of the work on written orders and accepted but not used because of unforeseen foundation conditions or a change in plans, payment will be made at 50% of the contract unit price for timber piles furnished. Such piling shall remain the property of the Contractor, and shall be removed from the project site before the completion of the work.

**(b) Timber Piles Driven.** Timber piles driven, complete in place and accepted, including test piles, will be paid for at the contract unit price per meter (linear foot) for pile, timber, driven. Payment will be made only for actual number of meters (linear feet) of piling left in place.

**(c) Epoxy Coated Piles.** Epoxy coated piles may be furnished and driven at lengths greater than those shown on the plans. Additional lengths of such epoxy coated piles left in place and accepted will be paid for as steel shell encased piles or steel H piles.

Payment will be made under:

| **Pay Item**<br>**Metric Pay Item**<br>**(English Pay Item)** | **Pay Unit Symbol**<br>**Metric Pay Unit Symbol**<br>**(English Pay Unit Symbol)** |
|---|---|
| Cored Hole in Rock, _____ mm (diameter) | m |
| (Cored Hole in Rock, _____ in. (diameter) | LFT) |
| Dynamic Pile Load Test | EACH |
| Pile, Concrete, Steel Shell Encased, _____ (shell thickness), _____ (diameter) | m (LFT) |
| Pile, Reinforced Concrete, Steel Shell Encased, Epoxy Coated, _____ (shell thickness), _____ (diameter) | m (LFT) |
| Pile, Steel H, Epoxy Coated, HP _____ x _____ (size) | m (LFT) |
| Pile, Steel H, HP _____ x _____ (size) | m (LFT) |
| Pile, Steel H, Reinforced Concrete Encased, HP _____ x _____ (size) | m (LFT) |
| Pile, Timber, Driven | m (LFT) |
| Pile, Timber, Furnished | m (LFT) |
| Pile, Timber, Treated, Driven | m (LFT) |

Pile, Timber, Treated, Furnished .....m (LFT)
Pile Tip, _____, _____ ..... EACH
pile size type
Static Pile Load Test, _____ ..... EACH
pile size
Test Pile, _____ ..... EACH
pile size
Test Pile, Restrike, _____ ..... EACH
pile size

The costs of furnishing, driving, placing piles, concrete or B borrow necessary to fill cored holes, and all necessary incidentals shall be included in the cost of this work.

The costs of cut off piling; piling which is not driven in accordance with these specifications; piling which was not ordered or is not acceptable; broken, split, or misplaced piles; piles driven with tops lower than the cutoff elevation; and all labor, equipment, and necessary incidentals shall be included in the cost of the pile, timber, driven. Such costs shall not include the cost of furnishing the piles.

The costs of the following items shall be included in the cost of steel shell encased piles or steel H piles.

(a) amounts cut off;
(b) broken, bent, damaged, or misplaced shells or piles;
(c) concrete filling;
(d) corrective location or alignment measures;
(e) epoxy coating;
(f) furnishing or splicing steel encased piles;
(g) modifying or replacing pile driving equipment;
(h) redriving piles which have heaved more than 6 mm (1/4 in.);
(i) reinforcing steel;
(j) repairing epoxy coating;
(k) replacing epoxy coated piling;
(l) shells of piles which are not acceptable or damaged during driving;
(m) shells of piles which were not driven in accordance with these specifications;
(n) splicing of jetted sites; and
(o) steel H piles.

No payment will be made for shells or piles delivered to the project site but not used due to unforeseen foundation conditions or a revision in the plans. Such shells or piles shall remain the property of the Contractor and shall be removed from the project site before completion of the work. No additional payment will be made if the Contractor elects to furnish and drive thicker walled pile shells than specified.

The costs of spudding or jetting of concrete piles to obtain the desired penetration shall be included in the cost of concrete piling.

The cost of reaction piles used in the static load test shall be included in the cost of the static load test. The reaction piles will not be paid for as production piles, even when used as a production pile.

The costs of reinforcing steel which extends beyond the limits of the epoxy coating as shown on the plans and of repair to damaged epoxy coating shall be included in the cost of the epoxy coated steel shell encased reinforced concrete pile.

## SECTION 702 – STRUCTURAL CONCRETE

**702.01 Description.** This work shall consist of furnishing and placing portland cement concrete for structures and incidental construction in accordance with these specifications and in reasonably close conformance with the lines, grades, and dimensions as shown on the plans or as directed.

**702.02 Classes of Concrete.** The following classes of concrete shall be used where specified:

| Class of Concrete | A | B | C |
|---|---|---|---|
| Cement content in kilograms of cement per cubic meter (pounds per cubic yard) of concrete | 335 (564) | 279 (470) | 391 (658) |
| Maximum water/cement ratio in kilogram (pounds) of water per kilogram (pound) of cement | 0.490 | 0.620 | 0.443 |

Unless specified otherwise, the concrete used shall be class A. When class A is specified, class C may be used as a substitution. When class B is specified, class A or class C may be used as a substitution.

**702.03 Materials.** Materials shall be in accordance with the following:

Admixtures for Concrete .....912.03
Castings .....910.05
Cast Iron Soil Pipe .....908.10
Coarse Aggregate
  For exposed concrete Class A or Higher,
    Size No. 8 .....904
  For non-exposed concrete, Class B or Higher,
    Size No. 8 .....904
Curing Materials .....912.01
Curing-Sealing Materials .....912.02

Fabric for Waterproofing .....913.16
Fine Aggregate Size No. 23.....904
Fly Ash .....901.02
Geotextile for Use With Underdrain.....913.19
Ground Granulated Blast Furnace Slag.....901.03
Permanent Metal Forms .....910.03
Portland Cement.....901.01(b)
Steel Drain Pipe .....910.07
Utility Asphalt, UA-I.....902.01(b)
Water.....913.01

Grout material for field drilled holes shall be either a high-strength, non-shrink, non-metallic, cementations grout in accordance with U.S. Army Corps of Engineers Specification CRD-C 621 or an approved 100% solids chemical anchor system.

**702.04 Shipping and Storage.** The cement shall be well protected from rain and moisture. All cement damaged by moisture or which fails to meet the specified requirements shall be rejected and removed from the work. Cement stored for a period longer than 60 days shall be retested before being used on the work. Cement of different brands, types, or from different mills shall be stored separately.

## CONSTRUCTION REQUIREMENTS

**702.05 Proportioning.** The proportion of ingredients of each batch shall be within the following limits, and shall be approved.

The relative yield of the concrete shall be determined in accordance with 505. The concrete when produced shall provide a relative yield of 1.00 $\pm$ 0.02. When the relative yield is outside the tolerances, adjustments to the batch weights shall be made. The minimum amount of cement shall be used for the desired class of concrete. The cement content shall not be increased more than 36 kg/m$^3$ (60 lb/cu yd). The relative yield of the concrete shall be maintained as stated above. If portland pozzolan cement, type IP, or air-entrained portland pozzolan cement, type IP-A, are to be used in the structural concrete, the cement content shall be increased by a multiplier of 1.06 times the minimum amount of cement required or the desired increased cement content for the specified class of concrete (i.e. 1.06 x 335 = 355 kilograms per cubic meter (1.06 x 564 = 598 lb/cu yd) for class A concrete).

Fly ash from an approved source may be used as a partial replacement for portland cement. The substitution of fly ash for portland cement will not be permitted in conjunction with the use of blended portland cement types, IP, IPA, IS, and ISA nor ground granulated blast furnace slag. Mix designs will be based on using a maximum 20% cement reduction with a minimum 1.25 to 1 ash-to-cement replacement ratio by weight.

Ground granulated blast furnace slag from an approved source may be used as a partial replacement for portland cement. The substitution of ground granulated blast furnace slag for portland cement will not be permitted in conjunction with the use of blended portland cement types, IP, IPA, IS, and ISA, nor fly ash. Mix designs will be based on using a maximum 30% cement substitution with a 1:1 slag-to-cement ratio, by weight.

Portland pozzolan cement, type IP, fly ash, and ground granulated blast furnace slag used as a pozzolan may only be used in concrete bridge decks between April 1 and October 15 of the same calendar year.

Fine aggregate shall be no less than 35% nor more than 45% of the total weight of aggregates used, except the limit may be increased to 50% when slag coarse aggregate is used. The aggregates shall be proportioned to use the maximum amount of coarse aggregate which produces a workable mix.

When fly ash or ground granulated blast furnace slag is used, an acceptable concrete mix design shall be submitted. Fly ash or ground granulated blast furnace slag and all other material sources proposed for portland cement concrete mix designs shall be furnished at least 15 days prior to the initiation of work. Prior to use, it shall be demonstrated by trial batch that the concrete mix design will produce concrete complying with all requirements. A concrete mix design will not be considered approved until this trial batch demonstration is successfully completed, including flexural strength data. The required 3,800 kPa (550 psi) flexural strength shall be obtained at an age consistent with the contract work schedule, but not to exceed 28 days.

Once a mix design has demonstrated for the contract that the concrete mix design with a specific fly ash source or a specific ground granulated blast furnace slag source produces a concrete which is in accordance with the mix design requirements, further trial batch demonstration will be at the Engineer's discretion for this contract and subsequent contracts.

All concrete shall have an air content of 6.5% $\pm$ 1.5% by volume. Air content shall be determined in accordance with 505. When fly ash is used, the first concrete truck on the contract will be tested by the Department for complete compliance with plastic concrete requirements for air content, slump, and yield. If not in complete compliance, the concrete will be rejected and no further concrete with fly ash in it will be considered on the contract until it is demonstrated by an additional trial batch that the concrete mix design, or modification thereof, complies. All demonstration testing shall be conducted by the Contractor. During the placement of concrete containing fly ash, the air content of the concrete shall be determined to be at least equal to the testing requirements set out in the Department's Manual for Frequency of Sampling and Testing and Basis For Use of Materials. Additional testing may be required, as

conditions warrant. All such air content testing of the concrete shall be performed by a certified technician. A certified technician must have successfully completed a concrete course offered by the Department's Human Resources Division, the National Ready Mix Concrete Association, the American Concrete Institute, or approved equal.

Portland cement concrete with fly ash or ground granulated blast furnace slag which does not consistently comply with Department concrete requirements due to the presence of the fly ash or ground granulated blast furnace slag will be grounds for rejection of its further use. In the event of such a rejection of further use, all unsatisfactory work shall be corrected with no additional payment and the contract shall be completed using portland cement without fly ash.

Powdered admixtures shall be measured by weight and paste or liquid admixtures by weight or volume, and all shall be within 3% of the amount required. When admixtures are used in small quantities in proportion to the cement, as is the case for air-entraining admixtures, mechanical dispensing equipment shall be provided.

Class C concrete shall contain either a water-reducing admixture or a water-reducing retarding admixture. The type used shall not be changed during any individual contiguous pour. The type admixture to be used will be selected based on the expected concrete or air temperature. When either temperature is expected to be 18°C (65°F) or above, a water-reducing retarding admixture shall be used. A water-reducing admixture shall be used when both temperatures are expected to be below 18°C (65°F) unless retardation is required due to the structure design or the proposed pour sequence such as the requirements for floor slab pours set out in 704.04. Air-entraining cements will not be permitted in class C concrete.

The manufacturer's data, which relates recommended addition rates to ambient temperatures, shall be furnished. The proposed addition rates and adjustments to the rates, as conditions require, will be approved using this data and the anticipated temperature. The addition rate shall not be reduced below the minimum rate recommended by the manufacturer, regardless of the concrete or air temperature. The air entraining admixture and water-reducing retarding admixture shall be added to the batch separately. The method and equipment for adding water-reducing retarding admixture will be approved.

If the contract requires stay-in-place metal forms for the bridge deck or if the Contractor elects to use such forms, the bridge deck concrete shall incorporate class AP coarse aggregate instead of class A.

**702.06 Batching.** Unless otherwise permitted, the minimum batch shall be 1.5 $m^3$ (2 cu yd). Measuring and batching of materials shall be done at a batching plant. Different kinds or sources of coarse aggregate or different brands of cement shall not be used in any one unit of the structure except in an emergency and then only by written permission.

**(a) Portland Cement.** Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed. All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be sealed and vented to preclude dusting during operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement does not lodge in it nor leak from it. Accuracy of batching shall be $\pm$ 1% of the required weight.

If fly ash is used as a pozzolan in portland cement concrete, the cement and fly ash shall be weighed and discharged separately when a manual operation is utilized. When an automatic batching plant is utilized, the fly ash may be weighed into the cement weigh hopper in one cumulative operation with the portland cement always being weighed in first.

**(b) Water.** Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within 1% of the required amount.

**(c) Aggregates.** The batch plant site, layout, equipment, and provisions for transporting material shall be such as to assure a continuous supply of reasonably uniform material to the work. Aggregate stockpiles shall be located in areas sufficiently well drained to prevent the dirt underneath from becoming softened and pumping into the aggregate to a level from which the aggregate is to be removed and used in the work. Stockpiles shall be built in layers not to exceed 1.8 m (6 ft) in depth. Upper layers shall be prevented from spilling over the sides of the layers below.

The removal of aggregates from stockpiles shall be done in such a manner that segregation will not occur. Aggregate which has become mixed with dirt shall not be used in the work.

Washed aggregates shall drain for at least 12 h prior to use. An increase in the drainage time may be required, as directed, at any time when the moisture becomes non-uniform in aggregates from any source. Aggregates from different sources shall not be stockpiled together without written approval.

Batching shall be conducted so as to obtain the weights of materials required within a tolerance of $\pm$ 2%.

**(d) Bins and Scales.** The batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a bin, hopper, and scale for cement shall be included. If fly ash is used, the separation of cement and fly ash bins will be as approved. Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

Means of control shall be provided so that as the quantity required in the weighing hopper is approached the material may be added slowly and shut off with precision. A port or other opening for removing an overload from the hopper shall be provided. A port for sampling cement shall be provided and may be either the overload

port or a separate port located at any point from the bottom of the storage bin to the weigh hopper. The sampling port shall be located and constructed so as to provide a representative sample of the cement being used. Weighing hoppers shall be constructed so as to eliminate accumulation of tare materials and to discharge fully.

For applied loads of 4450 N (1,000 lb) and greater on the cement scale and applied loads of 17 800 N (4,000 lb) and greater on the aggregate scale, the scales shall be accurate to 0.5%. For applied loads of less than 4450 N (1,000 lb) and 17 800 N (4,000 lb) for the cement and aggregate scales, respectively, the scales shall be accurate to 2.0% or one graduation, whichever is larger. Poises shall be designed to be locked in any position to prevent unauthorized change of position. Scales will be inspected as often as necessary to ensure their continued accuracy. No less than ten 23 kg (50 lb) weights shall be provided at all times for testing of scales.

Batching plants may be equipped with approved automatic weighing devices to proportion aggregates and bulk cement.

**(e) Batching.** When batches are hauled to the mixer, bulk cement shall be transported either in waterproof compartments or between the fine and coarse aggregates. When cement is placed in contact with the aggregates, batches may be rejected unless mixed within 1 1/2 h of such contact. Sacked cement may be transported on top of the aggregates.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss and, when more than one batch is carried on the truck, without spillage of material from one batch compartment into another.

**702.07 Mixing.** Concrete may be mixed at the site of construction, at a central point, or wholly or in part in truck mixers. Retempering concrete by adding water or by other means will not be permitted after initial set. When concrete is delivered in transit mixers, additional water may be added occasionally to increase the slump, if permitted, and additional mixing shall be performed as directed and all operations completed within the time limits in accordance with 702.09(c). The amount of water added shall be determined accurately and noted on the batch ticket. Such addition of water will not be permitted as a continuing operation. The total of all water included in the mix shall not exceed the maximum in accordance with 702.02. Concrete that is not within the specified slump limits at time of placement shall not be used. Except as required in 702.05 for class C concrete, a water reducing admixture, type A, or a water reducing and retarding admixture, type D, may be used in the concrete. Chemical admixtures type B, type C, and type E will be permitted only with prior written permission.

**702.08 Mixing at Site of Work.** For concrete to be acceptable, not more than 1 h shall elapse from the time mixing water has entered the mixer until the mixed batch is deposited into the forms.

The concrete shall be mixed in an approved batch mixer which has a rated capacity of not less than 85 kg (188 lb) except for pours of 15.3 $m^3$ (20 cu yd) or less, or where otherwise specifically permitted, a 42.5 kg (94 lb) minimum capacity mixer may be used. Mixers shall ensure a uniform distribution of ingredients throughout the mass. No mixer shall be operated beyond its factory rated capacity.

The concrete shall be mixed no less than 60 s after all ingredients, including water, are in the mixer.

During the period of mixing the drum shall rotate at the speed for which it was designed, which shall be no less than 14 nor more than 20 revolutions per minute. If this procedure does not mix the concrete thoroughly, a sufficient additional number of turns at the same rate shall be made until a thorough mixing of the ingredients is obtained.

The mixer shall be equipped with a batch meter for counting the number of batches discharged and a timer for automatically locking the discharge chute to prevent emptying the mixer prior to the specified minimum mixing time. Mixers shall be equipped with mechanical means for preventing the addition of ingredients, including water, after mixing is started. The first batch shall contain an additional quantity of cement, fine aggregate, and water sufficient to coat the inside surface of the drum in order to avoid diminishing the mortar content of the initial batch. The entire contents of the drum shall be removed before the materials for the next batch are introduced. Upon cessation of mixing for any considerable time, the drum shall be cleaned thoroughly.

Structural concrete shall be mixed only in such quantities as are required for immediate use and shall be placed while fresh before initial set has occurred. Hand mixing will not be permitted except in an emergency and then only with permission. Hand mixing shall be done on a watertight platform in such manner and so continued to ensure a homogeneous mixture of the required consistency. Hand mixed batches shall not exceed 0.4 $m^3$ (0.5 cu yd) in volume.

### 702.09 Ready-Mixed Concrete.

**(a) General Requirements.** Ready-mixed concrete shall be mixed and delivered by means of one of the following operations:

1. Mixed completely in a stationary mixer and the mixed concrete transported to the point of delivery in a truck-agitator or truck-mixer at agitating speed or in approved non-agitating equipment in accordance with 702.09(d). Concrete delivered under these provisions shall be known as central-mixed concrete.

2. Mixed partially in a stationary mixer and the mixing completed in a truck-mixer. Concrete delivered under these provisions shall be known as shrink-mixed concrete.

3. Mixed completely in a truck-mixer. Concrete delivered under these conditions shall be known as transit-mixed concrete.

The source of ready-mixed concrete shall be approved prior to delivery of the concrete. This approval will be based on the capacity and condition of the equipment, volume of production, and length of haul, with consideration of the use to which the concrete is to be put. Original approval will not constitute continued approval if satisfactory concrete or rate of delivery is not maintained.

Approval may be refused or previous approval may be withdrawn for a truck mixer or for a part of equipment not functioning in such manner as to produce and deliver uniform concrete to the site of the work at a uniform rate.

Before a pour is started, the number of trucks to be assigned to the work, the rate of production, and all other conditions necessary for furnishing satisfactory concrete shall be subject to approval. Such assigned equipment shall be in satisfactory operating condition prior to the start of the pour. Equipment once assigned to a pour shall not be diverted for another purpose without approval.

**(b) Mixers and Agitators.** Mixers and agitators shall be in accordance with the following:

1. Mixers may be stationary mixers or truck-mixers. Agitators may be truck-mixers or truck-agitators. Each mixer and agitator shall have attached to it in a prominent place a metal plate or plates on which are plainly marked, for the various uses for which the equipment is designed, the capacity of the drum or container in terms of the volume of mixed concrete, the speed of rotation of the mixing drum, and manufacturer's name and address. Stationary mixers shall be equipped with an acceptable timing device which does not permit the batch to be discharged until the specified mixing time has elapsed. Truck-mixers shall be equipped with means by which the number of revolutions of the drum may be verified readily. The counters shall be actuated at the time of starting mixing at mixing speed.

2. The mixer, when loaded to the manufacturer's rated capacity without overload, shall be capable of combining the ingredients of the concrete within the specified time into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity in accordance with requirement 4 of 702.09(b).

3. The agitator, when loaded to the manufacturer's rated capacity without overload, shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity in accordance with requirement 4 of 702.09(b).

4. Slump tests may be made of individual samples taken when discharged at approximately the 1/4 and 3/4 points of each load. If the slumps differ by more than 25 mm (1 in.) when the average slump is 76 mm (3 in.) or less, or by more than 50 mm (2 in.) when the average slump is greater than 76 mm (3 in.), the mixer or agitator shall not be used until conditions are corrected, except as set out in requirement 5 of 702.09(b).

5. Use of equipment may be permitted when operations with a longer mixing time or with a smaller load will permit the requirements in requirement 4 of 702.09(b) to be met.

6. Mixers and agitators shall be examined daily for changes in conditions due to the accumulations of hardened concrete or mortar or to wear of blades. When such change of conditions is found, the tests described in requirement 4 of 702.09(b) shall be repeated.

**(c) Mixing and Delivery.** Mixers and agitators shall be operated within the limits of the capacity and speed of rotations designated by the manufacturer. The following shall apply in fulfilling these requirements.

1. The complete mixing time for a stationary mixer shall be no less than 60 s. Mixing time shall be measured from the time all cement and aggregates are in the drum. The batch shall be so charged into the mixer that some of the water enters in advance of the cement and aggregates. All required water shall be in the drum by the end of the first quarter of the specified mixing time.

2. If a stationary mixer is used for shrink mixing, the time in the stationary mixer may be reduced to the minimum required to intermingle the ingredients, or approximately 30 s. Mixing shall then be completed in a truck-mixer by no less than 50 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as mixing speed. Additional mixing, if required, shall be at the speed designated by the manufacturer as agitating speed.

3. If the concrete is mixed in a truck-mixer loaded to its rated capacity, the number of revolutions of the drum or blades at mixing speed shall be no less than 70 nor more than 100, but not less than that recommended by the mixer manufacturer.

4. If a truck-mixer or truck-agitator is used for transporting concrete that has been completely mixed in a stationary mixer, further mixing during transportation shall be at the speed designated by the manufacturer of the equipment as agitating speed.

5. If a truck-mixer or truck-agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and its discharge completed within 90 min after the introduction of the mixing water to the cement and aggregates, or the introduction of cement to the aggregates, unless a shorter time is otherwise specified. When a truck-mixer is used for the complete mixing of the concrete, the mixing operations shall begin within 30 min after the cement has been added to the aggregates.

6. When authorized, a truck-mixer may be charged with aggregates and water at the batching plant and with bagged cement at the point of delivery, provided the truck-mixer is then operated at mixing speed for the required additional revolutions and satisfactory concrete produced.

7. For truck-mixers, wash water shall not be used as a portion of the mixing water for succeeding batches.

**(d) Non-Agitating Equipment.** Central mixed concrete may be transported from the mixing plant to the place of use in non-agitating equipment when and as approved. The following shall apply in fulfilling these requirements.

1. Bodies of non-agitating equipment shall be smooth, watertight, metal containers equipped with gates that permit control of the discharge of the concrete. Covers shall be provided for protection of the concrete when required.

2. The concrete shall be delivered to the site of the work in a thoroughly mixed and uniform mass and discharged with the degree of uniformity in accordance with requirement 3 of 702.09(d). Discharge shall be completed within 30 min after the introduction of the mixing water to the cement and aggregates.

3. Slump tests shall be taken in accordance with requirement 4 of 702.09(b). If the slumps differ by more than these tolerances the non-agitating equipment shall not be used until the conditions are corrected in accordance with requirement 4 of 702.09(d).

4. If the requirements of requirement 3 of 702.09(d) are not met when the non-agitating equipment is operated at minimum capacity for the maximum time of haul and with the concrete mixed the minimum time, the equipment may still be used when operated using smaller loads, shorter hauls, or longer mixing times, or combinations thereof, which permits the requirements in requirement 3 of 702.09(d) to be met.

**702.10 Pumping Concrete.** If the Contractor elects to convey concrete by means of pumping, the concrete shall be handled so as to minimize disturbance to the concrete which significantly alters the properties of the concrete being pumped, especially the loss or variability of the air content. The pumping equipment shall be mechanically sound, suitable in kind, and adequate in capacity for the proposed work. The concrete shall not be pumped through aluminum or aluminum alloy pipe. All pipes used for pumping concrete shall be kept clean and free from coatings of hardened concrete. Pump lines shall not rest directly on epoxy coated reinforcing steel. The pumping equipment shall be located such that operational vibrations will not damage freshly placed concrete.

When placing concrete directly from a truck mounted boom, the concrete pump lines shall have a flexible end section at least 3 m (10 ft) long. Methods of placement shall be such as to result in a steady and continuous discharge. If necessary, this may require the use of a restrictive device at or near the end of the discharge tube, the laying the flexible end section horizontally, or other means. For the initial placement of concrete pours which are predominantly vertical, the discharge end of the flexible end section shall be within 0.6 m (2 ft) of the bottom of the pour.

The Contractor shall submit a description of the pumping procedures which it intends to use, and shall notify the Engineer as to the pumping procedure at least 24 h in advance of concrete placement.

**702.11 Cold Weather Concrete.** When it is necessary to place concrete at or below an atmospheric temperature of 2°C (35°F), or whenever it is determined that the temperature may fall below 2°C (35°F) within the curing period, the water, aggregates, or both shall be heated and suitable enclosures and heating devices provided. Cold weather concrete shall be placed at the risk of the Contractor and shall be removed and replaced with no additional payment if it becomes frozen or otherwise damaged.

When aggregates or water must be heated, the concrete shall have a temperature of at least 10°C (50°F) and not more than 27°C (80°F) at the time of placing. Heating equipment or methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The equipment shall be capable of heating the materials uniformly. Neither aggregates nor water used for mixing shall be heated to a temperature exceeding 66°C (150°F). The maximum temperature of concrete produced with heated aggregates shall be 32°C (90°F). Materials containing frost or lumps of frozen material shall not be used. When either aggregates or water are heated to 38°C (100°F), they shall be combined first in the mixer before cement is added.

Stockpiled aggregates may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire. However, a drier in accordance with 409.02(a)5 may be used if approved.

When aggregates are heated in bins, steam-coil or water-coil heating or other methods which are not be detrimental to the aggregates may be used. The use of salt or other chemicals to accelerate hardening of the concrete will not be permitted unless approved in writing.

Immediately after a pour is completed, the freshly poured concrete and forms shall be covered so as to form a protective enclosure and the air in the enclosure kept at a temperature above 10°C (50°F) for at least 144 h for bridge decks, the top surface of reinforced concrete slab bridges, and for at least 72 h for all other concrete. If for any reason this temperature is not maintained, the heating period shall be extended. When dry heat is used, means shall be provided to maintain adequate moisture in the air within the enclosure.

All necessary measures shall be taken during protective heating to keep the heating equipment in continuous operation and to ensure maintenance of the proper temperature around the concrete. Adequate fire protection shall be provided where heating is in progress and such protection shall be accessible at all times.

Where practicable, forms insulated with at least 50 mm (2 in.) thick blankets made of fiberglass, rock wool, balsam wool, or similar commercial material capable of maintaining the surface of the concrete at no less than 10°C (50°F) may be used in lieu of other protection of concrete involving housing and heating. When forms are insulated, exposed horizontal surfaces shall be protected with a similar layer of the insulating material fastened securely in place. If the insulated forms do not maintain the proper temperature at the surface of the concrete, auxiliary protection and heat shall be used.

**702.12 Consistency.** Slump will be measured in accordance with 505 and shall be no less than 25 mm (1 in.) nor more than 100 mm (4 in.) except for concrete placed in foundation seals.

**702.13 Forms.**

**(a) Construction.** Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations, including vibration. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber.

Unless otherwise provided, all forms for exposed surfaces except the undersides of girders, slabs, and arch rings shall be lined with approved plywood, metal, or similar satisfactory composition. The lining shall not be sprung into place. Before concrete is placed, all open joints shall be filled with a satisfactory filler which is impervious to moisture, does not stain or otherwise injure the concrete, and produces a tight joint. The lining shall present a smooth uniform surface. Lining of sufficient thickness to resist the pressure of the concrete without deflection may be applied directly to the studding if it otherwise complies with the foregoing provisions for form lining.

In designing forms, fresh concrete shall be considered as a liquid weighing 2430 kg/m$^3$ (150 lb/cu ft) for vertical loads and 1600 kg/m$^3$ (100 lb/cu ft) for horizontal pressure. A live load allowance of 2.4 kPa (50 lb/sq ft) shall be used on horizontal projections of surfaces. The scheme of formwork for work on a span over active railroad tracks shall provide a horizontal clearance of not less than 2.4 m (8 ft) from the centerline of track and a clearance height of not less than 6.7 m (22 ft) from the top of the track rail.

Spreader blocks and bracing shall be removed from the inside of forms before concrete is placed and a portion of wood shall not be left in the concrete.

Forms shall be filleted and chamfered as shown on the plans and shall be given a bevel or draft for all projections, such as girders and copings, to ensure easy removal.

**(b) Ties.** Approved ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 25 mm (1 in.) from the face without injury to the concrete. Ties may be metal or fiberglass. Ties shall be capable of supporting the designed loads. Fiberglass ties shall be ground flush with the face of the concrete surfaces. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color. Filling of the cavities will not be required between the fascia beams or girders on the underside of decks, the bottom surface of slab decks, or the bottom deck surface of box culverts. In general, tie rods shall be designed to also act as struts or spreaders. The use of wood struts will not be permitted in copings, railings, and walls less than 0.6 m (2 ft) thick. Devices which, when removed, leave an opening entirely through the concrete will not be permitted unless approved in writing. Wire ties shall not be used.

**(c) Walls.** Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

**(d) Surface Treatment.** All forms shall be treated with a formulated form coating that allows them to be released without adhering, discoloring, or otherwise damaging the concrete.

**(e) Metal Forms.**

**1. Removable.** The specifications for forms as regards design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, re-use, and oiling apply to metal forms. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms together rigidly and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter.

**2. Permanent.** Fabricated permanent metal forms for concrete deck slabs may be used as an alternate method of forming on a steel beam, steel girder, prestressed concrete I-beam, prestressed concrete spread box beam, or prestressed concrete bulb-T beam bridge. Permanent metal forms shall not be removed, and shall otherwise be in accordance with the applicable requirements of 702.13(e).

The metal forms shall be designed on the basis of dead load of form, reinforcing steel, and plastic concrete plus 2.4 kPa (50 lb/sq ft) for construction loads. The unit working stress in the steel sheet shall be not more than 0.725 of the specified minimum yield strength of the material furnished but not to exceed 250 MPa (36,000 psi). Deflection under the weight of the forms, the plastic concrete and reinforcing steel shall not exceed 1/180 of the form span or 13 mm (0.5 in.) whichever is less. However, the deflection loading shall not be less than 5.8 kPa (120 lb/sq ft) total. The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits. The design span of the form sheets shall be the clear span of the form plus 50 mm (2 in.) measured parallel to the form flutes. If the design span of the form sheets exceeds 2.9 m (9.5 ft), concrete will not be permitted to be placed in the valleys of the corrugations of the metal forms. Physical design properties shall be computed in accordance with requirements of the American Iron and Steel Institute Specifications for the Design of Cold Formed Steel Structural Members.

All reinforcing steel shall have a minimum clearance of 25 mm (1 in.) from the forms. The plan dimensions from the top surface for all primary deck reinforcing steel shall be maintained. The deck reinforcing steel shall be tied down at a maximum of 1.8 m (6 ft) centers. Permanent metal forms shall not remain in place closer than one foot from any joint exposed to the underside of the slab, except when an overlay is used on the deck.

Fabricator's shop and erection drawings shall be submitted for approval. These plans shall indicate the grade of steel and the physical and section properties for all permanent metal bridge deck form sheets. If the bridge is a steel beam or steel girder structure, these plans shall also include a clear indication of locations where the forms are supported by steel beam flanges subject to tensile stress. The drawings shall be certified by a Registered Professional Engineer prior to submittal.

Form sheets shall not be permitted to rest directly on the top of the beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 25 mm (1 in.) at each end. All attachments shall be made by welds, bolts, clips, or other approved means. Except as amended by these specifications, welding and welds shall be in accordance with the requirements of 711.32 pertaining to fillet welds. However, 3 mm (1/8 in.) fillet welds will be permitted.

Form supports at steel beam or girder bridges shall be placed in direct contact with the top flange of the beam or girder and shall be adjusted to maintain the required deck thickness. If straps are used on the top flanges, the straps shall be 4.2 mm (No. 8 gage) thick, fit tight, and shall not be galvanized. Welding of form supports to flanges of non weldable grades of steel and to steel flanges subject to tensile stresses shall not be permitted.

Form supports at prestressed concrete I-beam and box beam bridges shall be placed in direct contact with the sides of the box or edge of the I-beam flange and shall be adjusted to maintain the required deck thickness. The form supports may be attached to steel inserts cast into the top of the box or I-beam, straps extending across the top of the flange, hangers mechanically attached to reinforcing steel extending from the top flange, or by other approved methods. If straps are used across the top flange, they shall be 4.2 mm (No. 8 gage) thick, fit tight, and shall not be galvanized. Welding of attachments directly to beam reinforcing steel shall not be permitted. In addition, the use of recesses cast into the beam to serve as a form support shall not be permitted.

All permanently exposed form metal, where the galvanized coating has been damaged, shall be thoroughly and satisfactorily cleaned, wire brushed, and painted with two coats of zinc oxide-zinc dust primer in accordance with Federal Specification TT-P-641(d), Type II, with no color added. Minor heat discoloration in areas of welds need not be touched up.

Concrete shall be placed in accordance with 702.19. Particular emphasis should be placed on proper vibration of the concrete to avoid honeycombs and voids, especially at construction joints, expansion joints, attachment hardware, and valleys and ends of form sheets. Pouring sequences, procedures, and mixes shall be approved.

If it is determined that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, at least one section of the forms shall be removed at a location and time selected for each span in the contract. This is to be done as soon after placing the concrete as practical in order to provide visual evidence that the concrete mix and the procedures are obtaining the desired results. An additional section shall be removed if it is determined that there has been any change in the concrete mix or in the procedures warranting additional inspection.

After the deck concrete has been in place for a minimum of two days, the concrete shall be tested for soundness and bonding to the forms by sounding with a hammer as directed. If areas of doubtful soundness are disclosed by this procedure, the forms shall be removed from such areas for visual inspection after the pour has attained adequate strength. This removal of the permanent metal bridge deck forms shall be with no additional payment. At locations where sections of the forms are removed, form replacement will not be required, but the adjacent metal forms and supports shall be repaired to present a neat appearance and ensure their satisfactory retention. As soon as the form is removed, the concrete surfaces will be examined for cavities, honeycombs, and other defects. If irregularities are found, and it is determined that these irregularities do not justify rejection of the work, the concrete shall be repaired as directed and shall be given a class 1 finish, in accordance with 702.20(a). If the

concrete where the form is removed is unsatisfactory, additional forms, as necessary, shall be removed to inspect and repair the slab, and the methods of construction shall be modified as required to obtain satisfactory concrete in the slab. All unsatisfactory concrete shall be removed or repaired as directed.

The amount of sounding and form removal may be moderated as directed after a substantial amount of slab has been constructed and inspected, if the methods of construction and the results of the inspections as outlined above indicate that sound concrete is being obtained throughout the slabs. All facilities shall be provided as are required for the safe and convenient conduct of inspection procedures.

**(f) Precast Concrete Deck Panels.** The construction and furnishing of precast prestressed concrete deck panels in accordance with 707.09.1 will be permitted as an alternate method of forming a bridge deck slab for a prestressed concrete I-beam bridge. Precast concrete deck panels will not be permitted on a prestressed concrete I-beam bridge which is built on a sag vertical curve or on a superelevation transition unless otherwise shown on the plans. Precast concrete deck panels will not be permitted for use on a steel beam, steel girder, prestressed concrete bulb-T beam, or prestressed concrete spread box beam bridge.

The deck panel system shall replace the bottom mat of slab reinforcing and, depending on panel depth, the bottom 65 or 75 mm (2 1/2 or 3 in.) of the class C concrete slab. Formwork is eliminated in the areas between the beams, but forms shall be used for the copings and diaphragms.

Mating surfaces of the deck panels shall have a maximum deviation of 3 mm in 1.8 m (1/8 in. in 6 ft). All other dimensions as shown on the plans shall be fabricated to $\pm$ 6 mm ($\pm$ 1/4 in.), except the vertical location of prestressing strands shall be $\pm$ 2 mm ($\pm$ 1/16 in.). All panel joints shall be mortar tight immediately prior to placing the cast-in-place portion of the deck slab. Immediately prior to placement of concrete, the precast deck panels shall be wetted until free moisture appears and remains without ponding.

**(g) Removal and Re-Use of Forms.** The forms for any portion of the structure shall not be removed until the concrete is strong enough to withstand damage. If field operations are not controlled by beam or cylinder tests, the following periods, exclusive of days when the ambient temperature is below 5°C (40°F), for removal of forms and supports may be used as a guide.

| | |
|---|---|
| Centering under beams | 15 days |
| Roadway Slabs | 7 days |
| Walls, Columns, Sides of Beams, and all other parts | 12 h |

If high-early strength cement is used, these periods may be reduced as directed. If portland-pozzolan cement, type IP or IP-A, fly ash or ground granulated blast furnace slag as a pozzolan is used in the structural concrete, these periods shall not apply and the removal of forms and supports shall be controlled by test beams in accordance with 702.12(g).

In order to obtain a satisfactory surface finish, forms for railings, parapets, and exposed vertical surfaces shall be removed no less than 12 h nor more than 48 h after the concrete is placed, depending on weather conditions.

Copings, corners, and projections shall not be cracked or injured during the removal of the forms. If damage occurs, the amount of concrete adjacent to the damaged portion shall be removed and replaced as directed with no additional payment.

The shape, strength, rigidity, water-tightness, and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged lumber shall be re-sized before being used. Unsatisfactory forms shall not be used.

**(h) Test Beams.** When it is to the advantage of the Department or Contractor, when portland-pozzolan cement, type IP or IP-A, is incorporated into the structural concrete elements listed below, when fly ash or ground granulated blast furnace slag is incorporated into the structural concrete elements listed below, or when field operations are being controlled by beam tests, the removal of forms, supports, and housings, and the discontinuance of heating and curing may be permitted when the modulus of rupture reaches or exceeds the following values:

| Concrete Used in | Required Flexural Strength, kPa (psi), Dead Load Only |
|---|---|
| Girders, Arches, and similar units | 2690 (390) |
| Interior Bent or Pier Caps | 3310 (480) |

The beams will be cured under the same conditions as the concrete which they represent. Beams will be tested for flexural strength as simple beams with third point loading in accordance with 505.

**702.14 Falsework and Centering.** Detailed plans for falsework and arch centering signed by and bearing the seal of a registered professional engineer shall be submitted. These plans shall be in such form that they may be readily reproduced by white printing or some similar process. They shall be approved before falsework and centering is started. Responsibility will not be relieved by the use of these plans. Since the quality of the lumber is not known and because of the uncertainty of computing nailed joints, no responsibility will be assumed for the strength of falsework and centering.

The falsework drawings shall include details for support of interior bent caps, hammerhead piers, and the portion of the bridge floor and coping beyond facia girders or beams if the overhang is 460 mm (18 in.), or more, or if a finishing machine, concrete spreader, or other equipment is to be supported by the overhang.

The scheme of falsework for work on a span over active railroad tracks shall provide a horizontal clearance of not less than 2.4 m (8 ft) from the centerline of track and a clearance height of not less than 6.7 m (22 ft) from the top of the track rail.

**(a) Design and Construction.** Falsework shall be designed and constructed so as to safely carry the full load coming upon it with a minimum settlement and deflection and with sufficient camber to counteract unavoidable shrinkage, deformation, and settlement. Structures shall have a permanent camber only when so shown on the plans, and the falsework shall be set to provide it.

For designing falsework and centering, a weight of 2400 kg/m$^3$ (150 lb/ft$^3$) shall be assumed for plastic concrete. A live load allowance of 2.4 kPa (50 lb/ft$^2$) shall be added for horizontal projections of surfaces. All beams supporting plastic concrete shall be so designed that there are no appreciable deflection under full load. The beams shall be considered as being unsupported by knee-bracing, such bracing to be considered as relieving sagging and bending only. The use of inclined columns, where properly braced, will be permitted.

The unsupported lengths of wooden columns and compression members shall not exceed 30 times the dimensions of the least side, or 30 times the least diameter.

Unit stresses in timber shall not exceed the following:

For Douglas fir, white oak, long-leaf yellow pine:
Bending ..... 12,410 kPa (1800 psi)
Columns..... 12,410 kPa (1800 [I-L/60D] psi)
For spruce, cypress, short-leaf pine, white pine, western hemlock:
Bending ..... 10,342 kPa (1500 psi)
Columns..... 10,340 kPa (1500 [I-L/60D] psi)
In the above:
L = Length of column in millimeters (inches)
D = Least diameter or least dimension in millimeters (inches).

Hardwood wedges may be required to take up any settlement in the falsework, either before or during the placing of concrete.

Arch centering shall be constructed so as to permit it to be lowered or released gradually and uniformly after pouring arch ribs and rings. Lagging for arch centering shall be of uniform thickness. Unless otherwise permitted, the nominal thickness shall be no less than 50 mm (2 in.). A smooth surface shall be produced on the undersides of arch rings. The upper sides of all lagging shall be oiled before concrete is placed.

Unless driving of piles for falsework bents is precluded by soil or other special conditions or unless otherwise permitted, all bents for falsework shall have driven piles. These shall be so driven to support the required loads without settlement, spacing, and subsequent removal shall be satisfactory.

If permission is given to place frame bents, they shall be placed on continuous concrete mudsills, or as approved.

**(b) Removal.** Unless otherwise provided or permitted, the following shall apply to the removal of falsework and centering:

1. Falsework under beams, slabs, girders, interior bent or pier caps, and arches shall, in warm weather, remain in place at least 15 days after the concrete is poured except, if directed, this period shall be increased.

2. Falsework and arch centering under multiple-span arch bridges shall not be released from any one span until the adjacent and spandrel walls have cured for the required time and the next adjacent arch ring has been poured for at least 48 h.

3. Falsework under continuously reinforced concrete slab and girder units shall not be released from any span until the entire continuous unit has been completed and all concrete cured for the required period.

4. For concrete poured during March, April, October, and November, or any time between April and October when the average temperature is less than 10°C (50°F), the above periods shall be increased 20%. For concrete poured during December, January, and February, they shall be increased 40%.

5. If field operations are controlled by beam tests, the provisions of 702.12(g) shall apply to the time of removal of falsework unless other provisions of these specifications prohibit removal.

6. Removal of supports shall be such that permits the concrete to take the stresses, due to its own weight, uniformly and gradually.

7. The removal of falsework shall be at the risk of the Contractor. Permission for removal may be refused if it is determined that there may be resulting damage to the structure.

## 702.15 Joints.

**(a) Construction Joints.** Construction joints shall be located across regions of low shearing stress and, so far as possible, where they are hidden from view in the finished structure. They shall be made only where shown on the plans, unless otherwise permitted in writing, in accordance with this specification.

Placing of concrete shall be continuous between construction joints. If placing is interrupted and a construction joint becomes necessary, provisions shall be made for interlocking with the preceding layer by constructing raised keyways as shown on the plans or as directed.

Where fresh concrete is to be joined to that in place which has already set, the surface of the concrete in place shall be cut over with a suitable tool to remove all loose and foreign material. This surface shall then be scrubbed with wire brooms and kept wet until the new concrete is placed thereon. Immediately before the new concrete is placed, the forms shall be drawn tight against the concrete in place and the exposed surface of the concrete shall be coated with a thin coating of mortar composed of one part cement and two parts No. 23 sand.

All concrete for slabs, beams, girders, cantilevered brackets, and footings shall be placed in one continuous operation to form monolithic construction. However, if, because of rain or other unavoidable reasons, concreting is interrupted where monolithic construction is required, the concrete shall be kept plastic by placing frequent small batches until this part of the work is completed or until normal operations can be resumed. If the interruption is such that even partial operations can not be carried on and construction joints are unavoidable, the joints shall be made in planes exactly normal to the main reinforcing bars and only where the shear is a minimum. In simply supported slabs, beams, and girders, such regions of minimum shear are at or near the center of the span.

Unless otherwise provided, pours in all abutments for an arch bridge shall be continuous from the top of footing to the skewback. If it is advisable to pour only a portion of the abutment at one time, a vertical construction joint may be placed parallel to the major reinforcement of the arch ring with written permission.

Horizontal construction joints will not be permitted in footings. If there is a probability that the entire amount of concrete can not be poured monolithically, vertical or other construction joints shall be provided as directed.

Horizontal construction joints in the shafts of reinforced piers, retaining walls, and abutments, other than abutments for arch bridges, may be made only if approved. Where such joints show on an exposed surface, special care shall be taken to make the joints truly straight, clean, and watertight. To avoid visible joints so far as possible on exposed faces, the top surface of the concrete shall be finished to the underside of a strip nailed to the form work for the exposed surface of the concrete, the strip to be placed as directed. If such a horizontal joint intersects any coping or any sloping surface where a featheredge would be formed, an inclined bulkhead shall be placed so

as to make the joint normal to the sloping surface for a distance of no less than 150 mm (6 in.) or, if there is a coping, no less than the depth of the coping. Horizontal construction joints will not be permitted in the stems of concrete T-beams nor at the junction of T-beam stems and flanges.

**(b) Expansion Joints.** Structural expansion joints shall be of the form, dimensions, material, and design shown on the plans. Open expansion joints shall be completely open for the dimensions specified and for their entire length. Preformed expansion joint material shall be placed true and even and with abutting sections pressed together tightly. The material shall be of the size shown on the plans and shall be in accordance with 906.01.

**(c) Folded Metal Joints.** These joints shall be free from kinks and watertight. At bends, the strip shall be one piece if possible. Unless otherwise shown on the plans, the joints shall be soldered. Copper shall be in accordance with 910.16. Lead sheets shall be no less than 3 mm (1/8 in.) thick.

**(d) Sliding Joints.** The surface of the supporting concrete for a sliding joint shall be troweled to a smooth finish and then covered with the required thickness of bituminous material, or otherwise treated if so designated.

**702.16 Drainage Pipes Through Concrete Masonry.** At all enclosures where water could not otherwise escape through the concrete, drainage pipes shall be installed as shown on the plans. Before fill is placed around these pipes, geotextile for use with underdrains shall be placed over the drain pipe and securely held in place and loose stone shall be laid by hand over the inlet end to provide a cover which shall be sufficient to retain the fill and permit free drainage. Drains through abutments and retaining walls shall be placed with a slight incline downward towards the exposed face.

**702.17 Incased Pipes and Conduits.** Pipes and conduits which are to be encased in the concrete shall be installed before the concrete is placed. Unless otherwise provided, such pipes and conduits shall be delivered at the site of the work by those for whose use they are intended. No direct compensation will be allowed for their installation. However, no deduction in concrete quantities will be made for the volume occupied.

**702.18 Roadway Surface Drainage.** Drainage grates and basins, necessary fittings, and connections to drainage pipes shall be placed as shown on the plans or as directed.

**702.19 Pouring Bent Caps.** Caps shall not be poured on end bents nor on any other bents falling within the limits of the approach grade until the filling material has been placed.

## 702.20 Placing Concrete.

**(a) General Requirements.** Concrete shall not be placed until forms and reinforcing steel have been checked and approved. The forms shall be clean of all debris before concrete is placed. The method and sequence of placing concrete shall be approved.

Where concrete floor slabs are to be poured, walkways shall be provided to protect reinforcement from pedestrian traffic. Before placing concrete, continuous walkways shall be placed parallel to the section of floor to be poured and shall remain in place until after the concrete is placed and hardened sufficiently so as not to be injured. Walkways shall be constructed so as not to come in contact with the reinforcement and be of sufficient width to provide for finishing operations entirely from the walkway.

Except as otherwise provided, concrete shall be placed in horizontal layers of no more than 600 mm (24 in.) thick. When less than a complete layer is placed in one operation, it shall be terminated by a vertical bulkhead. Each layer shall be placed and consolidated before the preceding layer has taken initial set in order to avoid planes of separation between the layers and injury to the plastic concrete underneath. On horizontal surfaces and at horizontal construction joints, the forms shall be overfilled approximately 13 mm (1/2 in.) and then struck off to the required elevation prior to the initial set of the concrete.

When placing is temporarily discontinued and as soon as it becomes firm enough to retain its shape, the concrete shall be cleaned of all laitance and other objectionable material to a depth sufficient to expose sound concrete. Unless otherwise authorized, depositing concrete shall not be discontinued within 460 mm (18 in.) of the top of a face. However, if provisions have been made for a coping of less than 460 mm (18 in.) thick, a construction joint may be made at the underside of the coping.

Where new concrete is to abut existing concrete, the existing concrete surfaces and existing exposed reinforcing steel shall be cleaned free of dust, chips and water. Epoxy resin adhesive, in accordance with 909.11, shall be used to coat the existing concrete surfaces. The epoxy coating shall be tacky at the time that the new concrete is placed. If the epoxy coating has cured beyond the obvious tacky condition, it shall be reapplied prior to placing the new concrete.

After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

The external surface of all concrete shall be worked thoroughly, during placing, by means of tools of an approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish substantially free from water and air pockets or honeycomb.

**(b) Chutes and Troughs.** Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. Open troughs and chutes shall extend as nearly as possible to the point of deposit. Equipment made of or coated with aluminum alloys shall not be used to transport concrete. Pumping of concrete shall be in accordance with 702.10. When the discharge must be intermittent, a hopper or other device for regulating the discharge shall be provided. Placement of supplementary bins or hoppers may be ordered above the point where concrete is being deposited. The concrete shall be allowed to accumulate in these containers in considerable quantity and shall be discharged immediately through pipes extending from the bottoms of these bins or hoppers. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete. The water used for flushing shall be discharged clear of the concrete already in place.

Concrete shall not be dropped in the forms a distance of more than 1.5 m (5 ft) except when confined by closed chutes or pipes. Each part of the form shall be filled by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

**(c) Vibrating.** Unless otherwise directed, the concrete shall be compacted with mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to ensure proper and adequate compaction. Vibrators shall be of an approved type and design, adequately powered and capable of transmitting 10,800 impulses per minute in air. The diameter of the head of the vibrator shall be 32 to 64 mm (1 1/4 to 2 1/2 in.). Vibrators shall be manipulated so that the concrete is thoroughly worked around the reinforcement and imbedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish compaction but shall not be prolonged to the point where segregation occurs. Vibrators shall not be attached to nor allowed to contact forms or reinforcement or to penetrate beyond any layer of fresh concrete.

**(d) Depositing Concrete Under Water.** No concrete except for foundation seals shall be deposited under water, without written permission. If such permission is granted, care shall be exercised to prevent the formation of laitance. Concrete shall not be deposited until any laitance, which may have formed on concrete previously placed, has been removed. Pumping shall be discontinued while depositing foundation concrete if it results in a flow of water inside the forms. If concrete, except for foundation seals, is deposited under water, the proportion of cement used shall be increased at least 25% with no additional payment to compensate for losses due to water. Concrete deposited under water shall be placed in a compact mass in its final position by means of a tremie, a closed bottom dump bucket, or other approved method and shall not be disturbed after being deposited.

A tremie shall consist of a tube having a diameter of no less than 260 mm (10 in.) and constructed in sections having flanged couplings fitted with gaskets. Support of the tremie shall be such that permits free movement of the discharge end over the entire top surface of the area on which the concrete is to be deposited and also permit rapid lowering when necessary to retard or stop the flow of the concrete. The discharge end shall be kept closed until immediately prior to depositing in order to prevent water entering the tube and shall be completely sealed except when concrete is actually being deposited. The tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete through the tube shall be started by slightly raising the discharge end, but always keeping it in the previously deposited concrete. The flow shall be continuous until all the required concrete is deposited.

**(e) Placing Footing Concrete.** Except as otherwise provided for a foundation seal, footing concrete shall not be placed except when the cofferdam is dewatered and so maintained during placement.

If it is necessary to operate the pump while placing footing concrete, or immediately thereafter, the seepage water shall be conducted to a sump at the pump intake in such manner that it does not flow over the fresh concrete. Special care shall be taken to prevent pumping cement out of the fresh concrete.

Footing concrete may be placed directly against sheet piling of the cofferdam when so shown on the plans or authorized in writing. Where class X excavation has been extended beyond established neat lines of a footing, the bottom 300 mm (12 in.) of such footing shall be poured to the actual limits of the excavation. When necessary, the foundation material on which the footing is to rest shall be protected from freezing. Where an existing structure is to be extended, the existing footings shall be protected from damage. Damaged footings shall be repaired as directed with no additional payment.

Piling, if any, shall be driven to or cut off at the proper elevation to permit embedment in the footing concrete equal to that shown on the plans. All laitance or other unsatisfactory material shall be removed from the exposed surface of the concrete in place by some means which does not injure the concrete. If a footing is to be constructed on a foundation seal, it shall be to the dimensions shown on the plans and, if necessary, the height of the shaft adjusted to bring the bridge seat to the required elevation.

Placing concrete in footings shall start at one end of the footing and be continued until the surface of the concrete is brought to the elevation of the top of the footing. The concrete shall be allowed to work forward, displacing any water with as little help as possible. The concrete shall not be dragged through or shoveled into water nor deposited into running water. Placing concrete in more than a few inches of water shall be done only with written permission.

**(f) Concrete Foundation Seal.** A foundation seal may be required by the plans, as requested, or as directed. When required by the plans, the seal shall be constructed to the size shown, or as specified in writing. Where adverse dewatering conditions are encountered as described in 206.09, a foundation seal may be required to be placed to such dimensions as are necessary. If a foundation seal is requested, written permission shall be obtained before starting such work. If approval is given, the seal shall be placed to designated dimensions.

Seals shall be of class A concrete having a slump of from 130 to 200 mm (5 to 8 in.), placed continuously from start to finish, and in accordance with 702.20(d). To ensure thorough bonding, each successive layer shall be placed before the preceding layer has taken initial set. The cofferdam shall have been vented or ported at low-water level. The surface of the concrete shall be kept as nearly horizontal at all times as practicable. The seal shall be of the thickness ordered. When the seal has hardened sufficiently to withstand the hydrostatic pressure, the cofferdam shall be dewatered and the remainder of the concrete poured in the dry.

**702.21 Finishing Concrete Surfaces.** Unless otherwise authorized, the surface of the concrete shall be finished immediately after form removal. Only the minimum amount of covering necessary to allow finishing operations to be carried on shall be removed at one time. Subject to approval, metal ties may be left in the concrete for the purpose of supporting or bracing subsequent work. Such ties shall be in accordance with 702.12(b) and shall be of a type which uses a cone and rod as both spreader and tie. Before final acceptance of the work, the cones shall be removed and the cavities filled, in accordance with 702.12(b).

All concrete surfaces shall be given a finish immediately following the removal of any forms.

The concrete surfaces of pier and bent caps, the front face of mudwalls, and any other concrete surfaces specified shall be sealed. The material used for sealing shall be in accordance with 709. It shall be applied so as to obtain a finished film thickness of at least 250 $\mu$m (10 mils). Mixing, surface preparation, and method of application shall be in accordance with the manufacturer's recommendations. However, the surfaces to be sealed shall be prepared in accordance with 709 prior to applying the sealer.

At the time of the removal of forms, the concrete surface shall be scraped to remove all fins and irregular projections. The surface shall then be power ground to smooth all joints and chamfers.

After grinding is completed, a paste of grout shall be applied to the concrete surface with a sponge float to fill all air holes and small irregularities. The paste grout shall be 6 parts of pre-mix mortar mix for masonry and 1 part white portland cement in accordance with ASTM C-150, Type 1.

After the paste grout takes its initial set, the surface of the concrete shall be scraped with a steel drywall knife to remove the paste from the surface.

**702.22 Curing Concrete.** Concrete in bridge decks or the top surface of reinforced concrete slab bridges shall be cured continuously for at least 168 h commencing immediately after the surface is able to support the protective covering without deformation. Curing of patches or small full depth deck replacement areas on existing bridge decks that are to be overlayed, may be controlled by test beams in accordance with 702.24(a).

Unless otherwise specified or permitted, all other concrete shall be cured for at least 96 h commencing immediately after the surface is able to support the protective covering without deformation. If portland-pozzolan cement, type IP or IP-A, or fly ash is used, the concrete shall be cured for at least 120 h.

Membrane forming curing compound may be used in lieu of protective covering curing methods. Where it has been determined that a surface treatment or class 2 finish is to be used, the membrane forming curing compound shall not be used.

The curing of surfaces to be waterproofed may be discontinued when waterproofing is started.

If field operations are controlled by beam tests, the curing time, except for bridge decks and the top surface of reinforced concrete slab bridges, shall be in accordance with 702.13(h).

If further precautions are necessary to ensure strength, they shall be taken as directed.

**(a) Protective Covering Curing Methods.** Surfaces to be cured shall be protected by covering with cotton mats, burlap, or other satisfactory protective material and shall be kept continuously and thoroughly wet during the curing period. The protective covering shall be suitably anchored to keep the protective materials in place during the curing period. Curbs, walls, handrails, copings, and other surfaces requiring a finish in accordance with 702.21 may have the covering temporarily removed for finishing, but the covering shall be restored as soon as possible.

**(b) Membrane Forming Curing Compound.** All surfaces shall be given the required surface finish prior to application of the curing compound. During the finishing period, the concrete shall be protected by the water method of curing.

The curing compound shall be mixed thoroughly within 1 h before use. The rate of application shall be as approved, with a minimum spreading rate per application of 3.8 L (1 gal.) of liquid coating for 14 $m^2$ (150 sq ft) of concrete surface. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after stripping of forms and acceptance of the concrete finish. If the surface is dry, the concrete shall be wetted with water and the curing compound applied just as the surface film of water disappears. The second application shall be applied after the first application has set. During curing operations all unsprayed surfaces shall be kept wet with water.

The coating shall be protected against marring for at least 10 days after application. All coatings marred or otherwise disturbed shall be given an additional coating. If the surface coating is continuously subjected to injury, immediate application of water curing may be required. If the use of a curing compound results in a streaked or blotchy appearance, the method shall be stopped and water curing applied until the cause of the defective appearance is corrected.

**(c) Curing-Sealing Materials.** Curing-sealing materials may be used in lieu of protective covering curing methods when surface seal is required. These materials may only be used on concrete surfaces that are not subjected to vehicular wear and that have been formed using the slip form method. Curing-sealing material shall not be applied to cast-in-place concrete.

When curing-sealing materials are used for curing concrete, surface seal will not be required.

The curing-sealing material shall be mixed in accordance with the manufacturer's instructions prior to application. The rate of application shall be as specified in the List of Approved Curing-Sealing Materials. All concrete cured-sealed by this method shall receive two applications of the curing-sealing compound. The first coat shall be spray applied after the finished surface has been achieved. The second coat shall be applied while the first coat is still tacky.

The use of curing-sealing material shall be discontinued if plastic shrinkage cracks occur that cannot be corrected by decreasing the application rate. The concrete shall then be cured and surface sealed in accordance with 702.22(a) and 709, respectively.

The coating shall be protected against damage after application. All coatings that have been disturbed shall be given an additional coating. If the surface coating is continuously subjected to injury, immediate application of curing in accordance with 702.22(a) may be required. The concrete shall then be surfaced sealed in accordance with 709.

**702.23 Waterproofing.** The expansion joint shall be waterproofed on the following: the back surfaces of retaining walls; the top surface of all slabs under fills; the extrados of arches; the inside faces of spandrel walls; and abutments up to the finish grade line. The inside face of spandrel walls and extrados of arches shall be waterproofed.

A firmly bonded membrane, consisting of two layers of dry fabric and three applications of waterproofing material, shall be placed at all expansion joints set out herein. One uncoated layer of fabric shall not touch another layer or the concrete at any point. There shall be at least three complete and separate applications of the waterproofing material. The application shall be sufficiently heavy to conceal the weave in the fabric. Sufficient fabric shall be placed in V-strips at the joints to permit the

movement of adjacent sections of concrete without tearing the fabric. The membrane shall be carefully flashed at all exposed edges and laps sealed down thoroughly. Waterproofing shall be planned so that, at the close of work each day, all fabric placed shall have received the final application of waterproofing material.

Concrete surfaces to be waterproofed shall be reasonably smooth and free from projections and holes. Immediately before the application, the surface shall be cleaned of dust and loose materials. Waterproofing shall be done only when the surface is at least dry enough to prevent the formation of steam when the hot material is applied. When the air temperature is below 2°C (35°F), waterproofing shall not be done, unless otherwise permitted.

The material shall be applied so as to cover the area completely. If necessary, more than one coat shall be applied in order to secure a satisfactory coating and proper adhesion. Coating and fabric shall stop a uniform distance below the top surfaces of walls. The material shall not be splattered over surfaces or faces of concrete which subsequently are exposed in the finished structure. Utility asphalt for waterproofing shall be heated to a temperature of between 150°C (300°F) and 177°C (350°F). The material shall be stirred frequently to prevent local overheating. The waterproofing material shall not be damaged when backfill is placed against a waterproofed joint.

**702.24 Application of Loads to and Acceptance of New Concrete.** Except as otherwise hereinafter provided, application of loads to new concrete shall be in accordance with the following:

(a) Equipment or traffic will not be permitted on structures until all concrete required to carry live loads has been poured for at least 15 days or a flexural strength of 3800 kPa (550 psi) for third point loading has been attained.

(b) Unbalanced backfill will not be permitted until the concrete required to resist it is at least 10 days old or a flexural strength of 3030 kPa (440 psi) for third point loading has been attained. The unbalanced height shall not exceed 3 m (10 ft) until the concrete is at least 15 days old or a flexural strength of 3310 kPa (480 psi) for third point loading has been attained.

(c) The dead weight of steel or precast concrete superstructure shall not be placed on concrete until the concrete is at least five days old, or longer as directed, or a flexural strength of 2760 kPa (400 psi) for third point loading has been attained. A dead load shall not be placed on hammer-head piers until the concrete is 15 days old or until test beams attain a flexural strength of at least 3310 kPa (480 psi) for third point loading. The concrete floor, if to be placed thereon, shall not be poured until the concrete supporting the superstructure is at least 10 days old or until test beams attain a flexural strength of at least 3030 kPa (440 psi) for third point loading.

(d) Concrete anchoring inserts to support falsework shall be in place 15 days or the test beams shall attain a flexural strength of at least 3310 kPa (480 psi) for third point loading, before a dead load of concrete is applied.

For concrete poured during March, April, October, November, or at any other time between April and October when the average temperature is less than 10°C (50°F), the above periods shall be increased 20%. For concrete placed during December, January, and February, the above periods shall be increased 40%. When test beams indicate the required flexural strength, the required time periods may be reduced. If at the expiration of the specified periods test beams do not indicate the required flexural strength, the periods shall be lengthened until the required strength is attained. If portland-pozzolan cement, type IP or IP-A, fly ash, or ground granulated blast furnace slag used as an additive is incorporated into the concrete, the specified periods shall not apply and the application of loads shall be controlled by beam tests. No time extension will be considered for delays due to additional time necessary to attain specified strengths.

Traffic, live loads, and backfill against wingwalls, spandrel walls, and abutments may be allowed when test beams indicate a flexural strength of 3300 kPa (480 psi) or greater for third point loading. Concrete pavement may be opened to traffic in accordance with 502.18. Beams will be prepared and tested in accordance with 702.12(g). Before traffic is permitted over a concrete structure built to be under fill, it shall be covered with 225 mm (9 in.) or more of earth or other suitable material, or otherwise protected. All other structures shall be properly protected against impact or other damage.

When compressive strength is used as a basis for acceptance of concrete, for determining when a latex modified concrete overlaid bridge deck may be opened to traffic, for determining form removal time, or for determining when a structure may be put into service, standard specimens shall be made and cured in accordance with ASTM C 31, and shall be tested in accordance with ASTM C 39. Strength requirements shall be in accordance with ASTM C 94, with the exception as follows: the strength shall be the average of the strengths of all cylinders tested at the age specified, with a minimum of two cylinders. This average shall be equal to or greater than the required strength. If the compressive strength of one or more cylinders in one strength test is below 75% of the required strength, the entire test will be considered as failed.

Failure to meet the strength requirements will be cause for rejection of the quantity of concrete represented by the cylinders. All molds, facilities, and materials necessary to prepare and cure the specimens shall be furnished with no additional payment.

**702.25 Field Drilled Holes in Concrete.** This work shall consist of field drilling holes of the diameter and length shown on the plans or as directed.

When vertical holes are to be drilled into the top of a concrete bridge deck, a minimum clearance of 50 mm (2 in.) shall be maintained between the bottoms of holes and bottom of slab. When vertical holes are to be drilled over a steel beam flange, the holes may be extended to the top of the beam flange. When vertical holes are to be drilled over a concrete I-beam, concrete box beam or concrete girder, the depths of the holes shall be as shown on the plans. If breakout occurs on the bottom of slab during the drilling process, the work shall be stopped, the breakout shall be repaired as directed, and an approved alternate drilling method shall be used to prevent breakout.

When grouted holes are specified, the diameter and length of the holes shall be in accordance with the grout manufacturer's recommendations.

**702.26 Artificial Lighting.** No portion of the work which cannot be finished during daylight hours shall be started unless written permission to the contrary is given, in which case adequate lighting shall be provided and maintained.

**702.27 Method of Measurement.** Concrete will be measured by the cubic meter (cubic yard) in accordance with the neat lines shown on the plans or as directed. No deductions will be made for the volume of joint material, embedded reinforcement, encased piles, or for a pipe with an area of less than 0.1 $m^2$ (1 sq ft).

Cast iron drain pipes, grates, basins, and fittings will be measured by the kilogram (pound) based on the theoretical mass (weight) shown on the plans. Bronze plates will be measured by the kilogram (pound) based on a theoretical mass of 8,540 $kg/m^3$ (weight of 536 $lb/ft^3$). The volume will be computed based on finished dimensions. Steel drain pipe will not be measured for payment. Field drilled holes will be measured by the number of holes drilled.

Concrete in railings will be measured in accordance with 706.06. Reinforcing steel will be measured in accordance with 703.07.

**702.28 Basis of Payment.** The accepted quantities of structural concrete will be paid for at the contract unit price per cubic meter (cubic yard) of concrete, for the class and use specified. Cast iron grates, basins, and fittings will be paid for at the contract unit price per kilogram (pound). Cast iron soil pipe will be paid for at the contract unit price per kilogram (pound) for the diameter specified. Bronze plates will be paid for at the contract unit price per kilogram (pound). Steel drain pipe will be paid for at the contract lump sum price. Field drilled holes in concrete will be paid for at the contract unit price per each.

Concrete in railings will be paid for in accordance with 706.07. Reinforcing steel will be paid for in accordance with 703.08.

If a foundation seal is constructed as shown on the plans, it will be paid for at the contract price per cubic meter (cubic yard) for concrete, foundation seal. If ordered to be done, or permitted to be done, payment will be made at a unit price per cubic meter (cubic yard) equal to 3/4 of the contract unit price per cubic meter (cubic yard)

for class B concrete in footings. The excavation for the foundation seal will be paid for at the contract unit price per cubic meter (cubic yard) for the class of excavation specified for the footing. Unless otherwise provided, the pay quantity for excavation for foundation seal will be equal to the theoretical volume bounded by the bottom of the proposed footing, the bottom of the approved excavation, and vertical planes 460 mm (18 in.) outside the neat line of the footing and parallel thereto, regardless of the quantity actually removed. If design of the structure requires sheeting to be outside these limits, the limits will be extended to 150 mm (6 in.) beyond the neat lines required by the design of the structure. If the Contractor chooses to construct a rectangular cofferdam around a U-shaped abutment in lieu of following the outline of the footing, the maximum allowable increase in the pay quantity above the theoretical shall not exceed 25%. The pay quantity for the foundation seal will be equal to the excavation volume described above.

Payment will be made under:

| **Pay Item**<br>**Metric Pay Item**<br>**(English Pay Item** | **Metric Pay Unit Symbol (English Pay Unit Symbol)**<br>**Metric Pay Unit Symbol**<br>**English Pay Unit Symbol** |
|---|---|
| Bronze Plates | kg (LBS) |
| Concrete, A, Substructure | m3 (CYS) |
| Concrete, A, Superstructure | m3 (CYS) |
| Concrete, B, Above Footings | m3 (CYS) |
| Concrete, B, Footings | m3 (CYS) |
| Concrete, C, _____ use | m3 (CYS) |
| Concrete, Foundation Seal | m3 (CYS) |
| Drain Pipe, Steel | LS |
| Field Drilled Hole in Concrete | EACH |
| Grates, Basins, and Fittings, Cast Iron | kg (LBS) |
| Soil Pipe, Cast Iron, _____ mm diameter | kg |
| (Soil Pipe, Cast Iron, _____ in diameter | LBS) |

The costs of forms, falsework, falsework piling, centering, expansion joints, waterproofing, curing, finishing, and necessary incidentals shall be included in the costs of the pay items. The cost of placing epoxy resin adhesive on existing concrete surfaces shall be included in the cost of new concrete which abuts the existing concrete. Payment for concrete used in footings in class X excavation will be made at the contract unit price only for the cubic meters (cubic yards) placed within the neat lines of the footings as shown on the plans or as revised.

If the Contractor elects to increase the cement content as allowed herein for its advantage, no additional compensation will be made.

The cost of permanent metal forms shall be included in the cost of concrete, C, superstructure. The pay quantity of concrete in the slab will be computed from the dimensions shown on the plans, with no allowance for form deflection or geometry.

The cost of precast prestressed concrete deck panels shall be included in the cost of concrete, C, superstructure. The pay quantity of such concrete in the slab will be computed from the dimensions for the formed and poured bridge floor slab shown on the plans. The pay quantity of reinforcing steel will be the plan quantity shown with no adjustment for eliminating the bottom reinforcing steel layer nor for additional reinforcing steel required due to use of the precast concrete deck panels.

Elastomeric bearings will not be paid for directly, unless otherwise specified. The cost thereof shall be included in the of the structural member they support. The cost of protecting existing footings to be extended shall be included in the cost of concrete, B, footings, unless otherwise specified.

The costs of grout for grouting reinforcing steel in place, the length of grouted hole recommended by the grout manufacturer in excess of the length shown on the plans, and the additional length of reinforcing steel required shall be included in the cost of field drilled hole in concrete.

## SECTION 703 – REINFORCING BARS

**703.01 Description.** This work shall consist of furnishing and placing reinforcing bars and threaded tie bar assemblies with reinforcing bars in accordance with 105.03.

**703.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Reinforcing Bars, Plain or Epoxy Coated | 910.01 |
| Reinforcing Bar Splicing System | 910.01(b)3 |
| Support Devices | 910.01(b)9 |
| Threaded Tie Bar Assembly | 910.01(b)2 |

**703.03 Bar List.** The quantity and size of the reinforcing bars shall be verified against the structure drawings. The necessary corrections, if any, shall be made before ordering. Errors in the bar list and bending schedule will not be cause for adjustment of the contract unit price.

**703.04 Protection of Materials.** Reinforcing bars shall be protected at all times from damage. When placed in the work, the reinforcing bars shall be free from dirt, harmful rust, detrimental scale, paint, oil, or other foreign substance. The various sizes and lengths shall be marked plainly to facilitate inspection and checking.

Epoxy coated reinforcing bars shall be handled and stored so as to prevent damage to the reinforcing bars and the coating. All systems for handling coated reinforcing bars shall have padded contact areas. All bundling bands shall be padded or banding shall be used which prevents damage to the coating. All bundles of coated bars

shall be lifted with a spreader bar, multiple supports, or a platform bridge to prevent bar to bar abrasion from sags in the bundles of coated reinforcing bars. The reinforcing bars shall not be dropped or dragged. The bundled bars shall be stored above the ground on wooden or padded supports.

Repairs to the epoxy coating on epoxy coated reinforcing bars shall be performed on all damaged areas larger than 5 mm by 5 mm (1/4 in. by 1/4 in.). A bar will be rejected if the total area of damage exceeds 2% of the surface area or if the total area of repair exceeds 5% of the surface area. All damage within each area shall be cleaned and the repair shall be performed before visible oxidation appears. The patching or repair material shall be in accordance with 910.01(b)9.

## CONSTRUCTION REQUIREMENTS

**703.05 Bending.** Reinforcing bars required to be bent shall be accurately cold bent in a bending machine to the shapes shown on the plans. All bars in which cracks or splits occur at bends will be rejected.

**703.06 Placing and Fastening.** All dimensions shown on the plans for spacing of reinforcing bars apply to centers of bars unless otherwise noted. All bars shall be accurately placed and, during placing of the concrete, held firmly in the position as shown on the plans. Distances from the forms shall be maintained by means of chairs, ties, hangers, or other approved support devices. All reinforcing bars shall be wired rigidly or fastened securely at sufficient intervals to hold the bars in place. Welding of reinforcing bars at intersections will not be permitted. Chairs and supports holding upper layers of reinforcing bars shall support the transverse bars. The upper layer of reinforcing bars in bridge floors shall be tied or fastened at such intervals as necessary to prevent an upward or a lateral movement of a bar from the planned position.

Layers of reinforcing bars shall be separated by spacers. Reinforcing bars shall be separated from horizontal surfaces by being suspended or supported on approved chairs and spacers capable of supporting the designed loads. Supports and spacers shall be of such shape as to be easily encased in concrete. That portion which is in contact with the forms shall be noncorrosive and non-staining material. They shall be of an approved type. Vertical stirrups shall always pass around main tension members and shall be securely attached thereto. The use of pebbles, pieces of broken stone or bricks, metal pipe, wooden blocks, and similar devices for holding bars in position will not be permitted.

After being placed, reinforcing bars will be inspected and approved before the concrete is deposited. The positions of the reinforcing bars shall not be disturbed both during and after depositing the concrete. All concrete placed in violation of this requirement may be rejected and its removal will be required. Where reinforcing bars project from construction joints, all mortar clinging to the reinforcing bars from previous pours shall be removed before the next enveloping pour is made.

All reinforcing bars shall be furnished in the full lengths shown on the plans unless splices are indicated. No other splicing will be allowed except with written permission. Unless otherwise shown on the plans, reinforcing bars shall be lapped 32 diameters to make a splice. Construction joints shall not be made within the limits of lapped bars. For lapped splices, reinforcing bars shall be placed in contact and rigidly clamped or wired in an approved manner. Insofar as possible, splices shall be staggered and well distributed or located at points of low tensile stress. Splices will not be permitted at points where the section does not provide a distance of at least 50 mm (2 in.) between the splice and the nearest adjacent bar or surface of the concrete.

When splicing is indicated or permitted, an appropriate splice system on the list of approved Reinforcing Steel Splicing Systems may be used in lieu of lapped bars. The splicing system shall be installed in accordance with the manufacturer's recommendations.

Welded wire fabric, when required, shall be placed as shown on the plans or as otherwise directed. The sheets shall overlap sufficiently to maintain uniform strength and shall be securely fastened at lapped ends and edges. The laps shall be no less than one mesh in width.

Spiral reinforcement, consisting of evenly spaced continuous spirals, shall be held firmly in place by attachment to vertical reinforcement. The spirals shall be held true to line by vertical spacers. Anchorage for spiral reinforcement shall be provided with 1 1/2 extra turns of the spiral rod or wire at each end of the spiral unit. Splices in spiral rods or wire shall be made with a lap of 1 1/2 turns.

Threaded tie bar assemblies may be used in lieu of spliced reinforcing bars shown on the plans. Threaded tie bar assemblies shall achieve the minimum load in accordance with 910.01(b)2.

**703.07 Method of Measurement.** Reinforcing bars will be measured by the kilogram (pound) based on the theoretical number of kilograms (pounds) complete in place as shown on the plans or placed as ordered. The quantities of materials furnished and placed shall be based upon the calculated masses (weights) of the reinforcing bars actually placed in accordance with these specifications. The masses (weights) calculated shall be based upon the following tables.

## Metric Table

| Bar Designation No. | Mass per meter, kilograms | Bar Designation No. | Mass per meter, kilograms |
|---|---|---|---|
| 10 | 0.560 | 29 | 5.060 |
| 13 | 0.994 | 32 | 6.404 |
| 16 | 1.552 | 36 | 7.907 |
| 19 | 2.235 | 43 | 11.38 |
| 22 | 3.042 | 57 | 20.24 |
| 25 | 3.973 | | |

## English Table

| Bar Designation No. | Weight per linear foot, pounds | Bar Designation No. | Weight per linear foot, pounds |
|---|---|---|---|
| 1/4 in. | 0.167 | 8 | 2.670 |
| 3 | 0.376 | 9 | 3.400 |
| 4 | 0.668 | 10 | 4.303 |
| 5 | 1.043 | 11 | 5.313 |
| 6 | 1.502 | 14 | 7.65 |
| 7 | 2.044 | 18 | 13.60 |

Threaded tie bar assemblies will be measured by the number of assemblies placed.

Welded wire fabric will not be measured.

**703.08 Basis of Payment.** The accepted quantities of reinforcing bars will be paid for at the contract price per kilogram (pound), complete in place.

If the substitution of reinforcing bars larger than those specified is permitted, payment will be made for only that mass (weight) which would be required if the specified bars had been used.

If the use of reinforcing bar lengths shorter than those shown on the plans is permitted for convenience in transporting or placing the bars, payment will be based on the mass (weight) of the lengths shown on the plans.

Payment for threaded tie bar assemblies will be at the contract unit price per each, complete in place. If epoxy coating is specified, payment for the assemblies will be at the contract unit price per each for threaded tie bar assembly, epoxy coated.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Reinforcing Bars | kg (LBS) |
| Reinforcing Bars, Epoxy Coated | kg (LBS) |
| Threaded Tie Bar Assembly | EACH |
| Threaded Tie Bar Assembly, Epoxy Coated | EACH |

The costs of metal chairs, spacers, clips, wire, or other mechanical means used for fastening or holding reinforcement in place, and laps shall be included in the cost of reinforcing bars. The costs of coating materials and repair of damaged coating materials on reinforcing bars and on metal chairs, spacers, clips, or other mechanical means used for fastening or holding reinforcement in place, and laps shall be included in the cost of epoxy coated reinforcing bars. If threaded tie bar assemblies are used in lieu of spliced reinforcing bars as shown on the plans, the cost of such assemblies shall be included in the cost of reinforcing bars.

If welded wire fabric is required, the cost of furnishing and placing it shall be included in the cost of the concrete in which it is placed.

## SECTION 704 – CONCRETE FLOOR SLABS

**704.01 Description.** This work shall consist of placing cement concrete and reinforcing steel as a bridge floor in accordance with these specifications and in reasonably close conformance with the lines, grades, and cross sections as shown on the plans or as directed.

**704.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Castings | 910.05 |
| Cast Iron Soil Pipe | 908.10 |
| Concrete, Class C | 702 |
| Joint Materials | 906 |
| Reinforcing Steel | 910.01 |

## CONSTRUCTION REQUIREMENTS

**704.03 Forms.** Forms shall be in accordance with 702.12.

The forms for transverse and longitudinal construction joints shall have a top plate conforming to either or both the grade and crown shown on the plans or as established. When forms are unsatisfactory in any way, either before or during placing of concrete, the placing shall be suspended until defects are corrected.

The welding of angles, clips, rods, or other designs for form supports to the flanges of steel beams or girders in the areas where flanges are designed to carry tensile stress will not be permitted. The areas where welding will be permitted will be established in writing.

**704.04 Placing Reinforcement and Concrete.** Applicable provisions of 703 shall apply to placing reinforcing steel. No concrete shall be placed until the reinforcement is entirely and securely in place and has been inspected and approved. Walkways shall be in accordance with 702.19(a). Placing of reinforcement during placing of concrete will not be permitted without prior written approval. Splices, when permitted, shall be at locations of least tension in the steel.

The concrete deck pour sequence and procedure shall be submitted for approval. The minimum pour rate is that which permits the finishing machine to progress at a rate of at least 7.6 m/h (25 ft/h). If this rate is not achieved, placement of transverse construction joints may be directed. The addition of construction joints shall be performed with no additional payment. Placement of concrete, when once started, shall be continuous between joints. Horizontal joints will not be permitted.

Floor drains shall be placed in gutters at locations shown on the plans and fastened securely before placing the surrounding concrete. The tops of the floor drains shall be no more than 13 mm (1/2 in.) below the adjacent gutter grade. The drains shall be constructed so drainage water is not discharged against portions of the structure.

Expansion joints shall be constructed as shown on the plans and the material shall be in accordance with 906.01.

Transverse construction joints as shown on the plans for the floor slab of prestressed concrete beam structures may be eliminated by written approval under the conditions as follows:

(a) A retarding or a water-reducing retarding admixture shall be used in the concrete to delay set as required and approved.

(b) Concrete shall be placed for the full width of the structure, unless otherwise approved.

(c) It is determined that the concrete on two adjacent spans can be placed within a period of time which is less than the time for the initial set of the concrete section over the pier common to the two spans.

**704.05 Finishing Concrete.** Concrete shall be placed and spread to the approximate contour for the full width being placed. The concrete may then be consolidated by the use of mechanical internal vibrators in accordance with applicable provisions of 702.19(c). Vibrators shall not be used to spread or move the concrete horizontally to the extent that they cause segregation. Excessive vibration shall be avoided.

The use of a self-propelled finishing machine shall be used on all structures when either a new floor or an overlay is placed. Concrete for the full width of all traffic lanes shall then be struck off to proper profile grade and cross section by an approved, self-propelled, oscillating, finishing machine. The finishing machine may be for traffic lane widths or full width of the structure when approved. Manually operated strike-off may be used on areas outside of the width of traffic lanes or where required construction joints limit the length of deck pours to 18.3 m (60 ft) or less.

The finishing machine shall be in accordance with the applicable requirements of 508.04(b) except it shall have a minimum of one reciprocating non-vibrating screen. The weight of the machine shall not cause undue deflection of the bridge members or falsework. The machine shall travel on steel rails, pipe, or other approved grade control, which shall be adequately supported by adjustable supports securely fastened in place at spacing sufficiently close to prevent any appreciable deflection of the screen. Welding of supports to structural bridge members will not be permitted. Prior to the placing of concrete, rails for the machine support shall be set to correct elevations shown on the plans or as approved. Rails shall extend a sufficient distance beyond the area to be placed so that the machine clears all finishing operations. The screen or strike-off beam shall be made of metal or the bottom shall be metal-clad. The bottom of the screed or strike-off shall be adjusted to the true cross section of the floor surface. The machine shall make only the number of passes over the slab as required to obtain a uniform surface free of voids and reasonably true to the planned profiles and cross section. Any necessary hand finishing after removing the rails and rail supports shall be accomplished promptly, in order to fill any depressions and remove any roughness of the surface in the area from which the supports are removed. The longitudinal mechanical screeding method will be permitted when approved. A mechanical bridge deck finishing machine using a rotating cylinder setting approximately parallel to the longitudinal movement of the machine and operating transversely may be used for screeding the bridge deck, when approved.

When a finishing machine is not required or used, as soon as the concrete is placed and consolidated it shall be struck-off to the specified cross section and grade by means of a steel template or other satisfactory metal clad implement having a minimum width of 225 mm (9 in.) or greater.

For all methods of striking off the surface, an excess of concrete shall be kept in front of the cutting edge at all times. The strike-off shall go over the entire area only for the number of times necessary to produce the required profile and cross section. In general, the strike-off process shall be in accordance with 504 except a vibrator on the strike-off will not be required.

Immediately after screeding to the required cross section, the surface shall be checked with a long handled 3 m (10 ft) straightedge of light construction laid parallel to the centerline at intervals of no more than 0.6 m (2 ft) transversely and 1.5 m (5 ft) longitudinally. In case it is impracticable to operate the straightedge otherwise, it shall be operated from a footbridge or from bridges on the floor. All high spots shall be removed and depressions filled with fresh concrete and then leveled with a float having a blade approximately 1.5 m (5 ft) long and 200 mm (8 in.) wide. Floating and

manipulating concrete to fill depressions shall be held to a minimum. Checking and leveling shall continue until the surface has the required contour and is free of voids. The application of water to the surface for the purpose of lubricating the floats and straight edges may be used only when absolutely necessary and shall be held to a minimum. The water applied for this purpose shall be limited to such quantity as may be applied by heavy fogging as approved.

As soon as the water begins to leave, the surface shall be given a final check with the light weight straightedge. The required cross section shall be preserved. The final surface shall be free from porous spots caused by the disturbance of coarse aggregate particles during the final checking and brooming. After final checking, the surface shall be tined in accordance with 504.03. If a new bridge deck is to be overlaid with latex modified concrete, the surface of such deck shall be heavily broom textured to provide maximum bonding of the overlay material.

Just before the concrete has taken the initial set, the ends of slabs, exposed edges, and transverse construction joints shall be rounded to a 6 mm (1/4 in.) radius. Longitudinal construction joints shall not be edged unless otherwise directed.

Smoothness shall be in accordance with 502.20. If, after the above requirements have been met, portions of the floor are not entirely satisfactory, the removal and replacement of such portions may be ordered to secure a satisfactory floor. Such removal and replacement shall be done with no additional payment.

**704.06 Curing.** Floor slabs shall be cured in accordance with one of the methods of 702.21. If membrane curing is used, no exposed reinforcing steel shall be coated with the material. Where it has been determined that a surface treatment to prevent scaling is to be used, the Engineer may prohibit the use of the membrane forming curing compound on the floor slab or any part of the superstructure. All vertical surfaces with reinforcing steel exposed shall be cured in accordance with 702.21. The floor shall be protected from pedestrian and vehicular traffic. If walking is necessary, the surface shall be timber laid on a double burlap cushion or approved equivalent.

Opening to traffic shall be in accordance with the applicable provisions of 702.24.

**704.07 Method of Measurement.** Concrete floor slab will be measured by the cubic meter (cubic yard) in accordance with 702.26. However, no allowance will be made for variations in beam fillet depths, coping depths, or diaphragm depths, which are deemed necessary due to the beam camber, as constructed, which varies from that shown on the plans. Reinforcing steel will be measured in accordance with 703.07. Castings and cast iron pipe will be measured in accordance with 702.26.

**704.08 Basis of Payment.** The accepted quantities of concrete floor slab will be paid for at the contract unit price per cubic meter (cubic yard) for concrete, C, superstructure. Reinforcing steel will be paid for in accordance with 703.08. Castings and cast iron pipe will be paid for in accordance with 702.27.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Concrete, C, Superstructure | m3 (CYS) |
| Reinforcing Steel | kg (LBS) |

The costs of forms, curing, finishing, preformed expansion joints within structure limits, and necessary incidentals shall be included in the costs of the pay items.

## SECTION 705 – SIDEWALKS ON STRUCTURES

**705.01 Description.** This work shall consist of placing cement concrete sidewalks as an integral part of structures in accordance with these specifications and in reasonably close conformance with the lines, grades, and dimensions shown on the plans or as directed.

**705.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Concrete, Class C | 702 |
| Joint Filler | 906.01 |
| Reinforcing Steel | 910.01 |

**705.03 Construction Requirements.** The concrete shall be placed in the forms in such amount that, after being tamped and struck off, the full required thickness results. Reinforcing steel shall be in accordance with 703.

After floating, the surface shall be marked into uniform rectangles by transverse markings formed with a jointer having 6 mm (1/4 in.) radii, if shown on the plans. On cantilevered sidewalks, a marking shall be placed over the center of each bracket and the space between brackets divided into uniformly marked rectangles as directed.

At expansion joints, the sidewalk and curb shall be cut entirely through and the specified type of joint installed. All edges shall be finished to a 6 mm (1/4 in.) radius.

As soon as finished, the sidewalk shall be cured for no less than 96 h in accordance with 704.06.

The surface shall be checked with a 3 m (10 ft) straightedge placed parallel to the centerline at sufficient transverse intervals to check the general contour. An acceptable surface shall vary no more than 3 mm (1/8 in.) from the straightedge, except at grade changes, and shall be free from blemishes.

**705.04 Method of Measurement.** Sidewalks on structures will be measured by the cubic meter (cubic yard) in accordance with the dimensions shown on the plans or as ordered. Reinforcing steel will be measured by the kilogram (pound) in accordance with 703.07.

**705.05 Basis of Payment.** The accepted quantities of sidewalks on structures will be paid for at the contract unit price per cubic meter (cubic yard) for concrete, C, superstructure. Reinforcing steel will be paid for at the contract unit price per kilogram (pound) in accordance with 703.08.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Concrete, C, Superstructure | m3 (CYS) |
| Reinforcing Steel | kg (LBS) |

## SECTION 706 – BRIDGE RAILINGS

**706.01 Description.** This work shall consist of the furnishing and placing of concrete or steel railings on bridges and on top of wingwalls and retaining walls in accordance with 105.03.

**706.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Barrier Delineators | 913.08(c) |
| Concrete, Class C | 702 |
| Organic Zinc Primer | 909.02(a)3 |
| Polyurethane Finish Coat | 909.02(c) |
| Reinforcing Bars, Epoxy Coated | 910.01 |
| Steel Bridge Railing Components | 910.20 |

## CONSTRUCTION REQUIREMENTS

**706.03 Concrete Railing.** Concrete railings shall not be placed until the falsework for all of the spans have been removed and the spans are self supporting. Concrete railings shall be constructed in accordance with 702 and 703.

Forms shall be smooth, tight fitting, held true to line and grade, and be removed without damaging the concrete. These forms shall be made from selected dressed lumber or steel. Moldings, panel work, and bevel strips shall be constructed according to the detail plans with mitered joints, true corners and be sharp, clean-cut, and free from cracks, spalls, or other defects. The forms shall be constructed with a plate at the

base of the copings. Lumber which is 50 mm (2 in.) thick shall be used for coping forms.

The slip form method may be permitted as a means to place concrete railing on bridge structures. If the slip form method is chosen, a signed and dated QCP shall be prepared and submitted to the Engineer for acceptance at least 15 days prior to the start of slip form barrier rail placement. The QCP shall include, as a minimum, the Contractor's concrete mix design, including materials sources and admixtures; the Contractor's methods of materials control and testing; the Contractor's proposed method of placement, including finishing and curing; and the corrective action that will be taken when defects are found. The QCP shall also contain documentation that shows the Contractor had a successful trial demonstration of the slip form machine previously and that proper consolidation around the reinforcing steel in the wall was achieved. The slip form paver shall consolidate, screed, and finish the freshly placed concrete in one complete pass in such a manner that a minimum of hand finishing will be necessary to provide a dense and homogeneous railing in conformance with the plans and specifications. The slump shall be 13 mm (1/2 in.) $\pm$ 13 mm (1/2 in.). The joints may be formed or sawed as long as a satisfactory joint is attained. If joints are to be sawed, the full depth saw cut shall be made before uncontrolled shrinkage cracking occurs and within 48 h of concrete placement. Before full depth sawing, partial depth saw cuts of 64 mm (2 1/2 in.) $\pm$ 13 mm (1/2 in.) at the joint locations may be made as soon as the concrete has hardened sufficiently to permit sawing without raveling. All saw cuts shall be made at the locations shown on the plans or as directed.

All concrete bridge railings shall be reflectorized in accordance with 602.03(f).

Posts and joints shall be constructed perpendicular to grade. The line and grade shall not follow any unevenness of the superstructure.

If concrete railing is not in compliance with the specified design, does not present a uniform appearance of smoothness or color, or is not otherwise a workmanlike job, the Engineer may require such railing to be removed and replaced. The surface of the concrete shall vary no more than 6 mm (1/4 in.) in 3 m (10 ft) from the specified cross section, as measured longitudinally.

**706.04 Steel Railings.** Fabrication and placement of steel railings shall be completed in accordance with the applicable requirements of 711. Ends of tube sections shall be milled or sawed. Cut ends shall be true, smooth, and free from burrs and ragged edges. The rail system shall be continuous except as shown on the plans. Joints shall be spliced as detailed on the plans. Welding of steel shall be in accordance with 711.32. Radiographic, magnetic particle, and dye penetrant inspection will not be required. Anchor bolts shall be pre-set in concrete.

**706.05 Method of Measurement.** Concrete railing, including all concrete work above the top of curb, will be measured by the meter (linear foot) or by the cubic meter (cubic yard) in accordance with the dimensions shown on the plans. No deductions will be made for reinforcing bars or joints. Concrete bridge railing transition will be measured per each for the type specified.

Reinforcing bars will be measured in accordance with 703.07.

Barrier delineators will be measured in accordance with 602.05.

Steel railing will be measured by the meter (linear foot) in accordance with the dimensions shown on the plans or as directed.

Linear measurements will be made from end to end of the railing along the centerline.

**706.06 Basis of Payment.** The accepted quantities of concrete railing will be paid for at the contract price per meter (linear foot) or cubic meter (cubic yard), for railing, concrete, of the class specified. Steel railing will be paid for at the contract unit price per meter (linear foot) of the type specified. Concrete bridge railing transitions will be paid for at the contract unit price per each for the type specified. Reinforcing bars for concrete railings and concrete bridge railing transitions will be paid for in accordance with 703.08. Barrier delineator will be paid for in accordance with 602.06.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Concrete Bridge Railing Transition, _____ (type) | EACH |
| Railing, _____ (type) | m (LFT) |
| Railing, Concrete, _____ (class) | m (LFT)<br>m3 (CYS) |

The cost of painting, washers, rivets, welding, anchor bolts, and necessary incidentals shall be included in the costs of the pay items in this section.

Concrete railing which the Engineer has ordered removed and replaced in accordance with 706.03 shall be with no additional payment.

## SECTION 707 – PRECAST AND PRESTRESSED CONCRETE STRUCTURAL MEMBERS

**707.01 Description.** This work shall consist of the construction and furnishing of reinforced or prestressed concrete structural members or, if specified, concrete deck panels cast outside the structure, transported to, and incorporated into the structure in accordance with 105.03.

**707.02 Materials.** Materials shall be in accordance with the following:

Coarse Aggregates, Class A or Higher, Size No. 91 .....904
Concrete Curing Materials and Admixtures .....912

Concrete Sealers.....909.09, 909.10
Elastomeric Bearings .....915.04
Fine Aggregates, Size No. 23 .....904
Fly Ash .....901.02
Portland Cement.....901.01(b)
Prestressing Steel.....910.01(b)7
Reinforcing Steel .....910.01

**707.03 General Requirements.** Structural members including bridge slabs, box-beams, and I-beams, shall be manufactured in an approved plant where strict control over manufacturing and curing procedure is maintained at all times. Dimensions and design requirements for structural members shall be as shown on the plans. Lengths and dimension tolerances shall be as shown on the plans or as otherwise specified.

If detailed design drawings are not included in the plans, one set of design computations and four sets of detailed shop drawings shall be submitted for approval. The submitted drawings shall be 560 mm by 860 mm (22 in. by 34 in.) in overall size. These shop drawings will be reviewed for design features only. The Contractor shall be responsible for dimensions, accuracy, and fit of work. Certified mill test reports shall be furnished for all high tensile steel. Fabrication shall not begin until the shop drawings are approved.

## CONSTRUCTION REQUIREMENTS

**707.04 Steel and Concrete Requirements.**

**(a) Reinforcing Steel.** A tight coat of concrete grout will be permitted on stirrups extending from precast members. All loose and flaky material shall be removed.

**(b) Welding Reinforcing Steel.** In lieu of tying, reinforcing steel except prestressing steel may be welded in accordance with the following:

1. Welding will be permitted only at intersections of bars. Splicing of the reinforcing steel by welding will not be permitted. Welds shall have a satisfactory appearance. There are no numerical strength requirements for the completed welds. However, they shall be of such strength as to adequately hold the crossing bars in their true position during the placement of concrete. As low a current as possible shall be used so as to preclude notching and undercutting and still provide a weld of the intended strength. Notching or undercutting of the bars will be cause for rejection of the bars so damaged and the bars shall be replaced as directed.

2. Welding shall be by the shielded metal-arc process using only electrodes with low hydrogen classifications E7015, E7016, E7018, or E7028 in accordance with AWS A5.1. No minimum preheat or interpass temperature is required, except that welding shall be done only when the base metal temperature is above 2°C (35°F). The low hydrogen electrodes shall be dried for at least 2 h at a temperature between 232°C (450°F) and 260°C (500°F) before they are used. Electrodes shall be stored immediately after drying in a storage oven held at a temperature of at least 121°C (250°F). Electrodes that are not used within 4 h after removal from a drying or storage oven shall be re-dried before use. Electrodes which have been wet shall not be used.

3. All welding procedures and welders to be employed shall be qualified by tests as prescribed below. Evidence may be accepted of previous qualification of the welding procedures and welders to be employed. The same bar stock and type of welding equipment that is required for fabrication of the steel shall be used in qualifying welding procedures and welders. Welding procedures shall be qualified by preparing and testing two sample welds of each combination of bar size and steel type to be welded at intersections in the construction work. Each sample shall be subjected to a tensile test across the point of the weld. The specimens shall develop the minimum requirements for tensile strength and yield strength of the bar stock. However, failure to be in accordance with the percentage of elongation specified for the steel bars used will not be cause for disqualifying the welding procedure or the welder.

4. Welders shall be qualified by preparing and testing samples in the same manner as specified above for qualification of welding procedures. Preparation of welds for qualifying procedures and welders shall be done in the presence of the Engineer. Such inspection shall be requested at least five days in advance. All necessary equipment, personnel, and materials shall be assembled and any experimental work performed so that qualification of welders and welding procedures can be concentrated on a reasonably short and continuous period of time. The cost of qualifying the welders and welding procedures shall be at the expense of the Contractor and will be considered incidental to and included in the pay item for structural members, except that testing of the specimens will be performed by the Department at no expense to the Contractor.

(c) Concrete. Concrete shall be air entrained and in accordance with the applicable requirements of 702.05. Chemical admixture types A, D, F, or G shall be used in combination with an air entraining admixture. High range water reducing, HRWR, and high range water reducing retarding, HRWRR, admixture systems may be used. Chemical admixture types B, C, and E will be permitted only with written

permission. Admixtures, other than air-entraining admixtures, shall not be used with air-entrained cement. The cement content of the mixed concrete shall be sufficient to obtain the specified minimum 28 day compressive strength. Slump shall be no less than 50 mm (2 in.) nor more than 125 mm (5 in.) for concrete without chemical admixtures or concrete containing chemical admixture types A and D.

Concrete containing admixture types F, G, or admixture systems shall have a slump no less than 75 mm (3 in.) nor more than 175 mm (7 in.). The amount of time from mixing to final placement and consolidation shall be a maximum of 30 min. The concrete shall not be retempered with additional amounts of chemical admixture types F or G after the initial mixing has been completed.

Precast concrete members which are not prestressed shall have a minimum compressive strength of 31 MPa (4500 psi) in 28 days. Prestressed members shall be in accordance with the following unless otherwise shown on the plans:

1. Maximum water/cement ratio in kilograms (pounds) of water per kilogram (pound) of cement shall be 0.400.

2. Minimum 28 day compressive strength of concrete shall be 34.5 MPa (5,000 psi).

3. Minimum compressive strength of concrete at time of prestressing shall be 27.6 MPa (4,000 psi).

4. Initial tension of prestressing steel shall be as shown on the plans.

Inspection of the precast member during manufacture and checking and testing aggregates, cement, concrete, and steel specimens will be performed. All specimens shall be furnished without cost to the Department. Notification shall be made as soon as reinforcing steel is available for sampling and testing, and also at least five days in advance of the beginning of the manufacture of the precast member. This inspection, checking, and testing performed by the Department will not relieve the Contractor or his manufacturers from performing their own inspection, testing, and checking as necessary to maintain strict control over the manufacturing, handling, and curing procedure. By means of a mechanical recording device, a permanent record of the force applied to each strand of prestressing steel and the identification of the strand and unit to which the record applies shall be provided.

**707.05 Forms.** Structural members shall be manufactured in steel forms which are unyielding, mortar-tight, and of sufficient rigidity to prevent distortion due to pressure of the concrete. They shall be so designed that the finished concrete is in accordance with the required dimensions and contours. The design of the forms shall take into account the effect of vibration of the concrete as it is placed. Forms shall be filleted at all sharp corners and shall be given a bevel or draft at all projections to ensure easy removal. Exposed edges of curbs shall be beveled or edged. Forms shall be set and maintained true to the lines designated until the concrete is sufficiently hardened or for periods hereinafter specified. Interiors of forms shall be treated with an approved

formulated form coating which allows them to be released without adhering, discoloring, or otherwise damaging the concrete. Form coating materials shall not come in contact with reinforcing or prestressing steel.

**707.06 Placing and Finishing Cement Concrete.** Concrete, during and immediately after depositing, shall be consolidated with vibrators and suitable spading tools. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators used may be internal, external, or a combination of both. Internal vibration shall be of sufficient duration and intensity to consolidate thoroughly, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point so that localized areas of grout are formed.

The entire operation of depositing and consolidating the concrete shall be conducted so that the concrete will be smooth, dense, and free from any honeycomb or pockets of segregated aggregates. The concrete in each member shall be placed in one continuous operation. The outside vertical faces of facia girders and the exposed face and top of the curb section shall be finished in accordance with 702.21.

The tops of all beams and the outside faces of the fascia beams shall be sealed with an approved concrete sealer in accordance with 709.

**707.07 Removal of Forms and Curing.** Side forms may be removed when no distortion, slump, or misalignment of the concrete will result. Precast members which are not prestressed shall remain on the bottom supporting forms for the span until the concrete has reached a strength of at least 13.8 MPa (2,000 psi) as evidenced by test cylinders made and cured in the same manner as the slab.

Curing may be done by wet curing or by accelerated curing.

When wet curing is used, the exposed surfaces of the members shall be covered by two layers of wet burlap and the burlap shall be kept wet. Additional curing of precast or prestressed units will not be required provided the minimum specified ultimate strength can be obtained.

When accelerated curing of the concrete is used, it shall be done by low pressure steam or radiant heat curing. Insulated blankets may be used to reduce heat and moisture loss subject to maintaining a 10°C (50°F) minimum temperature. The heat shall always be applied at a controlled rate following the initial set of the concrete, and an effective method of retaining the heat and moisture in the concrete shall be used during the curing cycle.

Curing shall be in a suitable enclosure to minimize heat and moisture loss. Except to maintain a minimum temperature of 10°C (50°F), heat shall not be applied until the concrete has attained its initial set. The time of initial set may be determined by ASTM C 403. When the initial set is not determined by ASTM C 403, the initial application of heat shall be from 2 to 4 h after final placement. If retarders are used, this time shall be increased to 4 to 6 h.

During the initial application of radiant heat or live steam, the ambient temperature within the curing enclosure shall increase at an average rate not exceeding 5°C/h (40°F/h) until the curing temperature is reached. Neither the maximum temperature within the enclosure nor the maximum temperature on the surface of the concrete shall exceed 71°C (160°F). The maximum curing temperature shall be held until the concrete has reached the minimum required strength for moving precast units. Detensioning should be accomplished immediately after accelerated curing has been discontinued. Additional curing of precast or prestressed units will not be required provided the minimum specified ultimate strength can be obtained.

Radiant heat may be applied by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. When steam is used, the jets shall be positioned so that they do not discharge directly on the concrete, forms, or test cylinders. The steam shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement.

During the period of initial set of the member and during the accelerated curing by radiant heat, the concrete shall be kept wet by the method outlined above for wet curing.

A recording thermometer shall be provided and used to verify compliance with the temperature requirements.

Approval shall be obtained before curing is done by any means other than those outlined above.

**707.08 Handling and Shipping.** The precast members shall not be subjected to excessive abuse which produces crushing or undue marring of the concrete. All members damaged during handling, storing, transporting, or erecting shall be replaced. Unless some other method is approved, precast members shall be handled with a suitable hoisting device provided with a spreader sling. The spreader shall be of sufficient length to prevent horizontal forces being produced in the member due to lifting and shall be equipped with leads and hooks at each end. The girders shall be lifted by the devices shown on the plans. Alternate lifting devices and procedures shall be at the owner's or supplier's option, and must be approved prior to use. If any other method of handling is used, it shall be shown on the shop drawings and approved prior to use. If the method produces horizontal forces in the precast member, sufficient steel reinforcement shall be added to compensate for them.

The members shall remain in an upright position at all times and shall be supported as indicated herein when in storage and during transportation to the construction site.

In storage, I-beams, box-beams, and slabs shall be fully supported across their width on battens not less than 100 mm (4 in.) wide with one being placed at each end at the centerline of the bearing. The supports of the members while in storage shall be maintained in a level position so no twisting occurs.

The precast members shall not be shipped nor used until the concrete reaches a strength of 31 MPa (4,500 psi) for members which are not prestressed and 34.5 MPa (5,000 psi) for members which are prestressed as evidenced by test cylinders made at the time of casting and cured in the same manner as the precast members which they represent. If they are shipped prior to 28 days, additional test cylinders shall be made to ensure adequate 28 day results in case of earlier failure.

During transportation, the members shall be supported with truck bolsters or battens no less than 100 mm (4 in.) wide which are padded with no less than 13 mm (1/2 in.) of rubber. The ends of I-beams shall extend no more than the depth of the beam and not more than 1 m (3.5 ft) beyond the supports. The ends of box-beams shall extend no more than 1 1/2 times their depth and not more than 0.9 m (3 ft) beyond the supports. The ends of slabs shall extend no more than the depth of the beam beyond the supports. Supports of cantilever beams shall be as shown on the plans. Trucks with double bolsters will be permitted, provided the beams are fully seated on the outer bolsters and the inner bolsters are no more than 2.4 m (8 ft) from the ends of the beams. Wood blocks or other suitable material shall be placed under the tie chains to prevent chipping the concrete.

**707.09 Placing Structural Members.** Erection of the precast deck shall commence at the centerline and proceed out to the curb, one member at a time. As each member is placed, the transverse tie bars, if shown on the plans, shall be inserted and secured. Any shifting of the members shall be done while they are held free of the supports by the hoisting device. The use of a steel pinch bar will not be permitted. Members shall be set to proper line and grade with uniform bearing on bridge seats, mortar joints, or bearing pads as required on the plans. When required, members shall be secured to the pier or bent with dowel rods. Holes for dowels shall be filled with mortar at fixed ends and with crack or joint filler at expansion ends. Longitudinal keyway joints shall be cleaned. A coat of cement mortar shall be scrubbed on the surface. The joint shall be filled with a non-shrinking grout composed of one part portland cement, two parts No. 23 fine aggregate, and an approved non-shrinking additive or a non-shrink, non-metallic cementation grout in accordance with ASTM C 1107. All bolts or drains shown on the plans as necessary or desirable to be placed in the concrete shall be placed by the methods and at the locations shown on the plans. Necessary tie rods, tie bolts, and hardware for tying members together shall be furnished.

Dowel holes shall not be grouted nor concrete or the forming therefor, be placed in floor slabs, diaphragms, or shear keys prior to receipt of complete documentation of the acceptability of the members and bearing pads, including the satisfactory laboratory reports and certifications in accordance with 915.04(e). Neither the members, nor the bearings will be considered incorporated into the work, and neither will be paid for until this documentation is accomplished satisfactorily.

Railing, when required, shall be of the type shown on the plans. The component parts shall be in accordance with 706, unless otherwise indicated on the plans. Other precast or prestressed structural members shall be placed in the structure in accordance

with the plans and the specifications or special provisions indicated for the type of structure being built.

Cranes or other heavy erection equipment may be operated on the precast or prestressed members only if approved in writing and if a proposed operating procedure is submitted showing loading, distribution of loads, resulting stresses, and that the design of the members is satisfactory to permit it. However, such approval shall not relieve the Contractor of any damage from this operation.

**707.09.1 Precast Prestressed Concrete Deck Panels.** Precast prestressed concrete deck panels shall be designed as a noncomposite section to support the dead load of the panel, reinforcement, plastic concrete, and a construction load of 2.4 kPa (50 lb/ft$^2$). The panel shall be designed as a composite section with the class C concrete to support the live load. The Contractor shall revise the area of top longitudinal reinforcing steel over interior supports for negative moment to be equal to the total area of top and bottom longitudinal reinforcing steel.

Shop drawings and design computations shall be submitted in accordance with 707.03. Design computations for deck panels shall be submitted for approval for total slab thickness greater than 200 mm (8 in.) or clear spans in excess of 2.3 m (7.5 ft). Design shall be in accordance with the AASHTO Standard Specifications for Highway Bridges. Details such as type, size, and location of the reinforcing steel, the prestressing strands, welded wire fabric, and concrete shall be as shown on the plans.

The concrete for deck panels shall be placed in accordance with 702.20. The concrete shall be vibrated to prevent honeycombs and voids, especially at the corners and edges of the panels. The tops of the deck panels shall be broom or wire brush finished in the direction of the prestressing strands. The corrugations formed shall be uniform in appearance and shall not be more than 6 mm (1/4 in.) in depth. The coarse aggregate shall not be displaced when preparing the roughened surface.

**707.10 Method of Measurement.** Precast or prestressed concrete structural members will be measured by the meter (linear foot) along the top of each member or by the square meter (square foot) of top surface of each member. Railing will be measured in accordance with 706.06 if specified as a pay item.

**707.11 Basis of Payment.** The accepted quantities of precast or prestressed concrete structural members will be paid for at the contract unit price per meter (linear foot) or per square meter (square foot) for structural member, concrete, of the type and size specified. Precast or prestressed concrete structural members for which the type and size is not shown in the Schedule of Pay Items will be paid for at the contract lump sum price for structural members, concrete.

Railing will be paid for in accordance with 706.07 when specified as a pay item.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Structural Member, Concrete, _____ , _____ (type, size) | m (LFT)<br>m2 (SFT) |

Reinforcing steel, elastomeric bearing pads, bearing beams required for box beams, bearing assemblies required for I-beams and box beams, bearing plates, expanded polystyrene, threaded dowels, threaded inserts in facia beams, hex bolts, sealer on the outside face of facia beams and on the tops of all beams, and necessary incidentals shall be included in the cost of this work.

No payment will be made for replacing precast members damaged during handling, storing, transporting or erecting.

The cost of railing shall be included in the cost of this work if such railing is not specified as a pay item.

## SECTION 708 – PNEUMATICALLY PLACED MORTAR

**708.01 Description.** This work shall consist of preparing stone, concrete, or other surfaces for and the pneumatic application of mortar as a plain or reinforced coating in accordance with these specifications and as shown on the plans or as directed.

**708.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Fine Aggregate | 904.02(c) |
| Fly Ash | 901.02 |
| Portland Cement | 901.01(b) |
| Water | 913.01 |
| Welded Steel Wire Fabric | 910.01(b)5 |

Welded steel wire fabric shall consist of wire, size W 1.5 or approximately 3.43 mm (No. 10 gage), spaced and welded at 75 mm (3 in.) intervals, or wire, size W 1 or approximately 2.68 mm (No. 12 gage), spaced and welded at 50 mm (2 in.) intervals.

## CONSTRUCTION REQUIREMENTS

**708.03 Preparing Surface.** The surface of all steel to be covered shall be thoroughly cleaned of all paint, rust, grease, dirt, or other foreign materials. All loose or defective portions of masonry to be covered shall be removed and the surface thus exposed cleaned. The use of a sand blast as an aid in cleaning any surface may be required.

**708.04 Reinforcement.** If wire mesh fabric is required, it shall be cut into sheets of the proper sizes and bent carefully over a template so that the mesh closely follows the outline of the member to be covered. It shall be attached to such members at intervals of not to exceed 0.6 m (2 ft).

Insofar as feasible, the mesh shall parallel the surface of steel members 19 mm (3/4 in.) out from the face. Where sheets meet, they shall lap at least 100 mm (4 in.) and shall be fastened together securely.

Wire fabric reinforcement shall be used in all areas where the thickness of the mortar exceeds 75 mm (3 in.) and also if the present steel reinforcement is exposed after the disintegrated concrete has been removed. The wire fabric shall be fastened to the concrete masonry with 6 mm (1/4 in.) machine bolts screwed into lead anchors driven into holes drilled into the concrete, or by pins or nails shot into the concrete by an impact gun. Such bolts or pins shall be spaced on 200 mm (8 in.) centers in each direction and shall be of sufficient length to space the fabric approximately 50 mm (2 in.) from the surface being repaired. Where the fabric can be fastened to the reinforcing steel, the bolts, pins, or nails may be omitted.

**708.05 Proportioning and Mixing.** The dry mixture shall consist of one part portland cement to three parts sand. The cement and sand shall be dry mixed in an approved proportioning plant or in batch boxes. Measurement may be by volume or weight. Before placing the proportioned materials in the hopper of the application gun, all lumps 6 mm (1/4 in.) or over shall be removed by screening.

**708.06 Placing Mortar.** This work shall be done only by experienced personnel. No one operating the nozzle will be deemed experienced unless he has done similar work on other structures of like type has been satisfactorily completed.

Just prior to placing mortar, the surface shall be washed with water and compressed air. The mortar shall be placed on a wet surface.

The equipment for placing the mortar shall be operated in accordance with the recommendations of the manufacturer.

In shooting any surface the nozzle shall be held at such distance and in such position that the flowing stream of material impinges, as nearly as possible, at right angles to the surface being covered. All deposits of loose sand shall be removed. Shooting shall start on those areas where the greatest thickness is required. Mortar shall not be applied more than 50 mm (2 in.) thick in one operation. Where a finished thickness of more than 50 mm (2 in.) is required, it shall be obtained in successive operations and enough time allowed to permit the previous layer to set. During application, the required thickness shall be maintained by shooting strips. A full thickness shall be obtained over thin edges of steel.

After completion of a section of coating, all high spots shall be cut off with a sharp trowel or screeded to a true plane as determined by the shooting strips. Finished edges shall be true and even.

**708.07 Finishing.** After all surfaces have been brought to the required contour and smoothness, they shall be finished with a flash coat approximately 3 mm (1/8 in.) thick. This coat shall produce a uniform color and finish and an approved appearance on all exposed surfaces. Proportioning and mixing of the flash coat shall be in accordance with 708.05 except white portland cement shall be used. Before placing the proportioned materials in the hopper of the application gun, all lumps 3 mm (1/8 in.) or larger shall be removed by screening. No less than one bag of the white cement to each 28 $m^2$ (300 sq ft) of surface shall be used.

Immediately after completion, the surface shall be covered with wet burlap or wet cotton mats and these shall be kept wet for at least 96 h. No mortar shall be placed when the air temperature is below 10°C (50°F) nor against a surface which contains frost. After the work has been completed, all rebound and other debris shall be removed from the work.

**708.08 Method of Measurement.** Pneumatically placed mortar will be measured by the square meter (square foot), complete in place. The area measured will be the actual finished surface. Welded steel wire fabric, where used, will be measured by the square meter (square foot), complete in place.

**708.09 Basis of Payment.** The accepted quantities of pneumatically placed mortar and welded steel wire fabric will be paid for at the contract unit price per square meter (square foot), complete in place.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Pneumatically Placed Mortar | m2 (SFT) |
| Welded Steel Wire Fabric | m2 (SFT) |

The areas where loose or defective portions of masonry exceed an average of 100 mm (4 in.) in depth will be paid for at a price to be determined by multiplying the contract unit price for pneumatically placed mortar, respectively, by the factors as follows:

(a) for portions thereof whose average depth is greater than 100 mm (4 in.) but less than 150 mm (6 in.)..... 1.25

(b) for portions thereof whose average depth is greater than or equal to 150 mm (6 in.) but less than 200 mm (8 in.)..... 1.50

(c) for portions thereof whose average depth is greater than or equal to 200 mm (8 in.) but less than 250 mm (10 in.) ..... 1.75

(d) for portions thereof whose average depth is greater than or equal to 250 mm (10 in.) but less than 300 mm (12 in.) ..... 2.00

(e) For all portions thereof whose average depth is greater than or equal to 300 mm (12 in.), the work shall be done as extra work. Payment will be made in accordance with 104.03.

## SECTION 709 – PORTLAND CEMENT CONCRETE SEALERS

**709.01 Description.** This work shall consist of cleaning the concrete surface by sandblasting and applying a concrete sealer in accordance with these specifications and in reasonably close conformance with the plans or as directed. Surfaces to be sealed with PCC sealers shall be given a finish in accordance with 702.21. Where existing concrete or bridge decks are to be sealed, their surfaces shall be sandblasted to remove all foreign material.

**709.02 Materials.** Materials shall be in accordance with the following:

Epoxy Penetrating Sealers ..... 909.09
Other Portland Cement Concrete Sealers ..... 909.10

### CONSTRUCTION REQUIREMENTS

**709.03 Surface Preparation.** The surface to be sealed shall be thoroughly cleaned of all foreign materials by sandblasting if the surface is a bridge deck or older existing concrete, or by air blasting for all other surfaces, just prior to sealing. The air compressor shall be equipped with suitable separators, traps, or filters which remove water, oil, grease, or other substances from the air lines. If rain sufficient to uniformly wet the surface occurs after the cleaning operations and prior to the sealing, the surface to be sealed shall be re-sandblasted or re-airblasted.

**709.04 Environmental Requirements.**

**(a) General Requirements.** Concrete sealer shall not be applied in rainy conditions or if rain is anticipated within 2 h after application. Concrete sealer shall be applied when the temperature of the concrete surface to be sealed is 5°C (40°F) or above and when the air temperature is 10°C (50°F) or above, unless otherwise approved in writing. Concrete sealer shall not be applied when the ambient temperature is expected to fall below 2°C (35°F) within 12 h after application.

**(b) Epoxy Penetrating Sealers.** Cast-in-place concrete shall have a minimum of 3 days dry cure prior to the application of epoxy penetrating sealer.

**(c) Other Portland Cement Concrete Sealers.** The concrete to be sealed shall be cured as stated on the Approved List of Other Portland Cement Concrete Sealers prior to sealer application.

**(d) Low Temperature Epoxy Penetrating Sealer.** A low temperature epoxy penetrating sealer shall be applied in accordance with the requirements for epoxy penetrating sealer. However, the low temperature epoxy penetrating sealer shall be applied when the temperatures of the concrete surface and the air are 2°C (35°F) or above. Low temperature concrete sealer shall not be applied when the ambient temperature is expected to fall below -7°C (20°F) within 12 h of application.

**709.05 Sealer Application.**

**(a) General Requirements.** The concrete surface to be sealed shall be completely cleaned and shall be dry and dust free prior to the application of concrete sealer. The concrete sealer shall be applied in a crisscross pattern and should any flat or dry spots appear, more sealer shall be applied. However, there shall be no puddling of material on the surface. The sealed surface shall be allowed to cure in accordance with the manufacturer's recommendations. No vehicular traffic will be allowed on the sealed surface during the curing time.

A qualified technical representative of the manufacturer may be required to be on the job the first day the sealer is used. It shall be this representative's responsibility to instruct the workers in proper mixing, application technique, and safety precautions.

**(b) Epoxy Penetrating Sealer.** The mixing of the 2-component parts of the epoxy penetrating sealer, their handling and application on the concrete surface shall be in strict accordance with the recommendations of the manufacturer except as may be otherwise specifically covered in these specifications. Under no circumstances shall any solvent be added to the compounds.

The epoxy penetrating sealer shall be applied at the rate of 2.2 to 2.7 $m^2/L$ (90 to 110 sq ft/gal.). The sealer shall be mixed in the exact manner the manufacturer recommends. After the material has been adequately mixed, preferably by power, and the induction time completed in accordance to manufacturer's recommendations, it shall be applied to the cleaned dry surface by brush, roller, squeegee, or other approved method.

All cracks shall be filled before beginning the complete sealing of the entire required surface. This crack filling operation shall cure a minimum of 2 h or in accordance with the manufacturer's recommendations before the complete surface is sealed with the epoxy penetrating sealer. After the surface has been sealed and properly cured, all cracks that are not completely filled shall be retreated. This retreatment of cracks shall be completed within 72 h.

After sufficient amounts of the epoxy penetrating sealer have been applied and before the material has started its initial set or becomes tacky, a light coating of dry clean sand shall be broadcast at a rate of 0.55 to 1.10 kg/m$^2$ (1 to 2 lb/sq yd) onto all treated surfaces which carry vehicular or pedestrian traffic. The sand shall contain not less than 90% silica and shall be in accordance with the following gradation:

| SIEVE | PERCENT PASSING |
|---|---|
| 1.18 mm (No. 16) | 100 |
| 150 $\mu$m (No. 100) | 0-5 |

After the sand has been applied, the sealed surface shall be allowed to cure.

**(c) Other Portland Cement Concrete Sealers.** The sealer chosen for use shall be applied at the application rate specified on the Approved List of Other Portland Cement Concrete Sealers. The sealer shall be applied without dilution or alteration. Sealers, which are applied by spraying shall be sprayed onto the concrete surface using low pressure spray equipment with a sufficient number of passes to achieve the minimum application rate and a uniform coverage. The low pressure spray apparatus shall have a 105 kPa (15 psi) maximum nozzle pressure with a course fan spray, such as a garden, form oil, horticulture, or other low pressure sprayer. The spray equipment tanks, and hoses shall be thoroughly clean, free of foreign matter, oil residue, and water prior to use. Sealers, which are applied by flooding the concrete surface, shall be spread to achieve uniform coverage and accordance with the Approved List of Other Portland Cement Concrete Sealers. If roller spreading is required, a clean new roller shall be used for each application sequence. If brooming is specified, a clean, stiff-bristled broom shall be used to spread and work the sealer into the concrete surface.

**(d) Clear Sealers.** Clear sealers shall be used on all vertical wall surfaces such as concrete bridge railing, barrier wall, exterior concrete bridge beams, etc., when sealing is specified for these items. The epoxy penetrating sealers are not clear sealers. Clear sealers will be those identified on the Approved List of Other Portland Cement Concrete Sealers.

**(e) Alternate To Concrete Sealers.** In lieu of concrete surface sealing for concrete barrier wall and concrete bridge railing, an alternate concrete mix design may be used. The concrete mix design shall be as specified, except either 3% silica fume by mass (weight) of cementitious material shall be added to the mix design or 30% ground granulated blast furnace slag substitution based on the required cement content shall be incorporated into the mix. The substitution of ground granulated blast furnace slag shall be in accordance with 702.05. A water-reducing admixture or a water-reducing retarding admixture shall be used in the mix design, and the amount of water added shall be adjusted accordingly. The use of these admixtures shall be in accordance with 702.05.

When one of these alternate concrete mix designs are used in lieu of a concrete surface sealer, a finish in accordance with 702.21 will be required.

**709.06 Safety Precautions.** Epoxy materials are toxic and may be dermititic. Precautions shall be taken to protect workers from the hazards of these materials. Solvents in the epoxy penetrating sealers and some of the other sealers are flammable. All necessary precautions shall be taken pertaining to the handling and potential overspray of these concrete sealers.

**709.07 Method of Measurement.** Since payment will be made in a lump sum, only those measurements necessary to verify application rates will be made.

**709.08 Basis of Payment.** The accepted quantities of this work will be paid for at the contract lump sum price for surface seal.

If an alternate concrete mix design in accordance with 709.05(e) is used in lieu of concrete surface sealing or portions thereof, it will be paid for as surface seal.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Surface Seal | LS |

The costs of all materials, labor, equipment, and necessary incidentals shall be included in the cost of this work.

If a curing-sealing material in accordance with 702.22(c) is used in lieu of sealing concrete surfaces or portions thereof, it will be paid for as surface seal.

## SECTION 710 – REPOINTING MASONRY IN STRUCTURES

**710.01 Description.** This work shall consist of repointing concrete, rubble, dressed stone, or brick masonry structures with mortar in accordance with these specifications and in reasonably close conformance with the plans or as directed.

**710.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Fine Aggregate | 904.01 |
| Hydrated Lime | 913.04 |
| Masonry Cement | 901.01(c) |
| Portland Cement | 901.01(b) |

## CONSTRUCTION REQUIREMENTS

**710.03 Repointing Concrete Masonry.** All honeycombed, weathered, or disintegrated areas in the concrete shall be cut out and thoroughly cleaned of all loose concrete, dirt, or other foreign material to a depth and over the area necessary to produce a firm and solid connecting surface for the adherence of the new mortar. This prepared surface shall be coated with epoxy resin adhesive in accordance with AASHTO M 235, class I, filled with mortar well driven in, and finished to meet approval. Where the surface is to be cleaned out to such depth and area that the new mortar does not stay in place without support, a form shall be placed over the area and the space so enclosed filled with well-consolidated mortar. After the forms are removed the mortar shall be protected in accordance with 708.07.

**710.04 Repointing Rubble Masonry.** All spaces around the rubble aggregate, after being cleaned, shall be well filled with mortar. If any of the rubble is loose, it shall be settled into place before the mortar has set.

**710.05 Repointing Dressed Stone and Brick Masonry.** The joints in the masonry shall be cleaned of all loose mortar and foreign material for a depth of at least twice the width of the joint. The joints shall then be filled with mortar, well driven in and neatly finished.

**710.06 Method of Measurement.** Repointing masonry in structures will be measured by the square meter (square foot) of actual surface area of masonry repointed. Individual patches of less than 0.1 $m^2$ (1 sq ft) in area will be considered as 0.1 $m^2$ (1 sq ft).

**710.07 Basis of Payment.** The accepted quantities of repointing masonry in structures will be paid for at the contract unit price per square meter (square foot) of repointed masonry complete in place.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Repointing Masonry in Structures | m2 (SFT) |

Areas where repointing masonry in structures exceeds an average of 100 mm (4 in.) in depth, the work shall be completed as extra work. Payment will be made in accordance with 104.03.

## SECTION 711 – STEEL STRUCTURES

**711.01 Description.** This work shall consist of furnishing, fabricating, erecting, and painting steel structures and parts of structures, except steel piling, in accordance with these specifications and in reasonably close conformance with the lines and grades shown on the plans or as directed.

**711.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Bronze and Copper-Alloy | 910.06 |
| Castings | 910.05 |
| Elastomeric Bearings | 915.04 |
| Steel Forgings and Steel Shafting | 910.04 |
| Structural Steel | 910.02 |

Material specifications shall be shown on the shop drawings if the materials are different than those shown on the plans. Materials which do not require mill test reports may be changed from those shown on the plans subject to approval.

Sheared plates or universal mill plates shall be used for girder webs. Such plates shall be ordered with sufficient additional width to allow for trimming of edges to provide built-in camber for dead load deflection and vertical curve. Sheared plates thicker than 13 mm (1/2 in.) shall be planed in accordance with 711.14.

## FABRICATION

**711.03 General Requirements.** The fabrication methods used shall be those applicable to and prescribed for the several parts of fabrication as it progresses and shall be in accordance with the requirements thereof and as further set out in this specification. Workmanship and finish shall be first class, equal to the best general practice in a modern fabricating shop, and in strict accordance with these specifications, the plans, and such additional instructions as may be given.

The requirements contained herein will not be waived, nor will they be modified to conform with any set of rules that any shop has adopted as its standard unless so authorized in writing.

Structural steel, regardless of its source, shall be fabricated within the continental limits of the United States of America.

**711.04 Certification of Fabricators.** The fabricator of structural steel furnished under this section shall be certified in accordance with the American Institute of Steel Construction and Quality Certification Program (Category III) before the fabricator will be permitted to fabricate a welded plate girder. It shall be the fabricator's responsibility to maintain a valid certification and annual endorsements thereto.

The fabricator shall be certified from the start of the fabrication process, through and including the shop assembly in accordance with 711.44. If the certification lapses during the course of the project, the fabricator shall have plans to maintain certification or complete the fabrication process before the expiration of his certification. Failure of the fabricator to maintain his certification during the fabrication shall result in a 10% reduction in the bid price for structural steel.

Approval of the fabricator shall be requested in writing prior to ordering structural steel. A valid certification with annual endorsement must be submitted with the request.

**711.05 Shop Drawings.** Five sets of detailed shop drawings shall be submitted for approval. Fabrication shall not begin until the shop drawings are approved. These shop drawings will be reviewed for design features only. The Contractor shall be responsible for dimensions, accuracy, and fit of work. One set will be returned either approved or showing changes or corrections required. If required to be changed or corrected, copies shall be resubmitted until they receive approval. No deviations will be allowed from the approved working drawings without written consent.

Shop drawings shall include a detailed bill of materials showing weights of materials completed in accordance with 711.70(b) when payment is on a unit weight basis. On completion of the shop fabrication and before the contract is completed, the tracings of all approved shop drawings shall be furnished. The tracings shall be linen cloth or a suitable reproduction, subject to approval. Drawings or tracings shall be 560 mm by 860 mm (22 in. by 34 in.) in overall size.

If the contract plans include detailed structural steel drawings, they may be used. These detailed structural steel drawings in the plans shall be checked, and the Contractor shall provide notification in writing that he is assuming responsibility for their correctness.

**711.06 Storage of Materials.** Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids, or other supports. It shall be kept reasonably free from dirt, grease, and other foreign matter and shall be protected as far as practicable from corrosion.

**711.07 Mill Orders and Shipping Statements.** If requested, one copy of mill orders, change orders, and mill shipping statements for structural steel shall be furnished. The pertinent order, bill, or statement shall be furnished far enough in advance so that inspection may be provided.

**711.08 Mill Test Reports.** Prior to, or concurrent with, the fabrication, four copies of mill test reports shall be furnished. If the manufacturer's mill test reports are not available, tests shall be made with no additional payment, and four certified copies of such tests shall be furnished. Four copies of an affidavit shall be furnished which shall state that the materials to be used for members not designated for calculated stress and not to be marked in accordance with ASTM A 6M (ASTM A 6), Article 9, are in accordance with the requirements of the specifications for the materials as shown on the plans. The fabricator shall have on file the mill test reports for the material from which these members were obtained.

Those items of structural steel which are considered as being in the category of members not requiring mill test reports and for which tests may not be required shall be listed on the shop plans. Approval of shop plans will indicate if it is satisfactory to waive testing of the items listed.

Mill test reports, reports from subsequent tests, and affidavits shall be marked in a manner to clearly identify them with the contract structure and also with the particular member of the bridge for which these tests were made.

**711.09 Notice of Beginning Work.** Written notification shall be given 10 days in advance of the date on which fabrication is intended to start. Between the dates of such notification and the start of fabrication, a surface inspection of the proposed materials will be made. Any such materials cut or work done prior to this inspection may be rejected.

**711.10 Facilities for Inspection.** Facilities for the inspection of material and workmanship in the mill and shop shall be furnished, and the inspectors shall be allowed free access to the necessary parts of the works.

**711.11 Straightening Material.** Material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that do not injure the metal. Sharp kinks and bends will be cause for rejection of the material.

The straightening of plates, angles, other shapes, and built up members, when permitted, shall be done by methods that do not produce fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved, by the carefully planned and supervised application of a limited amount of localized heat. Heat straightening of ASTM A 709M grade 690 (ASTM A 709 grade 100) steel members will not be permitted. The temperatures of the heated area shall not exceed 650°C (1200°F), a dull red, as controlled by temperature indicating crayons, liquids, or bimetal thermometers. Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat. They shall be allowed to cool very slowly. Water quenching will not be permitted. Following the straightening of a bend or buckle, the surface of the metal shall be inspected for evidence of fracture.

**711.12 Finish.** Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

All shop butt welds in flange plates shall be ground smooth and flush with the base metal on all surfaces. This shall apply to parts of equal thickness and parts of unequal thickness. Grinding shall be done in the direction of stress and in such a manner that the metal is kept below the blue brittle range. All defects exposed by grinding shall be cleaned, filled with weld metal, and reground to a uniform finish.

Curved surfaces of shoes shall be machined after weldments have been completed.

For cambered beams, the camber shall be to a smooth curve. Camber for beams shall be checked after shop welding is completed and while beams are supported so as to have no bending moment in the direction of camber. Beams which are not cambered shall be straight within a tolerance of 10 mm (3/8 in.) at center. If camber exists, beams shall be laid out with camber up. Beams shall be checked for camber while beams are supported so as to have no bending moment in the direction of camber.

**711.13 Flame Cutting.** Structural steel permitted by these specifications may be flame cut, provided a smooth surface free from cracks and notches is secured and provided that an accurate profile is secured by the use of a mechanical guide. Hand cutting shall be done only where approved.

In all flame cutting, the cutting flame shall be so adjusted and manipulated as to avoid cutting inside the prescribed lines. Flame cut surfaces shall meet the ANSI surface roughness rating value of 1,000 except that flame cut surfaces of members not subject to calculated stress shall meet the surface roughness value of 2,000. Flame cut surfaces of members carrying calculated stress shall have their corners rounded to a 2 mm (1/16 in.) radius by grinding after flame cutting.

Re-entrant cuts shall be filleted to a radius of not less than 19 mm (3/4 in.).

Surface roughness exceeding the above values and occasional gouges not more than 5 mm (3/16 in.) deep on otherwise satisfactory flame cut surfaces shall be removed by machining or grinding. Corrections of the defects must be faired with the surface of the cut on a bevel of 1:6 or less. Occasional gouges of flame cut edges more than 5 mm (3/16 in.) deep but not more than 11 mm (7/16 in.) deep may be repaired by welding with low hydrogen electrodes not exceeding 4 mm (5/32 in.) in diameter and with a preheat of 121°C (250°F). The completed weld shall be ground smooth and flush with the adjacent surface.

**711.14 Edge Planing.** Edge planing will not be required on plates having rolled edges.

Sheared edges of plates more than 13 mm (1/2 in.) in thickness and carrying calculated stress shall be planed to a depth of 6 mm (1/4 in.). Re-entrant cuts shall be filleted before cutting.

Visually observed defects in sheared or flame cut edges of plates 100 mm (4 in.) or less in thickness, except ASTM A 709M grade 690 (ASTM A 709 grade 100) steel plates, shall be investigated or repaired in accordance with the following table. Repairs made by welding shall be in accordance with 711.32.

TABLE

| Description of Discontinuity | Repair Required |
|---|---|
| All discontinuity of 3 mm (1/8 in.) Maximum depth | None-depth shall be explored as directed. |
| Any discontinuity over 25 mm (1 in.) in length with depth over 3 mm (1/8 in.) but not greater than 6 mm (1/4 in.) | Remove and weld. |
| Any discontinuity over 25 mm (1 in.) in length with depth over 6 mm (1/4 in.) but not greater than 11 mm (7/16 in.). | Remove completely and weld. Aggregate length of welding not over 20% of plate edge length being repaired. |
| Any discontinuity over 25 mm (1 in.) in length with depth greater than 11 mm (7/16 in.). | Plate rejected. Defective portion may be removed and remainder may be used in 11 mm (7/16 in.) depth. |

**711.15 Abutting Joints.** Abutting joints in compression members and girder flanges of trusses and arches, and in tension members where so specified on the plans, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 6 mm (1/4 in.).

**711.16 End Connection Angles.** Floorbeams, stringers, and girders having end connection angles shall be built to the exact length shown on the plans measured between the heels of the connection angles, with a permissible tolerance of +0 to 2 mm (+0 to 1/16 in.). Where continuity is to be required, end connections shall be faced. The thickness of the connection angles shall be no less than that shown on the detail drawings after facing.

**711.17 Blank.**

**711.18 Blank.**

**711.19 Bent Plates.** Cold bent, load carrying, rolled steel plates shall be in accordance with the following:

(a) They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling.

(b) The radius of bends shall be such that no cracking of the plate occurs. Generally accepted minimum radii, measured to the concave face of the metal, are shown in the following table:

| Thickness, t, in mm (inches) | Up to 13 mm (1/2 in.) | Over 13 mm (1/2 in.) to 25 mm (1 in.) | Over 25 mm (1 in.) to 38 mm (1 1/2 in.) | Over 38 mm (1 1/2 in.) to 63 mm (2 1/2 in.) | Over 63 mm (2 1/2 in.) to 100 mm (4 in.) |
|---|---|---|---|---|---|
| All grades of structural steel in this specification | 2t<br>51 mm | 2 1/2t<br>63 mm | 3t<br>76 mm | 3 1/2t<br>89 mm | 4t<br>102 mm |

If a shorter radius is essential, the plates shall be bent hot at a temperature no greater than 649°C (1200°F). Hot bent plates shall be in accordance with requirement (a) of 711.19.

(c) Before bending, the corners of the plate shall be rounded to a radius of 2 mm (1/16 in.) throughout that portion of the plate at which the bending is to occur.

**711.20 Fit of Stiffeners.** Bearing stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing. This bearing shall consist of either milled, ground, or weldable steel in compression areas of flanges, welded as shown on the plans or as otherwise specified on the flanges to which they transmit load or from which they receive load. The opposite end of bearing stiffeners may have a gap between the end of the stiffener and the flange not exceeding six times the web thickness.

Stiffeners not intended to support concentrated loads, including transverse intermediate stiffeners and full depth diaphragm connection plates, shall be attached to the compression flange as shown on the plans. These stiffeners may bear on the tension flange or may have a gap between the end of the stiffener and the near face of the flange not exceeding 6 times the web thickness. Regardless of the gap dimension, the distance between the end of the stiffener weld and the near edge of the web-to-flange fillet weld shall not be less than four nor more than six times the web thickness.

**711.21 Bolt Holes.**

**(a) High Tensile Strength Bolts, and Unfinished Bolts.** All holes for bolts shall be punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 2 mm (1/16 in.) larger than the nominal diameter of the bolts whenever the thickness of the metal is no greater than 19 mm (3/4 in.) for structural steel or 16 mm (5/8 in.) for high-strength steel. If there are more than five thicknesses or when the main material is thicker than 19 mm (3/4 in.) for structural steel, or 16 mm (5/8 in.) for high strength steel, or if required in accordance with 711.24, all holes shall be subpunched or subdrilled 5 mm (3/16 in.) smaller and, after assembling, reamed 2 mm (1/16 in.) larger or drilled from the solid to 2 mm (1/16 in.) larger than the nominal diameter of the bolts.

**(b) Ribbed Bolts, Turned Bolts, or other Approved Bearing-Type Bolts.** All holes for ribbed bolts, turned bolts, or other approved bearing type bolts shall be subpunched or subdrilled 5 mm (3/16 in.) smaller than the nominal diameter of the bolt. They shall be reamed assembled, reamed to a steel template, or, after assembling, drilled from the solid at the option of the fabricator. The finished holes shall always provide a driving fit as shown on the plans or as specified.

**711.22 Punched Holes.** The diameter of the die shall not exceed the diameter of the punch by more than 2 mm (1/16 in.). If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

**711.23 Reamed or Drilled Holes.** Reamed or drilled holes shall be cylindrical, perpendicular to the member, and shall be in accordance with 711.21 as to size. Where practicable, reamers shall be directed by mechanical means. Drilled holes shall be 2 mm (1/16 in.) larger than the nominal diameter of the bolt. Diameters of holes in all material connecting top shoes to beam or girder flanges shall be 3 mm (1/8 in.) larger than the diameters of the bolts. Bolts connecting the flange to the top shoe shall extend into the top shoe a minimum of 25 mm (1 in.). Open holes for high strength bolts shall be 24 mm (15/16 in.) in diameter unless otherwise shown on the plans. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and held securely while being reamed or drilled, and shall be match marked before disassembling.

The shop drawings shall indicate whether reaming is to be done in the shop or in the field. If beams or girders are shop reamed or drilled, progressive beam or girder assembly will be permitted in accordance with 711.44 unless otherwise directed. Beams or girders spliced over the supports may be shop reamed or drilled with the webs either in a horizontal or vertical position. If the webs are vertical, they shall be supported relative to their final erection position. If reamed with the webs horizontal, a minimum of one line of beams or girders shall be shop assembled and inspected for fit in accordance with the blocking diagram for webs vertical shown on the plans. Beams or girders spliced at the points of contraflexure shall be shop reamed or drilled while assembled in accordance with the no-load camber and reaming diagram shown on the plans. For hinged beams or girders, holes for pins shall be bored or reamed to the dimensions shown on the plans after the beams or girders are assembled in position in accordance with the no-load camber diagram shown on the plans. Flange splice bars shall be subdrilled and reamed or drilled full size while assembled.

When girder sections are fit up in the shop for reaming or drilling of field splices, the centerlines of opposing flanges shall not deviate more than 3 mm (1/8 in.) with the webs in alignment.

**711.24 Subpunching and Reaming of Field Connections.** Holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, each face of towers, plate girders, and rigid frames shall be subpunched, or subdrilled if subdrilling is required in accordance with 711.21. These subsize holes shall subsequently be reamed while assembled, or reamed to a template, in accordance with 711.44. All holes for floor beams and stringer field end connections shall be subpunched and reamed to a steel template or reamed while assembled. Reaming or drilling full size of field connection holes through a steel template shall be done after the template has been located as to position and angle, and bolted firmly in place. Templates used for reaming matching members, or the opposite faces of a single

member, shall be exact duplicates. Templates used for connections on like parts or members shall be so accurately located that the parts or members are duplicates and require no match marking.

**711.25 Accuracy of Punched or Subdrilled Holes.** Before any reaming is done, the punching, subpunching, or subdrilling shall be so accurate that after assembling, a cylindrical pin 3 mm (1/8 in.) smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75% of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If a hole does not pass a pin which is 5 mm (3/16 in.) smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

**711.26 Accuracy of Reamed Holes and Holes Drilled Full Size.** When holes are reamed or drilled full size, 85% of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 0.8 mm (1/32 in.) between adjacent thicknesses of metal. All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. The centerlines shall be used in locating accurately the template from the milled or scribed ends of the members.

**711.27 Fitting for Bolting.** Mating surfaces of steel shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformation.

**711.28 Filler Plates.** Filler may be required at the connections due to the variation in depth of a given section or to the use of different sections at a connection point. Where filler plates are shown on the plans at such connections, the specified thickness is the theoretical thickness required. During fabrication the thickness of such fillers shall be adjusted to the actual clearances as determined by measurements of the members involved. The minimum thickness of any filler plate shall be 3 mm (1/8 in.), unless otherwise approved.

**711.29 Toothed Expansion Plates.** These plates in the roadway expansion joints shall be cut from a single plate by burning in such a way that, after the plate is cut and the toothed plates placed in the same relative position as before burning, no part of the cut shall be wider than 6 mm (1/4 in.). The cuts shall be straight enough that a 3 mm (1/8 in.) plate passes between the parts on any designated straightline cut.

**711.30 Blank.**

**711.31 Blank.**

**711.32 Welds.** Welding of steel shall be done only as shown on the plans or as specified and only with specific approval. Welding may be done to remedy minor defects, if approved. No temporary or permanent welds, if not shown on the plans or otherwise specified, shall be made without specific written authorization.

**(a) AWS Requirements.** Welding of steel structures, when authorized, shall be performed in accordance with the following AWS Specifications.

A5.1 Mild Steel Covered Arc-Welding Electrodes.
A5.5 Low-Alloy Steel Covered Arc-Welding Electrodes.
A5.17 Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding.
A5.18 Mild Steel Electrodes for Gas Metal-Arc Welding.
A5.20 Mild Steel Electrodes for Flux-Cored Arc Welding.
D1.5 (AASHTO/AWS) Bridge Welding Code.

Welders, welder operators, and tack welders shall be qualified in accordance with AWS D1.5 Chapter 5 Part B.

**(b) Edge Blocks.** Edge blocks shall be used when radiographing flange butt shop welds of greater than 13 mm (1/2 in.) thickness. The edge blocks shall have the dimensions shown on the plans. The edge block shall be centered on the weld with a snug fit against the plate being radiographed, with the maximum gap shown on the plans. Edge blocks shall not be tack welded. Edge blocks shall be made of radiographically clean steel. The surface shall have an ANSI finish of 3 $\mu$m (0.125 mil) or smoother.

Field welding shall be in accordance with the requirements herein, except where welded connections do not carry calculated stresses. Magnetic particle inspection will not be required, so ANSI/AASHTO/AWS D1.5-88 Table 4.4 "Minimum Preheat and Interpass Temperature" as it refers to thicknesses to 19 mm (3/4 in.) inclusive, shall read "None". Electrodes with a low hydrogen classification will not be required.

**711.33 Stud Shear Connectors.** Stud shear connectors shall be in accordance with 711.32 and as shown on the plans.

**711.34 Annealing and Stress Relieving.** Structural members which are indicated in the contract to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and full annealing shall be in accordance with ASTM E 44. The temperatures shall be maintained uniformly throughout the furnace during the heating and cooling so that the temperatures at two points on the member differ by no more than 38°C (100°F) at any one time.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instruments, including recording pyrometers, shall be provided for determining the temperature of members in the

furnace. The records of the treatment operation shall be available and meet approval. Members, such as bridge shoes, pedestals, or other parts which are built up by welding sections of plate together shall be stress relieved in accordance with the procedure of the AWS when required by the plans or as otherwise specified.

**711.35 Eyebars.** Pin holes may be flame cut at least 50 mm (2 in.) smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together in the order that they are placed on the pin and bored at both ends while so clamped. Eyebars shall be packed and match marked for shipment and erection. All identifying marks shall be stamped with steel stencils on the edge of one head of each member after fabrication is completed so as to be visible when the bars are nested in place on the structure. The eyebars shall be straight and free from twists, and the pin holes shall be located accurately on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 5 mm in 1 m (1/16 in. in 1 ft).

The edges of eyebars that lie between the transverse centerline of their pin holes shall be cut simultaneously with two mechanically operated torches abreast of each other, guided by a substantial template, in such a manner as to prevent distortion of the plates.

**711.36 Facing of Bearing Surfaces.** The top and bottom surfaces of steel slabs, base plates, and cap plates of columns and pedestals shall be planed, or the plates hot-straightened. Parts in contact with them shall be faced.

Sole plates of beams and girders shall have full contact with flanges. Sole plates and masonry plates shall be planed or heat straightened.

Cast pedestals shall be planed on surfaces to be in contact with steel and shall have surfaces to be in contact with masonry, rough finished.

Surfaces of bronze bearing plates intended for sliding contact shall be finished.

The surface finish of bearing plates, base plates, and other bearing surfaces that are to come in contact with each other or with concrete shall meet the following ANSI surface roughness requirements as defined in ANSI B46.1:

| | |
|---|---|
| Bridge rollers and rockers | ANSI 250 |
| Heavy plates in contact with shoes to be welded | ANSI 1000 |
| Milled ends of compression members, milled or ground ends of stiffeners and fillers | ANSI 500 |
| Pins and pin holes | ANSI 125 |
| Sliding bearings | ANSI 125 |
| Steel slabs | ANSI 2000 |

**711.37 Pins and Rollers.** Pins and rollers shall be turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than 230 mm (9 in.) in diameter shall be forged. Pins and rollers 230 mm (9 in.) or less in diameter may be forged or cold finished, carbon steel shafting. In pins larger than 230 mm (9 in.) in diameter, a hole no less than 50 mm (2 in.) in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling.

**711.38 Boring Pin Holes.** Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member, and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut. The distance outside to outside of end holes in tension members, and inside to inside of end holes in compression members shall not vary from that specified more than 1 mm (1/32 in.). Boring of holes in built-up members shall be done after the bolting is completed.

**711.39 Pin Clearances.** The diameter of the pin hole shall not exceed that of the pin by more than 0.5 mm (1/50 in.) for pins 125 mm (5 in.) or less in diameter, nor 1 mm (1/32 in.) for larger pins.

**711.40 Threads for Bolts and Pins.** Threads for all bolts and pins for structural steel construction shall be in accordance with the United Standard Series UNC-ANSI B 1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 35 mm (1 3/8 in.) or more shall be threaded 6 threads per 25 mm (1 in.).

**711.41 Pilot and Driving Nuts.** Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

**711.42 Finishing Cast Steel.** The surface shall be finished as called for on the detail plans. Surfaces marked "finish" shall be made to exact size and shape and in such manner that removes all tool marks. If marked "rough finish" the tool marks need not be removed. However, there shall be no irregularities greater than 1 mm (1/32 in.) in height on rough finished surfaces.

**711.43 Finished Members.** The several pieces forming a built-up member shall fit together closely and accurately, and the finished member shall be true to line and free from twists, bends, and open joints.

Cover plates on trusses, beams, and girders shall be so nearly straight that variations do not exceed 1 mm in 1 m (1/16 in. in 5 ft), with a maximum variation not to exceed 5 mm (3/16 in.) at the center of the plates.

**711.44 Shop Assembling.** The field connections of main members of trusses, arches, continuous beam spans, bents, tower faces, plate girders, and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing and then shall have their sub-size holes reamed to specified size while the connections are

assembled. Assembly shall be full truss or girder assembly unless progressive beam or girder assembly, full chord assembly, progressive chord assembly, or special complete structure assembly is shown on the plans or otherwise specified.

Each assembly including camber, alignment, accuracy of holes, and fit of milled joints will be approved before reaming is commenced.

A camber diagram shall be furnished by the fabricator showing the camber at each panel point of each truss, arch rib, continuous beam line, plate girder, or rigid frame. When the shop assembly is full truss or girder assembly or special complete structure assembly, the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly is used, the camber diagram shall show calculated camber.

**(a) Full Truss or Girder Assembly.** Full truss or girder assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at one time.

**(b) Progressive Beam or Girder Assembly.** Progressive beam or girder assembly shall be accomplished by one of the following methods. In case the structure is on a horizontal curve, other assembly methods may be approved on shop plans.

1. This method shall consist of the assembly of at least three contiguous members, and no less than 46 m (150 ft). At least one beam or girder shall be added at the advancing end of the assembly before any member is removed from the rearward end so that the assembly portion of the structure is never shorter than that specified above. Each successive laydown assembly shall always include a previously reamed splice and the main member on each side of this splice.

2. The alternate method shall consist of placing the required number of contiguous shop members so that two complete spans are assembled for the first laydown. Each successive laydown shall consist of the required number of contiguous members to complete the next two spans while retaining in the new laydown the last bearing member from the previous laydown. On laydowns for structures comprised of an odd number of spans, a laydown of one span shall be permitted to complete the structure. This laydown shall be the last span unless otherwise approved on shop plans. Each retained bearing member shall be reassembled in its second laydown with the same relative orientation to a common base line as it was in the first laydown.

**(c) Full Chord Assembly.** Full chord assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connections to steel templates set at geometric, not cambered, angular relation to the chord lines.

Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member. The templates at both ends of the member shall be located accurately from one of the milled ends or scribed lines.

**(d) Progressive Chord Assembly.** Progressive chord assembly shall consist of assembling contiguous chord members in the manner specified for full chord assembly and in the number and length specified for progressive truss or girder assembly.

**(e) Special Complete Structure Assembly.** Special complete structure assembly shall consist of assembling the entire structure, including the floor system. This procedure is ordinarily needed only for complicated structures such as those having curved girders or extreme skew in combination with severe grade or camber.

**711.45 Drifting of Holes.** Except where drifting is specifically prohibited by this specification, the drifting done during assembly shall be only to bring the parts into position and not sufficient to enlarge the holes or distort the metal. If a hole must be enlarged to admit the bolt, it shall be reamed.

**711.46 Match Marking.** Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match marked and a diagram showing such marks shall be furnished.

**711.47 Shop Cleaning and Painting.** Shop cleaning and painting shall be in accordance with applicable requirements of 619.

**711.47.1 Shop Cleaning and Storage of ASTM A 709M Grade 345W (ASTM A 709 Grade 50W) Steel.** The fabricator shall protect bare steel sections and sub-assemblies so as not to damage or stain them. The use of paints, crayons, or other materials used for identification purposes shall be avoided. Storage shall be such to permit free drainage to avoid moisture pockets.

A sound uniform surface for the for formation of a protective oxide coating on surfaces shall be prepared as follows:

**(a) Hot Rolled Products.** These products shall include structural shapes, plates, hot-rolled sheets, and hot-rolled strip. The outside of each facia beam or girder, including the bottom of the bottom flange, shall be cleaned in accordance with 619.08(c). Contamination from grease, oil, or shop marking shall be avoided. If such contamination is unavoidable, such surfaces shall be cleaned in accordance with 619.08(b).

**(b) Welded Areas.** All exposed welds on facia surfaces shall be prepared by means of power grinding or blast cleaning in accordance with 619.08(d) to remove welding flux, slag, scale, or spatter.

**711.48 Furnishing Bolts.** Sufficient field bolts shall be furnished to complete the entire structure.

**711.49 Weighing of Members.** If it is specified that part of the material is to be paid for by actual weight, finished work shall be weighed in the presence of the inspector, if practicable. Satisfactory scales shall be supplied, and all work involved in handling and weighing the various parts shall be performed.

**711.50 Full Size Tests.** When full size tests of fabricated structural members or eyebars are required by the contract, the plans or specifications shall state the number and nature of the tests, the results to be attained, and the measurements of strength, deformation, or other performance that are to be made. Suitable facilities, material, supervision, and labor necessary for making and recording the tests shall be provided. The cost of testing including equipment, handling, supervision, labor, and incidentals for making the tests shall be included in the contract price for structural steel, unless otherwise specified.

**711.51 Acceptance.** Acceptance of any material or finished member shall not preclude its rejection if found to be defective, either during fabrication or erection. Rejected material shall be replaced and poor workmanship corrected promptly.

**711.52 Shipping.** Structural members shall be loaded on trucks or cars in such manner that they can be transported to and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

If required, pins, nuts, bolts, and other small details shall be boxed or crated, and the weight of each piece or box marked on it in plain figures.

Written permission shall be obtained prior to shipping plate girders with the webs horizontal.

Splice plates shall not extend beyond the ends of beams or girders after bolting for shipment.

Member lengths shall be subject to the provisions of the current edition of the Oversize-Overweight Vehicular Permit Handbook.

The Contractor shall be responsible for obtaining all required transportation permits.

## ERECTION

**711.53 General Requirements.** The erection methods shall be those prescribed for the several parts which constitute the finished structure and shall be in accordance with the requirements set forth herein. Workmanship and finish shall be first class and

all work done in a substantial and workmanlike manner in accordance with these specifications and in reasonably close conformance with the lines, grades, dimensions, and details shown on the plans, or as directed.

No erection shall be done without the approval of the Engineer. Before starting erection, information shall be fully given as to the erection methods and the amount and character of the equipment proposed to be used, which shall be subject to approval. Approval, if given, shall not be considered as relieving the Contractor of its responsibility for the safety of its methods or equipment or from carrying out the work in full accordance with the plans and specifications.

**711.54 Delivery of Materials.** If the contract is for erection only, the materials entering into the finished structure will be provided free of charge at the place designated and loaded or unloaded as specified. Material, which is required to be unloaded, shall be unloaded promptly on delivery to the place designated. Otherwise, the Contractor shall be responsible for demurrage charges.

**711.55 Handling and Storing.** Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, the material shall be checked against the shipping lists and all shortages or injuries discovered shall promptly be reported in writing. The Contractor shall be responsible for the loss or damage of material after receipt.

**711.56 Falsework.** The falsework shall be properly designed and substantially constructed and maintained for the loads which come upon it. Plans for falsework or for changes in an existing structure necessary for maintaining traffic shall be prepared and submitted for approval. Approval of these plans shall not be considered as relieving the Contractor of any responsibility.

**711.57 Bearings and Anchorages.** Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed, or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing on the masonry.

The holes shall be drilled and the anchor bolts, except where the bolts or anchor plates are built into the masonry, shall be set. The bolts shall be set accurately and fixed with portland cement grout completely filling the holes. The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of the erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

**711.58 Field Straightening Material.** If it is necessary to straighten beams, plate girders, plates, angles, and other shapes in the field, it shall be done in accordance with the applicable requirements of 711.11.

Before straightening a carrying member, a proposed method of straightening shall be submitted in writing. Approval shall be received prior to commencing the work.

**711.59 Field Assembly of Steel.** Parts assembled in the field shall be assembled accurately as shown on the plans. Matchmarks shall be followed. The materials shall be handled carefully so that no part is bent, broken, or otherwise damaged. Hammering which would injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned thoroughly before assembling.

Unless erected by the cantilever method, truss spans shall be erected on blocking so placed to give the trusses the required camber. Truss spans shall be completely bolted on the blocking except for stringers and bottom lateral connections which shall be bolted after the span is swung. In emergencies or special cases and with specific approval, truss spans may be swung with main joints fully filled with bolts and drift pins.

Structural steel shall be erected using sufficient full size drift pins to permit placement of bolts without damage thereto and to facilitate setting splices to grade.

At the time of erection, no less than 50% of the holes in all connections shall be filled with bolts. The bolts shall not be tightened more than snug tight at this stage.

Any drifting required shall be only such that draws the parts into position but not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled.

All field splices are optional, except as shown on the plans. The shop drawings shall indicate which splices are to be eliminated. Splice elevations have been calculated to include structural steel dead load only, with falsework removed. The tops of beam or girder splice plates shall be adjusted to the splice elevations shown on the plans before bolting field splices.

Splices shall be set to grade with the steel unsupported by falsework and prior to final bolting. After bolting is complete, these elevations will be checked. Adjustment shall be made as directed, if steel elevations are not within allowable tolerances.

**711.60 Misfits.** The correction of minor misfits involving harmless amounts of reaming, cutting, and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately and approval of the method of correction shall be obtained. The correction shall be made in his presence of the inspector. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for

all misfits, errors, and injuries and shall make the necessary corrections and replacements. If the contract is for erection only, the inspector, with the cooperation of the Contractor, shall keep a correct record of labor and materials used. Within 30 days, an itemized bill shall be presented for approval.

**711.61 Pin Connections.** Pilot and driving nuts shall be used in driving pins. They shall be furnished without charge. Pins shall be driven so that the members take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

**711.62 Blank.**

**711.62.1 Diaphragm Connections** Diaphragm connections other than those shown on the plans may be permitted. If other connections are to be used, details shall be submitted for approval. The Contractor shall assume full responsibility for layout of all diaphragm connections and for the accuracy of all fitted parts. Connections will not be permitted which require welding to the web, except at supports.

**711.63 Bolted Connections Using High Strength Bolts.**

**(a) General.** This subsection covers the assembly of structural joints using ASTM A 325M (ASTM A 325) high strength carbon steel bolts, or equivalent fasteners, tightened to a high tension. The bolts are to be used in holes provided in accordance with 711.21, 711.22, and 711.23.

High strength bolts shall be 22 mm (7/8 in.) in diameter unless noted.

**(b) Bolts, Nuts, and Washers.** Bolts, nuts, and washers shall be in accordance with 910.02(e). All galvanized nuts shall be lubricated with lubricant containing a visible dye. Black bolts shall be oily to the touch when installed. Weathered or rusted bolts shall be cleaned and lubricated prior to installation.

**(c) Bolted Parts.** The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit together solidly when assembled and shall not be separated by gaskets or any other interposed compressible material. When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of dirt, loose scale, burrs, other foreign material, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or rust inhibitor.

**(d) Installation.**

**1. Bolt Tension.** Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in Table A for the size of fastener used.

TABLE A

BOLT TENSION FOR ASTM A 325M (ASTM A 325) BOLTS

| Bolt Size mm (in.) | Minimum Bolt Tension,* kilonewtons | (pounds) |
|---|---|---|
| 13 (1/2) | 54 | (12,050) |
| 16 (5/8) | 86 | (19,200) |
| 19 (3/4) | 126 | (28,400) |
| 22 (7/8) | 175 | (39,250) |
| 25 (1) | 229 | (51,500) |
| 29 (1 1/8) | 251 | (56,450) |
| 32 (1 1/4) | 319 | (71,700) |
| 35 (1 3/8) | 380 | (85,450) |
| 38 (1 1/2) | 463 | (104,000) |

* Equal to the proof load (length measurement method) given in ASTM A 325M (ASTM A 325).

Threaded bolts shall be tightened with properly calibrated wrenches or by the turn-of-nut method. If required because of bolt entering and wrench operation clearances, tightening by either procedure may be done by turning the bolt while the nut is prevented from rotating. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 s.

Installation of all high strength bolts shall be in accordance with AASHTO Standard Specifications for Highway Bridges, Division II. The snug tight condition as defined in AASHTO Specifications for Highway Bridges, Division II, shall be obtained for all final tightening.

A Skidmore-Wilhelm calibrator or other acceptable bolt tension indicating devices will be required on the project site for use during bolt installation. Periodic tests shall be performed to ensure the installed bolt, nut, and washer assembly meets the above requirements. Such tests shall be performed each work day when calibrated wrench tightening is used. For short grip bolts, direct tension indicators with solid plates may be used to perform these tests. Direct tension indicators shall first be checked with a longer grip bolt in the Skidmore-Wilhelm calibrator.

**2. Washers.** All fasteners shall have a hardened washer under the nut or bolt head turned in tightening. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

**3. Calibrated Wrench Tightening.** If calibrated wrenches are used to provide the bolt tension specified in 711.63(d)1, the settings shall be such as to induce a bolt tension of 5% to 10% in excess of this value. These wrenches shall be calibrated at least once each working day by tightening, in a device capable of indicating actual bolt tension, no less than three typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to stall or cut-out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the calibrating tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in

tightening motion when torque is measured. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be turned to touch up bolts previously tightened which may have been loosened by the tightening of subsequent bolts. This shall be continued until all are tightened to the required amount.

**4. Turn-of-Nut Tightening.** When the turn-of-nut method is used to provide the bolt tension specified in 711.63(d)1, there shall first be enough bolts brought to a snug tight condition to ensure that the parts of the joint are brought 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, bolts shall be placed in all remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table B with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

**TABLE B**

NUT ROTATION [1] [2] FROM SNUG TIGHT CONDITION

Disposition of Outer Faces of Bolted Parts

| Both faces normal to bolt axis, or one face normal to axis and other face sloped[3] (bevel washer not used). | | Both faces sloped[3] from normal to bolt axis (bevel washers not used). |
|---|---|---|
| Bolt length[4] not exceeding 8 diameters or 200 mm (8 in.) | Bolt length[4] exceeding 8 diameters or 200 mm (8 in.). | For all lengths of bolts. |
| 1/2 turn | 2/3 turn | 3/4 turn |

[1] For coarse thread heavy hexagon structural bolts of all sizes and lengths and heavy hexagon semi-finished nuts.

[2] Nut rotation is rotation relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation: 1/6 of a turn over and nothing under.

[3] Slope 1:20 maximum.

[4] Bolt length is measured from underside of head to extreme, end of point.

**(e) Inspection.**

1. It will be determined that requirements 2 and 3 of 711.63(e) are met in the work. When the calibrated wrench method of tightening is used, the Engineer shall be given full opportunity to witness the calibration tests prescribed in 711.63(d)3.

2. The installation and tightening of bolts will be observed to determine that the selected tightening procedure is properly used and that all bolts are tightened.

3. The following inspection shall be used unless a more extensive or different inspection procedure is specified.

a. An inspection wrench which may be either a torque wrench or a power wrench that can be adjusted accurately in accordance with 711.63(d)3 shall be used.

b. Three bolts of the same grade, size and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. Length may be any length representative of bolts used in the structure. There shall be a washer under the part turned in tightening each bolt.

c. When the inspecting wrench is a torque wrench, each bolt specified in requirement 3b of 711.63(e) shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in 711.63(d)1. The inspecting wrench shall then be applied to the tightened bolt. The torque necessary to turn the nut or head 5 degrees, or approximately 25 mm (1 in.) at a 300 mm (12 in.) radius, in the tightening direction shall be determined. The average torque measured in the tests of 3 bolts shall be taken as the job inspecting torque to be used in the manner specified in requirement 3e of 711.63(e).

d. When the inspecting wrench is a power wrench, it shall be adjusted so that it shall tighten each bolt specified in requirement 3b of 711.63(e) to a tension at least 5% but no more than 10% greater than the minimum tension specified for its size in 711.63(d)1. This setting of wrench shall be taken as the job inspecting torque to be used in the manner specified in requirement 3e of 711.63(e).

e. Bolts represented by the sample prescribed in requirement 3b of 711.63(e) which have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspection wrench and its job inspecting torque to 10% of the bolts, but no less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection shall be accepted as properly tightened. If a nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection. All bolts whose nut or head is turned by the job inspection torque shall be tightened and reinspected, or alternatively, the fabricator or erector, at his option, may retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

**711.64 Bolted Connections Using Other Than High Strength Bolts.** Bolts for these connections shall be in accordance with 910.02(f).

**711.65 Final Clean-Up.** Final clean-up shall be conducted in accordance with 104.07.

**711.66 Structural Steel Cutting, Rivet and Bolt Removal, and Drilled Bolt Holes in Repair Projects.** Field cutting of structural steel shall be done as shown on the plans or as directed.

Rivets or bolts connecting steel at locations shown on the plans or as directed shall be removed. This work shall be done in a manner that does not damage the surrounding steel. If necessary, such work shall be done by drilling.

Bolt holes shall be drilled as directed in the field. A bolt hole is a hole required for one bolt drilled through any number and thicknesses of metal plates.

**711.67 Jacking and Supporting Beams.** When jacking and supporting a beam is required on a bridge repair project, the proposed method for jacking and supporting shall be submitted for approval. This work shall not be performed until a method is approved.

**711.67.1 Field Cleaning and Storage of ASTM A 709M Grade 345W (ASTM A 709 Grade 50W) Steel.** Cleaning of structural steel specified to be left unpainted shall be in accordance with 619.08(b) or 619.08(f) depending on the severity of the soilage. Foreign matter which adheres to the steel after it has been blasted, and which inhibits formation of the oxide film shall be removed as soon as practical. The use of acids to remove scale and stains will not be permitted.

Storage shall be such to permit free drainage to avoid moisture pockets.

**711.68 Painting.** After erection is complete, the structure shall be painted unless otherwise provided. Painting shall be in accordance with the applicable requirements of 619.

**711.69 Method of Measurement.** Plain structural steel shapes, fabricated steel, steel castings, iron castings, bolts, pins, rollers, rockers, anchor bolts, and threaded rods will be measured by the kilogram (pound). If the Schedule of Pay Items includes a lump sum item for structural steel, all of the materials listed above shall be included in such pay item. No measurement will be made.

Stud shear connectors placed on new structural steel will not be measured. Stud shear connectors placed on existing structural steel will be measured by the number installed.

Bronze plates will be measured by the kilogram (pound). Pay mass (weight) will be based on a theoretical mass of 8,590 kg/m$^3$ (weight of 536 lb/cu ft). Volume will be computed based on finished dimensions. No deductions will be made for drilled holes.

Field cutting of structural steel will be measured by the square millimeter (square inch) as determined by the multiplication of the length times the depth of the cut. Removal of rivets and removal of bolts will be measured by the number of each removed. Drilled holes for bolts on repair work will be measured by the number of drilled holes.

Jacking and supporting structural members will not be measured for payment.

**711.70 Basis of Payment.** The accepted quantities of plain structural steel shapes, fabricated steel, steel castings, iron castings, bolts, pins, rollers, rockers, anchor bolts, and threaded rods will be paid for at a contract lump sum price if the Schedule of Pay Items includes a lump sum pay item for structural steel. Changes from the estimated quantities shall be in accordance with 711.70(a). If the Schedule of Pay Items does not include a lump sum pay item for structural steel, the accepted quantities of structural steel will be paid for at the contract unit price per kilogram (pound) for structural steel. Such pay item will include all work listed above, complete in place. Payment will be in accordance with 711.70(b).

Stud shear connectors placed on existing structural steel will be paid for at the contract unit price per each, complete in place and accepted.

The accepted quantities of bronze plates will be paid for at the contract unit price per kilogram (pound). The accepted quantities of field structural steel cutting will be paid for at the contract unit price per square millimeter (square inch) for structural steel, field cut. The accepted quantities of rivet removal, bolt removal, and drilled holes will be paid for at the contract unit price per each for rivet, remove; per each for bolt, remove; and per each for drilled hole.

Jacking and supporting structural members, if specified as a pay item, will be paid for at the contract lump sum price for jacking and supporting the types of structural members shown in the Schedule of Pay Items.

Bolts, including anchor bolts and threaded rods, will be paid for as the full mass (weight) computed on the basis of 7,850 kg/$m^3$ (490 lb/cu ft), including nuts and washers, for the actual number of bolts in the structure.

If welding is shown on the plans, the masses (weights) of the structural steel parts will be computed as described above.

The mass (weight) of castings will be computed on the basis of 7,850 kg/$m^3$ (490 lb/cu ft) for cast steel, and 7,210 kg/$m^3$ (450 lb/cu ft) for cast iron, based on the net volume of the finished castings as shown on the plans, including fillets at angles. No deductions will be made for holes required to be drilled in castings or for rounding the corners of castings.

**(a) Lump Sum Basis.** An estimated mass (weight) of structural steel will be shown on the plans. Such mass (weight) will be computed by the same method as that used when computing the estimated mass (weight) when paid for on a unit price per kilogram (pound) basis from semi-detailed plans. This mass (weight) will include all structural steel and miscellaneous metals unless otherwise included in specific pay items.

The mass (weight) of structural steel shown on the plans is approximate only. For a lump sum pay unit, the Contractor shall determine the mass (weight) on which the bid is based.

If there is a discrepancy between the plan mass (weight) and the actual mass (weight), no decrease or increase in the payment for the work will be made on account of such discrepancy.

If a change in the plans is made which will affect the mass (weight) of material to be furnished, payment for the addition or reduction of structural steel quantities required as a result of such change in plans will be made at a unit price per kilogram (pound) obtained by dividing the lump sum amount for structural steel by the total estimated mass (weight) of structural steel shown on the plans. Such unit price may be adjusted in consideration of the fabricating and connection costs. Changes in the plans involving classifications of structural steel may increase the pay quantities. Such additional quantities will be paid for on comparison of evidence of invoice prices.

**(b) Unit Weight Basis.** The mass (weight) of materials will be shown in the bill of materials on the plans when shop details are included in such plans, or as computed from the fabricator's approved shop details, when shop details are not included in the plans. In either case, such mass (weight) shall include all changes ordered.

For rolled sections, the gross mass (weight) of the steel will be considered. The mass (weight) will be figured on the basis of 7,850 kg/m$^3$ (490 lb/cu ft). The mass (weight) of each piece will be the mass (weight) of the smallest regular shape from which the detail piece can be cut, not deducting cuts or holes. When so shown on the contract plans or on the approved shop plans, the mass (weight) of groups of two or more pieces shall be the mass (weight) of the smallest regular shape from which the given group of detail pieces may be cut by properly arranging the cuts.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Bolt, Remove | EACH |
| Bronze Plates | kg (LBS) |
| Drilled Hole | EACH |
| Jacking and Supporting _____ (structural member type) | LS |
| Rivet, Remove | EACH |

Structural Steel ..... LS
kg (LBS)
Structural Steel, Field Cut ..... mm2 (SIN)
Stud Shear Connectors ..... EACH

The costs of drilling holes for anchor bolts, bridge bearing pads, fabrication, erecting falsework, welding material, Charpy V-Notch toughness tests, and necessary incidentals shall be included in the costs of the pay items.

The cost of stud shear connectors placed on new structural steel will be included in the costs of structural steel.

No increase in pay weight will be permitted if diaphragm connections other than those shown on the plans are approved and used.

Shims between beams and top shoes of the thicknesses necessary to adjust the steel to planned elevations shall be furnished using either the plan datum or another datum as established. No adjustment will be made to the pay quantities as long as the total mass (weight) of shims required does not exceed that planned. No shim shall be less than 3 mm (1/8 in.) in thickness.

No allowance in mass (weight) will be made for work which is done at the option of the Contractor. No payment will be made for material used at the convenience of the Contractor in excess of the quantities shown on the plans.

## SECTION 712 – TIMBER STRUCTURES

**712.01 Description.** This work shall consist of furnishing the materials for and the construction of timber structures, such parts of other structures which are of timber, and wood plank floors for structures in accordance with these specifications, in reasonably close conformance with the lines, grades, dimensions, and details shown on the plans or as directed.

**712.02 Materials.** Materials shall be in accordance with the following:

Iron Castings ..... 910.05(b)
Lumber and Timber (Treated) ..... 911.02
Lumber and Timber (Untreated) ..... 911.01
Malleable Iron Castings ..... 910.05(d)
Preservatives ..... 911.02(f)
Steel Castings ..... 910.05(a)
Structural Steel ..... 910.02
Waterborne Finish Paint ..... 909.02(d)

Machine bolts, drift bolts, and dowels shall be medium steel. Machine bolts shall have square heads and nuts, unless otherwise specified. Nails shall be full-barbed, heavy, bright, flat-head, car nails. Lumber and timber shall be treated or untreated. Rods, plates, bars, and shapes shall be structural steel. Castings shall be steel or iron. Washers may be cast OG or malleable castings or they may be cut from medium steel plates. Spikes shall be cut, wire, or boat spikes. Spikes, bolts, dowels, washers, and lag screws shall be black or galvanized.

## CONSTRUCTUON REQUIREMENTS

**712.03 General Requirements.** The ground underneath and in the immediate vicinity of all stored material shall be cleaned of weeds and rubbish and kept well drained. Lumber and timber at the site of the work shall be stored in piles. Untreated lumber shall be open stacked at least 300 mm (12 in.) above the ground surface, arranged to shed water and prevent warping, and protected by a weatherproof covering when so required. Creosoted timber and piling shall be closed-stacked so that warping is prevented and the tops of the stacks are covered. Treated timber shall be handled carefully without sudden dropping, breaking of outer fibers, bruising, or penetrating surfaces with tools. It shall be handled with rope slings. Canthooks, peaveys, spikes, or hooks shall not be used. Creosoted piling may be handled with chains.

Workmanship shall be first-class throughout. Competent bridge carpenters shall be employed. All framing shall be true and exact. Nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces will be considered evidence of poor workmanship and sufficient cause for the dismissal of a worker causing them.

In structures of untreated timber the ends, tops, and all contact surfaces of sills, caps, floor beams, stringers, end joints, contact surfaces of bracing, the back faces of bulkheads, and all timber which is to be in contact with earth, road material, or other timber shall be coated with two coats of hot creosote oil before being assembled. Countersinking shall be done where smooth faces are required. The recesses formed by countersinking shall be painted with hot creosote oil and filled with hot pitch after the bolt or screw is in place.

All cuts in treated piles or timber and all abrasions, after having been trimmed, shall be covered with two applications of a mixture of 60% creosote oil and 40% roofing pitch, or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch. Insofar as practicable, cutting, framing, and boring of timber to be treated, except pile cut-offs, shall be done before treatment.

All lumber and timber shall be cut accurately and framed to a close fit in such manner that joints will have even bearing over the entire contact surfaces. Mortises shall be true and even for their full depth and tenons shall fit snugly. Shimming will not be permitted in making joints nor will open joints be accepted. Timbers requiring an exact fit shall be matchmarked.

Holes for bolts, dowels, rods, and lag screws shall be bored as follows:

(a) machine bolts shall be the same diameter as the bolt;

(b) round drift bolts and dowels shall be 2 mm (1/16 in.) less in diameter than that of the bolt or dowel to be used;

(c) square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel;

(d) rods shall be 2 mm (1/16 in.) larger than the rod; and

(e) lag screws shall be the screw diameter to the base of thread, and half the screw diameter to the point of the screw.

Before driving bolts, hot creosote oil shall be poured into all bolt holes so that the entire surface of the hole is coated. Any unfilled holes, after being treated with creosote oil, shall be plugged with creosoted plugs.

A washer of the size and type specified shall be used under each bolt head and under each nut which would otherwise come in contact with wood. Any portion of a bolt projecting more than 6 mm (1/4 in.) beyond the nut shall be cut off. The threads of each bolt shall be checked at the face of the nut after the nut has been finally tightened. The ends of bracing shall be bolted through the pile, post, or cap with bolts of no less than 16 mm (5/8 in.) in diameter. Intermediate intersections shall be bolted or spiked with wire or boat spikes as shown on the plans.

**712.04 Caps.** Timber caps shall have an even and uniform bearing over the tops of supporting posts or piles and shall have their ends evenly aligned. All caps shall be secured by drift bolts of no less than 19 mm (3/4 in.) in diameter extending at least 230 mm (9 in.) into the approximate center of posts or piles. Pile heads, after being cut to receive the caps and prior to placing the caps, shall be treated to prevent decay. The sawed surfaces of creosoted piles shall be covered with three applications of a mixture of 60% creosote oil and 40% roofing pitch or brush coated with three applications of hot creosote oil and covered with hot roofing pitch. A covering of medium weight roofing felt or galvanized iron shall be placed on this treatment, bent over the sides of the pile, and fastened securely. Edges shall be trimmed to present a satisfactory appearance. The sawed surfaces of untreated piles shall be brush coated with two applications of hot creosote oil.

**712.05 Stringers.** Stringers shall be sized at bearings and so placed in position that any knots at or near edges are in the top portion. Outside stringers may have butt joints with the ends cut on a taper. Interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least 13 mm (1/2 in.) for the circulation of air and shall

be securely fastened to the cap by drift bolting where specified. Where stringers are two panels in length, the joints shall be staggered. Cross-bridging between stringers shall be neatly and accurately framed and securely toenailed with at least two nails in each end.

**712.06 Bents.** Untreated timber, if used for mudsills, shall be of heart cedar, heart cypress, redwood, or other approved durable timber. Mudsills shall be embedded firmly and evenly to solid bearing and tamped in place. Concrete pedestals for the support of framed bents shall be carefully finished so that the posts or sills take even bearing on them. The sills or posts shall be anchored to pedestals with dowels and the dowels set when the pedestals are poured. They shall be no less than 19 mm (3/4 in.) in diameter and shall project at least 150 mm (6 in.) above the top of each pedestal. Sills shall have true and even bearing on mudsills, grillages, piles, or pedestals. They shall be drift-bolted to mudsills or piles with bolts no less than 19 mm (3/4 in.) in diameter and extend into the mudsills or piles at least 150 mm (6 in.). When feasible, all earth shall be removed from contact with sills to permit free circulation of air around them.

Posts shall be fastened to pedestals with dowels of no less than 19 mm (3/4 in.) in diameter extending at least 150 mm (6 in.) into the posts. Posts shall be fastened to sills, as shown on the plans, by means of drift bolts of not less than 19 mm (3/4 in.) in diameter driven diagonally through the base of the post, and extending at least 230 mm (9 in.) into the sill, or by means of dowels of no less than 19 mm (3/4 in.) in diameter extending at least 150 mm (6 in.) into posts and sills. Pile bents shall be driven in accordance with 701.

**712.07 Wheel Guards and Railings.** These shall be framed and erected true to line and grade. Wheel guards and rails shall be surfaced as shown on the plans. Wheel guards shall be laid in sections of no less than 3.7 m (12 ft) in length.

**712.08 Painting.** Paint shall be applied to untreated lumber and timber as shown on the plans or as otherwise specified. Lumber or timber treated with preservative shall not be painted, unless otherwise specified. The color shall be as specified.

Surface preparation shall be the removal of all contamination such as oil, grease, dirt, foreign matter, rust, mold, mildew, and sealers. Knots and pitch streaks shall be scraped or burned, and sanded. All nail holes or small openings shall be caulked with a general purpose caulking compound.

The surfaces shall be painted with one coat of waterborne finish paint. The paint shall be applied by brush or roller only and at the rate recommended by the manufacturer. All finishes shall be uniform in texture and color. If a painted surface is unsatisfactory, the paint shall be removed and the surface shall be cleaned and repainted or corrected as may be directed.

At the end of each work day, paint stains and splatters shall be removed from all surfaces not intended to receive the paint applied for that day.

**712.09 Single-Ply Plank Floors.** These floors shall consist of a single thickness of plank supported by stringers or joists. The planks shall be laid heartside down with 6 mm (1/4 in.) openings for seasoned material and with tight joints for unseasoned material. Each plank shall be fastened securely to each joist or stringer. The planks shall be carefully selected for thickness and laid so that a smooth riding surface is obtained.

**712.10 Two-Ply Plank Floors.** These floors shall consist of two layers of wood planks supported by stringers or joists. Both courses shall have been pressure treated with creosote oil. The top course shall be laid parallel to the roadway centerline with each piece fastened securely to the lower course. The lower course shall be fastened as provided above for single-ply. Joists shall be staggered at least 0.9 m (3 ft). Ends shall be fastened securely. If required, the outer ends of the top planks shall be beveled at each end of the bridge.

**712.11 Method of Measurement.** Structural timber and lumber, both treated and untreated, will be measured by the cubic meter (1,000 feet board measure). Planks for floors will be measured by the square meter (square foot). Computation of the amount of lumber and timber will be based on full size for rough lumber and nominal size for dressed lumber on the shortest commercial lengths which may be used.

Metal parts, other than hardware, will be measured by the kilogram (pound) computed in accordance with 711.70(b). Bolts, dowels, washers, nails, spikes, and lag screws will be classed as hardware.

**712.12 Basis of Payment.** The accepted quantities of lumber and timber will be paid for at the contract unit price per cubic meter (1,000 feet board measure) for lumber and timber, either treated or untreated as specified. Plank floors will be paid for at the contract unit price per square meter (square foot) for plank floors of the ply specified. Metal parts will be paid for at the contract unit price per kilogram (pound).

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Metal Parts | kg (LBS) |
| Plank Floors, _____ Ply | m2 (SFT) |
| Lumber and Timber, Treated | m3 (MFBM) |
| Lumber and Timber, Untreated | m3 (MFBM) |

The costs of preservative treatment, hardware, painting, and necessary incidentals shall be included in the costs of the pay items.

## SECTION 713 – TEMPORARY BRIDGES AND APPROACHES

**713.01 Description.** This work shall consist of the construction and maintenance of temporary pile or timber trestle bridges and approaches in accordance with these specifications and in reasonably close conformance with the lines and grades shown on the plans or as directed.

**713.02 Materials.** Materials shall be in accordance with the following:

Delineators .....913.08
Delineator Posts .....910.15
Fence .....910.18
Piling .....701

## CONSTRUCTION REQUIREMENTS

**713.03 General Requirements.** Unless otherwise provided, the right-of-way will be furnished for temporary bridges and approaches.

Information indicating the details of the temporary bridge proposed to be built shall be submitted for approval. If this information is not in accordance with the plans, details of the proposed temporary bridge signed by and bearing the seal of a registered professional engineer shall be submitted. These details shall be supplied in triplicate or in such form that may be reproduced readily. Information or details, or both if required, regarding temporary bridges shall be submitted and approved before work is started.

Where it is necessary to remove existing fence, a temporary fence shall be erected along the temporary right-of-way line, if so directed. This fence shall be substantially as good as the existing fence. It shall be built and maintained satisfactorily.

**713.04 Temporary Bridge.** Unless otherwise provided, the temporary bridge shall have a clear roadway of no less than 8.5 m (28 ft) and be designed to carry an HS20 truck loading. The bridge shall be provided with substantial railings which shall be kept painted white. Backwalls shall be built at each end bent to hold the approach fills. Each bent shall have at least four piles or four substantial posts on an adequate mudsill. The temporary bridge shall be built to an elevation of not less than that shown on the plans. It shall have a clear length opening no less than shown or otherwise designated. Unless otherwise specified, all timber and piles may be treated or untreated.

**713.05 Temporary Approaches.** Temporary approaches shall be constructed to a line and grade which will provide a reasonably convenient and safe connection between the temporary bridge and the existing road. The grade and crown elevation shall be as shown on the plans. The roadway and slopes shall be as shown on the plans. All necessary drainage shall be provided. Embankment shall be compacted in accordance with 203. If it becomes necessary to reconstruct the connection of the approaches with

the existing roadway, either because of the operations or other cause, such adjustment shall be made as directed. HMA pavement for temporary approaches shall be in accordance with 402. Temporary pavement markings in accordance with 801.12 shall be placed as shown on the plans. Delineators in accordance with 804 shall be placed as shown on the plans.

Guardrail and guardrail end treatment shall be provided at each corner of the temporary bridge as shown on the plans or as directed. The furnishing of materials and installation shall be provided in accordance with 601. After removal, the guardrail and guardrail end treatment will remain the property of the Contractor.

**713.06 Maintenance.** Unless otherwise provided, where a temporary bridge is required, traffic over the existing bridge shall not be prohibited until the temporary bridge and approaches are satisfactorily completed and opened to traffic. They shall be so maintained until the new structure is opened to traffic. The necessary material and labor shall be furnished to repair or replace any portion of the temporary bridge and approaches which may have deteriorated under traffic. During the winter months, salt or other equivalent materials shall be used as directed to prevent slippery conditions.

**713.07 Removal.** When the new work which made the temporary bridge and approaches necessary is opened to traffic, all the temporary work shall be removed and the temporary right-of-way shall be restored as nearly as possible to its original or satisfactorily altered state. All bents in the stream shall be removed entirely or down to the bed of the stream and all other bents either removed entirely or to 0.6 m (2 ft) below the ground surface, unless the property owner of the temporary right-of-way consents in writing to have them cut at the ground line. Temporary bituminous HMA pavement, when no longer required for maintenance of traffic, shall be removed and shall be disposed of in accordance with 203.10.

**713.08 Method of Measurement.** Temporary bridges and approaches will not be measured for payment unless otherwise specified. HMA mixtures for temporary pavement will be measured by the megagram (ton). Guardrail of the type specified will be measured by the meter (linear foot) along the top of rail. Guardrail end treatments will be measured per each of the type specified. Temporary pavement markings will be measured in accordance with 801.17. Seeding and sodding will be measured in accordance with 621.12. The removal and disposal of temporary HMA pavement will not be measured for payment.

**713.09 Basis of Payment.** The accepted quantities of temporary bridge and approaches will be paid for at the contract lump sum price for the work, complete in place and later removed as specified. HMA mixtures for temporary pavement will be paid for as the type of mixture specified, in accordance with 610.06, complete in place. Guardrail installed along approaches will be paid for at the contract unit price per meter (linear foot). Guardrail end treatment will be paid for at the contract unit price per each for the type specified. Temporary pavement markings will be paid for in accordance with 801.18.

Seeding and sodding will be paid for in accordance with 621.13.

If adjustment of approach embankments is necessary, the additional excavation and borrow will be paid for in accordance with 203.28.

Payment will be made under:

| **Pay Item**<br>**Metric Pay Item**<br>**(English Pay Item** | **Pay Unit**<br>**SI Pay Unit Symbol**<br>**English Pay Unit Symbol)** |
|---|---|
| Guardrail End Treatment, _____, Temporary Bridge Approaches<br>type | EACH |
| Guardrail, W-Beam, ____ m Spacing, Temporary Bridge Approaches | m |
| (Guardrail, W-Beam, ____ ft.- ____ in. Spacing, Temporary Bridge Approaches | LFT) |
| Temporary Bridge | LS |
| Temporary Bridge and Approaches | LS |

The costs of excavation, embankment, backfill, removal and disposal of temporary HMA pavement, delineators, and temporary fence, shall be included in the costs of the pay items.

The costs of furnishing, installation, and removal of guardrail and guardrail end treatment shall be included in the costs of the pay items.

If the Contractor elects to build a longer bridge or approaches than specified, such work shall be done with no additional payment. If such work requires additional right-of-way, it shall be provided with no additional payment.

## SECTION 714 – CONCRETE CULVERTS AND RETAINING WALLS

**714.01 Description.** This work shall consist of the construction of concrete retaining walls, concrete drainage structures with less than 6.1 m (20 ft) span, and such parts of similar structures composed of concrete in accordance with these specifications and 105.03.

**714.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Bituminous Mastic Pipe Joint Sealer | 906.05 |
| Chemical Anchor System | 310.02 |
| Concrete | 702 |
| Geotextile | 913.18 |

Joint Membrane System for Precast Reinforced
Concrete Box Sections.....906.05.1
Precast Reinforced Concrete Box Culverts .....907.05
Reinforcing Steel .....910.01
Structure Backfill.....904

Concrete in cast-in-place splices between an existing culvert and a precast reinforced concrete box section extension or used to seal existing culverts shall be class A.

## CONSTRUCTION REQUIREMENTS

**714.03 General Requirements.** Unless otherwise specified, applicable provisions of 702 and 703 shall apply to the construction of culverts, culvert extensions, retaining walls, and concrete parts of similar structures. Excavation and disposal shall be in accordance with the applicable requirements of 206. The areas designated for waterproofing shall be waterproofed in accordance with 702.23. All underground drains encountered during excavation for the structure shall be perpetuated as dictated by field conditions. Drainage openings through masonry shall be in accordance with 702.16.

Detailed plans for falsework and centering will not be required.

**714.04 Extension of Existing Culverts.** All pertinent requirements of this specification shall apply to extensions of existing box culverts, slab top culverts, and arch culverts. Such portions of the existing culvert designated for removal shall be removed. All portions of the existing structure which are to remain in place and are damaged shall be repaired or replaced as directed. Those portions left in place which are wholly or partially filled with debris shall be cleaned out. Material removed shall be disposed of in accordance with the applicable requirements of 202.02.

All existing reinforcing steel exposed after concrete removal shall be cleaned and straightened in preparation for lapping with reinforcement from adjacent new work. Where existing reinforcing steel has deteriorated or been damaged during the removal operation, holes shall be drilled into the face of the existing structure to provide embedment for replacement reinforcing steel. The holes shall be of the diameter and length shown on the plans or as directed and shall be cleaned prior to placement of the reinforcement and an approved chemical anchor system.

Existing culverts shall be extended by one of the following methods:

**(a) Precast Concrete Box Sections Extension.** A cast-in-place concrete splice shall be constructed as a transition between the existing structure and the precast extension. The splice reinforcement shall be lapped with the exposed existing structure reinforcing steel and with exposed reinforcing mesh from the extension as shown on the plans.

**(b) Cast-In-Place Concrete Culvert Extension.** The reinforcing steel for the extension shall be directly lapped with the exposed reinforcement of the existing structure as shown on the plans.

**714.04.1 Precast Reinforced Concrete Box Section Joints.** Precast reinforced concrete box section joints shall be sealed as shown on the plans. A bituminous mastic pipe joint sealer system or self-adhering joint membrane systems shall be applied when the concrete surface temperature is above 5°C (40°F) or sufficient to allow adherence. Prior to application of the mastic or membrane material, the concrete surfaces shall be cleaned and dry. Heat may be applied to the concrete surfaces until they are in accordance with the temperature and dryness requirements. The mastic or membrane material shall be centered on both sides of the joint as it is being applied. After application, the geotextile or membrane material shall be rolled to avoid wrinkling. If the roll of geotextile or membrane material does not cover the full length of the joint, an overlap of at least 65 mm (2 1/2 in.) shall be required to start the next roll of material. The manufacturer's application instructions shall apply in addition to the above requirements.

**714.05 Sealing Existing Culverts.** When existing culverts are no longer needed, but do not require removal, they shall be sealed with concrete at both ends as shown on the plans or as directed. Existing headwall removal shall be as shown on the plans or as directed.

**714.06 Method of Measurement.** Concrete used in retaining walls, culverts, and culvert extensions will be measured in accordance with 702.27. Reinforcing steel will be measured in accordance with 703.07. Precast reinforced concrete box sections and precast reinforced concrete box section extensions will be measured by the meter (linear foot), complete in place. Structure backfill will be measured in accordance with 211.09. Field drilled holes will be measured in accordance with 702.27.

**714.07 Basis of Payment.** The accepted quantities of concrete used in retaining walls, culverts, and culvert extensions will be paid for at the contract unit price per cubic meter (cubic yard) for concrete, of the class specified, structures. Reinforcing steel will be paid for in accordance with 703.08. Precast reinforced concrete box sections will be paid for at the contract unit price per meter (linear foot) for culvert, precast reinforced concrete box sections, of the size specified, complete in place. Precast reinforced concrete box section extensions will be paid for at the contract unit price per meter (linear foot) for culvert extension, precast reinforced concrete box sections, of the size specified, complete in place. Structure backfill will be paid for in accordance with 211.10. Field drilled holes will be paid for in accordance with 702.28.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Concrete, _____, Structures (class) | m3 (CYS) |
| Concrete Culvert Extension, Precast Reinforced Concrete Box Sections, _____ mm (span) x _____ mm (rise) | m |
| (Concrete Culvert Extension, Precast Reinforced Concrete Box Sections, _____ ft (span) x _____ ft (rise) | LFT) |
| Culvert, Precast Reinforced Concrete Box Sections, _____ mm (span) x _____ mm (rise) | m |
| (Culvert, Precast Reinforced Concrete Box Sections, _____ ft (span) x _____ ft (rise) | LFT) |

The costs of excavation except as provided in 206.11(a), expansion joint material, perpetuation of existing drains shown on the plans, sealing of existing structures, removal of existing structures, removal of portions of existing structures, cleaning out old channels, approved chemical anchor system, precast reinforced concrete structure joints and necessary incidentals shall be included in the costs of the pay items.

No additional payment will be made for carrying an underground drain through a culvert or culvert extension. However, no deduction will be made for the volume of concrete occupied by the drain pipe in a cast-in-place culvert or culvert extension.

No additional payment will be made for the repair or replacement of existing concrete damaged by Contractor operations.

## SECTION 715 – PIPE CULVERTS, AND STORM AND SANITARY SEWERS

**715.01 Description.** This work shall consist of the construction or reconstruction of pipe culverts, storm or sanitary sewers, slotted drain pipe, or slotted vane drain pipe in accordance with 105.03.

### MATERIALS

**715.02 Materials.** Pipe materials, minimum thickness or strength classification, and protective treatments for pipes except underdrains and drain tile will be determined based on height of cover, required service life, site abrasiveness, and structure pH criteria shown on the plans. Pipe with material thickness, strength classification, or protective coatings in excess of the minimum required by the above noted criteria may be used.

Concrete used for anchors, collars, grated box end sections, encasements, and sealing existing pipes shall be class A. Corrugated polyethylene pipe, type S has a smooth interior liner with a corrugated outer wall. Type SP pipe is a type S pipe with perforations.

Materials shall be in accordance with the following:

B Borrow .....211
Bituminous Mastic Pipe Joint Sealer.....906.05
Concrete .....702
Flowable Backfill .....213
Reinforcing Steel .....910.01
Rubber Type Gaskets.....906.04
Straps, Hook Bolts, and Nuts .....908.12
Structure Backfill.....904

**(a) Type 1 Pipe.** Type 1 pipe shall be used for culverts under mainline pavement and public road approaches.

Clay Pipe, Extra Strength .....907.08
Corrugated Aluminum Alloy Pipe and Pipe-Arches .....908.04
Corrugated Polyethylene Pipe, Type S.....907.19
Corrugated Steel Pipe and Pipe-Arches .....908.02
Fiber Bonded Bituminous Coated Corrugated Steel
Pipe and Pipe-Arches .....908.07
Non-Reinforced Concrete Pipe, Class 3 .....907.01
Polymer Precoated Galvanized Corrugated Steel
Pipe and Pipe-Arches .....908.08
Profile Wall Polyvinyl Chloride Pipe.....907.22
Reinforced Concrete Horizontal Elliptical Pipe.....907.03
Reinforced Concrete Pipe.....907.02
Ribbed Polyethylene Pipe.....907.20
Smooth Wall Polyethylene Pipe .....907.21
Smooth Wall Polyvinyl Chloride Pipe.....907.23
Structural Plate Pipe and Pipe-Arches.....908.09

**(b) Type 2 Pipe.** Type 2 pipe shall be used for storm sewers.

Clay Pipe, Extra Strength .....907.08
Corrugated Polyethylene Pipe, Type S.....907.19
Fully Bituminous Coated and Lined Corrugated Steel
Pipe and Pipe-Arches .....908.13
Non-Reinforced Concrete Pipe, Class 3 .....907.01
Profile Wall Polyvinyl Chloride Pipe.....907.22

Reinforced Concrete Horizontal Elliptical Pipe.....907.03
Reinforced Concrete Pipe.....907.02
Ribbed Polyethylene Pipe.....907.20
Smooth Wall Polyethylene Pipe .....907.21
Smooth Wall Polyvinyl Chloride Pipe.....907.23

**(c) Type 3 Pipe.** Type 3 pipe shall be used for culverts under all drives and field entrances. All Type 1 pipe materials are acceptable.

**(d) Type 4 Pipe.** Type 4 pipe shall be used for drain tile and longitudinal underdrains.

Clay Pipe*.....907.08
Corrugated Polyethylene Drainage Tubing .....907.17
Corrugated Polyethylene Pipe, Type S* .....907.19
Corrugated Polyethylene Pipe, Type SP .....907.19
Drain Tile* .....907.11
Non-Reinforced Concrete Pipe .....907.01
Perforated Clay Pipe* .....907.09
Perforated Polyvinyl Chloride Semicircular Pipe .....907.18
Profile Wall Polyvinyl Chloride Pipe.....907.22

* These materials shall be used for drain tiles only.

**(e) Type 5 Pipe.** Type 5 pipe shall be used for broken-back pipe runs where coupled or jointed pipe is desirable.

Corrugated Aluminum Alloy Pipe and Pipe-Arches .....908.04
Corrugated Polyethylene Pipe, Type S.....907.19
Corrugated Steel Pipe and Pipe-Arches .....908.02
Fiber Bonded Bituminous Coated Corrugated
Steel Pipe and Pipe-Arches .....908.07
Fully Bituminous Coated and Lined Corrugated
Steel Pipe and Pipe-Arches .....908.13
Polymer Precoated Galvanized Corrugated Steel
Pipe and Pipe-Arches .....908.08
Profile Wall Polyvinyl Chloride Pipe.....907.22
Ribbed Polyethylene Pipe.....907.20
Smooth Wall Polyethylene Pipe .....907.21
Smooth Wall Polyvinyl Chloride Pipe.....907.23

**(f) Slotted Drain Pipe.** Slotted drain pipe shall be used to drain paved median and concrete gutter areas. Slotted drain pipe shall be in accordance with 908.14.

**(g) Slotted Vane Drain Pipe.** Slotted vane drain pipe shall be used to drain driveway areas. Slotted vane drain pipe shall be smooth wall polyvinyl chloride pipe in accordance with 907.23. The slotted vane drain casting shall be in accordance with 910.05(b). The finish shall be standard black asphalt emulsion. Individual units shall have a minimum mass (weight) of 70 kg (155 lbs).

**(h) End Bent Drain Pipe.** End bent drain pipe shall be perforated smooth wall polyvinyl chloride pipe in accordance with 907.23.

**(i) Underdrain Outlet Pipe.** Pipe shall be in accordance with 907.24.

**(j) Grated Box End Sections.** Steel pipe and steel tubing shall be in accordance with ASTM A 53, Grade B or ASTM A 501. Such pipe and tubing shall be galvanized in accordance with ASTM A 123. All other related hardware shall be galvanized in accordance with ASTM A 153. Structural steel grates shall be ASTM A 36 M (ASTM A 36) for end sections having widths less than or equal to 0.9 m (3 ft) and shall be ASTM A 572M grade 345 (ASTM A 572 grade 50) for widths greater than 0.9 m (3 ft). Threaded inserts shall have a minimum pull-out capacity of 27 kN (6,000 lb). The M13 (1/2 in.) round bolts shall have hex heads, cut washers, and where necessary, shall be furnished with the grating. The aggregate leveling bed required for precast units shall be coarse aggregate No. 8 in accordance with 904.03. The hardware cloth used to cover the weep holes, may be plastic with 6 mm (1/4 in.) mesh or galvanized steel wire No. 4 mesh with a minimum wire diameter of 0.8 mm (1/32 in.). It shall be firmly anchored to the outside of the structure and shall be centered on the holes.

Pipe with a 100 mm (4 in.) outside diameter and in accordance with ASTM A 513, Type 5, may be used as an alternate to the 100 mm (4 in.) outside diameter pipe specified. The pipe used as an alternate shall have a minimum wall thickness of 8 mm (5/16 in.) and a minimum yield strength of 345 MPa (50,000 psi). Steel tube of 100 mm by 100 mm by 9.5 mm (4 in. by 4 in. by 3/8 in.), and in accordance with ASTM A 500, Grade B, will also be permitted as an alternate to the 100 mm (4 in.) outside diameter pipe specified.

Pipe furnished as an alternate as described herein shall be covered by a type B certification in accordance with 916.

**715.02.1 General Requirements.** The construction requirements, method of measurement, basis of payment, and pay items described herein shall apply, except for the following, which are described in their respective sections.

Drain Tile .....719
Structural Plate Pipe and Pipe-Arches.....717
Underdrains .....718

A pipe order shall be prepared and submitted prior to delivery of pipe to the project site. The order shall include the following:

(a) structure number and location;

(b) manhole, inlet, or catch basin type, if applicable;

(c) pipe length, as determined by construction engineering;

(d) pipe size, as shown on the plans;

(e) pipe material including all information required to verify conformance with cover and service life criteria; and

(f) number and type of end sections or quantity of concrete, A, structures.

## CONSTRUCTION REQUIREMENTS

**715.03 Excavation.** Unless otherwise directed, the trench cross sectional dimensions shall be as shown on the plans. The trench bottom shall give full support to the pipe as shown on the plans. Recesses shall be cut to receive any projecting hubs or bells.

Where pipe is to be placed in fill sections, a portion of the fill shall be constructed prior to installation of the pipe as shown on the plans.

Where rock or boulder formation is encountered at or above the proposed trench bottom elevation, the trench shall be excavated at least 200 mm (8 in.) below the proposed grade, backfilled with Structure backfill, and compacted in accordance with 211.04.

In case a firm foundation is not encountered at the required grade, the unstable material shall be removed to such depth that when replaced with suitable material, usually B borrow, compacted, and properly shaped, it will produce a uniform and stable foundation along the entire length of the pipe. A timber mat shall be placed to hold the pipe to line and grade if it is necessary.

All trenches shall be kept free from water until any joint filling material has hardened sufficiently not to be harmed.

**715.04 Laying Pipe.** Each section of pipe shall have a full firm bearing throughout its length, true to the line and grade given. All pipes which settle or which are not in alignment shall be taken up and re-laid. Pipe shall not be laid on a frozen trench bottom.

Concrete and clay pipe shall be laid with hub upgrade, with the spigot end fully extended into the adjacent hub, and with all ends fitted together tightly.

Concrete pipe shall not be laid in muck or sulphate soils.

Except for circular concrete pipe, pipe joints designed to accommodate seals or pipe joints requiring seals shall be sealed with approved rubber type gaskets, caulking, bituminous mastic pipe joint sealer, elastomeric material, or sealing compound. Circular concrete pipe joints shall utilize rubber type gaskets.

If the infiltration of water is a factor, each joint, regardless of the type used, shall be sealed with an approved compression type joint sealer in accordance with ASTM C 425 or ASTM C 443, whichever is applicable.

Joints and stub-tee connections for plastic pipe shall be in accordance with the requirements of the respective material specifications for each type of pipe.

Connections of plastic pipe to manholes, catch basins, and inlets shall be in accordance with the manufacturer's recommendations.

Prior to being lowered into the trench, corrugated metal pipe sections shall be examined closely and so fitted that they will form a true line of pipe when in place. Sections which do not fit together properly shall not be used.

At the time of acceptance, all pipe shall have been cleaned and be free from silt and other foreign matter.

Prior to constructing a pipe extension, the existing structure shall be cleaned of all foreign materials. Existing anchors, end sections, or headwalls shall be removed as shown on the plans or as directed. All existing pipes which are damaged by the removal operation shall be replaced. Removed materials shall be disposed of in accordance with 202.

**715.05 Joining Pipe.** At the connection of a pipe extension to an existing structure where the extension is a different pipe material from that in place, or a satisfactory joint cannot be obtained, a concrete collar shall be constructed. Portions of the existing structure shall be removed as shown on the plans, or as necessary, to ensure proper fit of the extension to the existing pipe. If not shown on the plans, the collar shall have a width of at least 450 mm (18 in.) and a thickness of at least 150 mm (6 in.) around the entire joint.

If rigid pipe connections are of lesser strength than that of the main barrel of a pipe structure, these connections shall be encased with concrete at least 150 mm (6 in.) thick.

Any pipe which is damaged during installation shall be repaired or replaced as directed.

Slotted drain pipe or slotted vane drain pipe shall be constructed in 6 m (20 ft) sections with shop fabricated elbows. The upgrade end of slotted drain pipe shall be plugged with a metal cap before backfilling. The upgrade end of slotted vane drain pipe shall be plugged with class A concrete. Such concrete shall extend 150 mm (6 in.) inside the upgrade end of the pipe.

**715.06 Tee and Stub-Tee Connections.** At locations shown on the plans, or where directed, a stub-tee connection of the size specified shall be furnished and placed as a tee connection to corrugated metal pipe, corrugated metal pipe-arch, concrete pipe, reinforced concrete pipe, or reinforced concrete horizontal elliptical pipe.

The stub-tee connection to a corrugated metal pipe or pipe-arch shall be constructed of corrugated metal and the length of the stub shall be no less than that which readily accommodates the connecting band. It shall be made by shop welding a stub of corrugated metal pipe to the corrugated metal pipe or pipe-arch at the time of fabrication. Where field conditions warrant, stub-tee or other connections may be field connected by using shop fabricated saddle connectors. Welds, flame cut edges, and damaged spelter coating shall be regalvanized or painted with zinc dust-zinc oxide paint in accordance with Federal Specification TT-P641, Type II or MIL-P-21035. Where applicable, damaged bituminous coating shall be repaired with asphalt mastic in accordance with AASHTO M 243. The pipe connection to the stub shall be made by means of connecting bands of required size or by means of concrete collars as directed.

The stub-tee connection to concrete pipe, reinforced concrete pipe, or reinforced concrete horizontal elliptical pipe may be field constructed or factory constructed. The concrete used in the stub shall be of the same proportions as that used in the construction of such pipe. The length of the concrete stub shall be no less than 150 mm (6 in.) nor more than 300 mm (12 in.). The pipe connection to the concrete stub shall be made by means of a cement mortar bead or concrete collar or as directed.

**715.07 Blank.**

**715.08 Backfilling.** All plastic pipes, except longitudinal underdrains, which are not fabricated with hydrostatic design basis rated resins and are installed within 1.5 m (5 ft) of mainline or public road approach pavement, paved shoulders, or sidewalks shall be backfilled with flowable backfill. Flowable backfill shall be placed in accordance with 213.07. All other pipe installations shall be backfilled as shown on the plans or as directed. Structure backfill shall be placed in accordance with 211.04.

Prior to placing flowable backfill, all standing water shall be removed from the trench. If the water cannot be removed from the trench, structure backfill shall be used in lieu of flowable backfill to an elevation 0.6 m (2 ft) above the groundwater. The remainder of the trench shall be backfilled as shown on the plans.

Except where prohibited due to groundwater, flowable backfill may be used as a substitute for structure backfill.

After the completion of the backfill operation and prior to beginning the paving operation, all plastic pipes, except longitudinal underdrains, not fabricated with hydrostatic design basis rated resins installed within 1.5 m (5 ft) of mainline or public road approach pavement, paved shoulders, or sidewalks shall be mandrel tested. The mandrel shall be a go/no go mandrel with a minimum of nine arms or prongs and a diameter of 5% less than the pipe pay item diameter. If the mandrel does not pass through the pipe when pulled by hand or the mandrel damages the pipe, the deficient pipe shall be removed, replaced, and mandrel tested after the flowable backfill has been replaced.

Where material other than structure backfill or flowable backfill is permitted and used for backfilling, it shall be of such nature that compacts readily. That portion around and for 150 mm (6 in.) above the top of the pipe shall be free from large stones. This material shall be placed in layers not to exceed 150 mm (6 in.), loose measurement, and each layer compacted thoroughly by means of mechanical tamps.

An adequate earth cover, as shown on the plans, shall be placed over the structure before heavy equipment is driven over it.

Backfill for slotted drain pipe and slotted vane drain pipe shall consist of class A concrete on both sides of the pipe. During the backfilling and paving operations, the slot shall be covered to prevent infiltration of material into the pipe.

**715.09 Pipe End Sections, Anchors, Grated Box End Sections, and Safety Metal End Sections.** Pipe end sections, anchors, grated box end sections, and safety metal end sections shall be constructed as shown on the plans or as directed. Straps or hook bolts required for anchors shall be as shown on the plans. A dimpled connection band shall be used for connecting pipe end sections and safety metal end sections to ends of corrugated metal pipe whose end corrugations are not perpendicular to the centerline of the pipe.

Grated box end sections shall be constructed according to the required pipe size and surface slope of the grated box end section specified at each location. Precast units shall be cast as a single complete unit except for the toewall which shall be cast in place. They shall be set and leveled on a 150 mm (6 in.) thick bed of coarse aggregate. If precast units are used and the adjoining pipe is to be field connected directly to the precast unit, the connection shall be made using a class A concrete collar of 150 mm (6 in.) minimum longitudinal and radial thickness. Inserts for approved lifting devices may be cast in the bottom slab of the precast sections. The number and location of lifting devices needed for handling shall be determined by the fabricator. All reinforcing steel shall have a minimum cover of 40 mm (1 1/2 in.) and shall have a minimum lap of 540 mm (21 in.). The type A construction joint between the floor and the wall is optional for cast in place units.

**715.10 Re-Laid Pipe.** Where shown on the plans or as directed, existing pipe shall be taken up, re-laid, and if necessary, extended. Removal of the pipe shall be in accordance with 202.04 and the operations involved in its relaying shall be in accordance with similar operations contained herein for laying new pipe.

**715.11 Method of Measurement.** The accepted quantities of circular pipe, deformed pipe, slotted drain pipe, slotted vane drain pipe, end bent drain pipe, and sanitary sewer pipe will be measured by the meter (linear foot), complete in place. The length of pipe to be measured for payment will be based on the net length of pipe used, which will be obtained by multiplying the nominal length of each pipe section by the number of sections used. If the pipe connects to manholes, inlets, or catch basins, the terminal sections will be field measured to the outside face of the structure. The length of beveled or skewed terminal sections of circular corrugated metal pipe to be measured for payment will be the average of the top and bottom centerline lengths for beveled ends or of the sides for skewed ends. Measurement of deformed pipe will be made along the bottom centerline of the pipe.

Reinforcing steel, straps, and hook bolts used in anchors will not be measured for payment. Concrete used for backfill of slotted drain pipe and slotted vane drain pipe will not be measured for payment.

Excavation above the trench bottom elevation shown on the plans will not be measured for payment. Additional excavation below the proposed trench bottom elevation required to install the pipe at a lower elevation or to remove rock or unsuitable material will be measured in accordance with 203.27(b).

Pipe end sections, concrete anchors, and safety metal end sections will be measured by the number of units of each size installed. The size of the end section, concrete anchor, and safety metal end section will be considered as the nominal diameter of the pipe to which they are attached. A concrete anchor attached at one end of twin pipes will be measured as two concrete anchors. A concrete anchor attached at one end of triple pipes will be measured as three concrete anchors.

Tee, stub-tee, and wye branch connections will be measured along the centerline of the barrel. An additional allowance of 1.5 m (5 lft) of the smaller diameter pipe will be permitted for making such connection.

Elbow connections will be measured along the centerline of such connection. An additional 0.6 m (2 lft) of pipe of the same diameter as that of the elbow will be permitted for each such connection.

If increaser or reducer connections are made, measurement will be made on the basis of the larger diameter pipe for the full length of the section forming such connections.

Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08.

For structures for which the plans permit pipes of differing sizes for either smooth or corrugated interiors, and the corrugated interior alternate is installed, measurement of B borrow for structure backfill or flowable mortar will be based on the neat line dimensions shown on the plans for the smooth interior alternate.

Grated box end sections will be measured per each for the specified type, surface slope, and pipe size.

**715.12 Basis of Payment.** The accepted quantities of pipe will be paid for at the contract unit price per meter (linear foot) for pipe of the type, shape, and size specified, complete in place.

Pipe end sections, concrete anchors, and safety metal end sections will be paid for at the contract unit price per each for the size specified, complete in place. A concrete anchor attached at one end of twin pipes will be paid for as two concrete anchors. A concrete anchor attached at one end of triple pipes will be paid for as three concrete anchors. Structure backfill will be paid for in accordance with 211.10. If utilized as a substitute for structure backfill or if used to backfill thermoplastic pipes fabricated of non-hydrostatic design basis resins, flowable backfill will be paid for as structure backfill. Otherwise, flowable backfill will be paid for in accordance with 213.09.

If a pipe structure is lowered, relocated, or if unsuitable material is encountered so that additional excavation is necessary over and above that shown on the plans at the original location, such additional excavation will be paid for at three times the contract unit price for the class of excavation involved. If the contract does not include rock excavation or unclassified excavation, rock removal below the proposed trench bottom elevation will be paid for at three times the contract unit cost for common excavation. However, in each of the above cases, such excavation will not be paid for if the additional amount involved at such structure is 8 $m^3$ (10 cu yd) or less.

Tee, stub-tee, and wye connections will be paid for by means of the allowance of 1.5 m (5 lft) of the smaller diameter pipe. Elbow connections will be paid for by means of the allowance of 0.6 m (2 lft) of pipe of the same diameter as the elbow. Increaser and reducer sections will be paid for at the contract unit price for the larger diameter pipe.

For structures for which the plans permit pipes of differing sizes for either smooth or corrugated interiors, and the corrugated interior alternate is installed, payment for pipe backfill will be made based on the neat line dimensions shown on the plans for the smooth interior alternate.

Grated box end sections will be paid for at the contract unit price per each for the specified type, surface slope, and pipe size.

Payment will be made under:

| **Metric Pay Item (English Pay Item Pay Item** | **Metric Pay Unit Symbol English Pay Unit Symbol) Metric Pay Unit Symbol (English Pay Unit Symbol)** |
|---|---|
| Concrete Anchor, _____ mm (diameter) | EACH |
| (Concrete Anchor, _____ in. (diameter) | EACH) |
| Concrete Anchor, Min. Area _____ sq m | EACH |
| (Concrete Anchor, Min. Area _____ sq ft | EACH) |
| Concrete Anchor, _____ mm (diameter) or _____ mm (diameter) | EACH |
| (Concrete Anchor, _____ in. (diameter) or _____ in. (diameter) | EACH) |
| Concrete Anchor, Min. Area _____ sq m or _____ sq m | EACH |
| (Concrete Anchor, Min. Area _____ sq ft or _____ sq ft | EACH) |
| Grated Box End Section, ____ (type), _____ (slope), _____ mm (diameter) | EACH |
| (Grated Box End Section, ____ (type), _____ (slope), _____ in. (diameter) | EACH) |
| Grated Box End Section, _____ (type), _____ (slope), Min. Area _____ sq m | EACH |
| (Grated Box End Section, _____ (type), _____ (slope), Min. Area _____ sq ft | EACH) |
| Grated Box End Section, _____ (type), _____ (slope), _____ mm (diameter) or _____ mm | EACH |
| (Grated Box End Section, _____ (type), _____ (slope), _____ in. (diameter) or _____ in. | EACH) |
| Grated Box End Section, _____ (type), _____ (slope), Min. Area _____ sq m or _____sq m | EACH |
| (Grated Box End Section, _____ (type), _____ (slope), Min. Area _____ sq ft or _____ sq ft | EACH) |
| Grated Box End Section, _____ (type), _____ (slope), _____ mm (diameter) or Concrete Anchor, _____ mm (diameter) | EACH |
| (Grated Box End Section, _____ (type), _____ (slope), _____ in. (diameter) or Concrete Anchor, _____ in. (diameter) | EACH) |

Grated Box End Section, _____, _____, Min. Area _____ sq m or
type slope
Concrete Anchor, Min. Area _____ sq m..... EACH
(Grated Box End Section, _____, _____ Min. Area _____ sq ft or
type slope
Concrete Anchor, Min Area _____ sq ft ..... EACH)
Pipe, End Bent Drain, _____ mm..... m
diameter
(Pipe, End Bent Drain, _____ in. ..... LFT)
diameter
Pipe End Section, _____ mm..... EACH
diameter
(Pipe End Section, _____ in. ..... EACH)
diameter
Pipe End Section, Min. Area _____ sq m..... EACH
(Pipe End Section, Min. Area _____ sq ft ..... EACH)
Pipe End Section, _____ mm or _____ mm..... EACH
diameter diameter
(Pipe End Section, _____ in. or _____ in. ..... EACH)
diameter diameter
Pipe End Section, Min. Area _____ sq m or _____ sq m ..... EACH
(Pipe End Section, Min. Area _____ sq ft or _____ sq ft ..... EACH)
Pipe End Section, _____ mm or Concrete Anchor, _____ mm.... EACH
diameter diameter
(Pipe End Section, _____ in. or Concrete Anchor, _____ in. .... EACH)
diameter diameter
Pipe End Section, Min. Area _____ sq m or Concrete Anchor,
Min. Area _____ sq m..... EACH
(Pipe End Section, Min. Area _____ sq ft or Concrete Anchor,
Min Area _____ sq ft ..... EACH)
Pipe End Section, _____ mm or Grated Box End
diameter
Section, _____, _____, _____ mm..... EACH
type slope diameter
(Pipe End Section, _____ in. or Grated Box End
diameter
Section, _____, _____, _____ in. ..... EACH)
type slope diameter
Pipe End Section, Min. Area _____ sq m or Grated Box End
Section, _____, _____, Min. Area _____ sq m ..... EACH
type slope
(Pipe End Section, Min. Area _____ sq ft or Grated Box End
Section, _____, _____, Min. Area _____ sq ft..... EACH)
type slope
Pipe End Section, _____ mm or Safety Metal End
diameter
Section, _____, _____ mm ..... EACH
slope diameter

(Pipe End Section, _____ in. or Safety Metal End
diameter
Section, _____, _____ in. ..... EACH)
slope diameter
Pipe End Section, Min. Area _____ sq m or Safety Metal End
Section, _____, Min. Area _____ sq m ..... EACH
slope
(Pipe End Section, Min. Area _____ sq ft or Safety Metal End
Section, _____, Min. Area _____ sq ft..... EACH)
slope
Pipe Extension, Circular, _____ mm, _____ ..... m
diameter material
(Pipe Extension, Circular, _____ in., _____..... LFT)
diameter material
Pipe Extension, Deformed, Min. Area _____ sq m, _____ ..... m
material
(Pipe Extension, Deformed, Min. Area _____ sq ft, _____ ..... LFT)
material
Pipe, Relaid, _____ mm..... m
diameter
(Pipe, Relaid, _____ in. ..... LFT)
diameter
Pipe, Relaid, _____ mm x _____ mm..... m
span rise
(Pipe, Relaid, _____ in. x _____ in. ..... LFT)
span rise
Pipe, Sanitary Sewer, _____ mm..... m
diameter
(Pipe, Sanitary Sewer, _____ in. ..... LFT)
diameter
Pipe, Slotted Drain, _____ mm, _____ mm ..... m
diameter thickness
(Pipe, Slotted Drain, _____ in., _____ in. ..... LFT)
diameter thickness
Pipe, Slotted Vane Drain, _____ mm..... m
diameter
(Pipe, Slotted Vane Drain, _____ in. ..... LFT)
diameter
Pipe, Type ____, Circular, _____ mm ..... m
diameter
(Pipe, Type ____, Circular, _____ in..... LFT)
diameter
Pipe, Type ____, Deformed, Min. Area _____ sq m..... m
(Pipe, Type ____, Deformed, Min. Area _____ sq ft ..... LFT)
Pipe, Underdrain Outlet, _____ mm..... m
diameter
(Pipe, Underdrain Outlet, _____ in. ..... LFT)
diameter

Safety Metal End Section, _____, _____ mm ..... EACH
slope diameter
(Safety Metal End Section, _____, _____ in. ..... EACH)
slope diameter
Safety Metal End Section, _____, Min. Area _____ sq m ..... EACH
slope
(Safety Metal End Section, _____, Min. Area _____ sq ft ..... EACH)
slope
Safety Metal End Section, _____, _____ mm or _____ mm ..... EACH
slope diameter diameter
(Safety Metal End Section, _____, _____ in. or _____ in. ..... EACH)
slope diameter diameter
Safety Metal End Section, _____, Min. Area _____ sq m or
slope
_____ sq m ..... EACH
(Safety Metal End Section, _____, Min. Area _____sq ft or
slope
_____sq ft ..... EACH)
Safety Metal End Section, _____, _____ mm or
slope diameter
Concrete Anchor, _____ mm ..... EACH
diameter
(Safety Metal End Section, _____, _____ in. or
slope diameter
Concrete Anchor, _____ in. ..... EACH)
diameter
Safety Metal End Section, _____, Min. Area _____ sq m or
slope
Concrete Anchor, Min. Area _____ sq m ..... EACH
(Safety Metal End Section, _____, Min. Area _____sq ft or
slope
Concrete Anchor, Min. Area _____ sq ft ..... EACH)
Safety Metal End Section, _____, _____ mm or Grated Box End
slope diameter
Section, _____, _____, _____ mm ..... EACH
type slope diameter
(Safety Metal End Section, _____, _____ in. or Grated Box End
slope diameter
Section, _____, _____, _____ in. ..... EACH)
type slope diameter
Safety Metal End Section, _____, Min. Area _____ sq m or Grated
slope
Box End Section, _____, _____, Min. Area _____ sq m ..... EACH
type slope

(Safety Metal End Section, _____ Min. Area _____sq ft or Grated
slope
Box End Section, _____, _____, Min. Area _____ sq ft ..... EACH)
type slope

The costs of reinforcing steel, straps, and hook bolts used in anchors shall be included in the cost of the concrete anchor. The costs of the toe plate anchor and galvanized bolts required for pipe end sections and safety metal end sections shall be included in the costs of the pay items. The cost of concrete backfill for slotted drain pipe and slotted vane drain pipe shall be included in the costs of the pay items.

B borrow obtained from planned excavation may be used to backfill culverts. No deduction will be made from the excavation or borrow quantities.

If existing concrete building foundations, concrete walls, concrete columns, or concrete steps not visible and not shown on the plans are encountered within the limits of the trench, the removal of such items, as required, will be paid for in accordance with 203.28.

The costs of sawing of pavement, excavation above the trench bottom elevation shown on plans, backfilling with material other than structure backfill or flowable backfill, dewatering, shoring, timber mats, pavement replacement, class A concrete required for collar construction or sealing existing pipe, joint materials, replacing pipe which is damaged during installation or re-laying operations, sanitary sewer testing required by the local utility, and all other necessary incidentals shall be included in the cost of the pay items. The cost of removal of pavement, existing pipe, end sections, anchors, or headwalls, concrete collars, encasements, and the disposal of surplus materials shall be included in the cost of the pay items.

The costs of concrete, grating, pipe tubing, reinforcing steel, aggregate leveling bed, hardware cloth, and necessary incidentals for construction of grated box end sections will be included in the cost of the grated box end section.

## SECTION 716 – TRENCHLESS PIPE INSTALLATION

**716.01 Description.** This work shall consist of installing pipes underground using construction techniques that eliminate open cutting of the pavement or of the ground all in accordance with 105.03.

The techniques included are auger boring, guided boring, horizontal directional drilling, micro-tunneling, pipe jacking, and pipe ramming. Other methods may be utilized when approved.

The size of installations by the directional drilling method shall be limited to those that can be accomplished by using a 600 mm (24 in.) maximum sized reamer unless otherwise approved.

## MATERIALS

**716.02 Materials.** The materials shall be in accordance with the following.

Cement.....901.01(b)
Clay Pipe, Extra Strength .....907.08
Fine Aggregate .....904
Fly Ash .....901.02
Foam Concentrate.....ASTM C 869
Polyvinyl Chloride Pipe.....907.23
Reinforced Concrete Pipe.....907.02
Smooth Wall Polyethylene Pipe .....907.21
Steel Pipe .....908.11
Water.....913.01

Concrete pipe shall be class IV or stronger and shall have tongue and groove joints. All reinforced concrete pipes shall have steel reinforcement concentric with the pipe wall, and where required, additional reinforcement at the ends of the pipe.

Steel pipe used as a carrier pipe shall have the following minimum wall thickness.

| Outside Diameter, mm (in.) | Wall Thickness mm (in.) |
|---|---|
| 457 or less (18 or less) | 6 (1/4) |
| 483 –508 (19 – 20) | 8 (5/16) |
| 533 – 660 (21 – 26) | 10 (3/8) |
| 686 – 762 (27 – 30) | 13 (1/2) |
| 787 – 1070 (31 – 42) | 13 (1/2) |
| 1092 – 1219 (43 – 48) | 14 (9/16) |

The cellular concrete grout shall be designed and produced in accordance with ASTM C 796 except as herein modified.

Admixtures, retarders, and plasticizers used shall be in accordance with the foam concentrate supplier's specifications.

The grout shall be made using the preformed foam process using foam generating equipment calibrated daily by the foam manufacturer to produce a precise and predictable volume of foam. The foam concentrate shall be certified by the manufacturer to have specific liquid/foam expansion ratio at a constant dilution ratio with water.

The specific job mix shall be submitted by the foam concentrate supplier certified or licensed grouting contractor to the Engineer for approval prior to use on the project. The mix shall have a minimum 28 day compressive strength of 1040 kPa (150 psi). The mix shall be tested and will be approved based on the test results or will be approved based on prior acceptance and suitable performance on Department projects.

Grout mixed off site shall be delivered to the job site in a truck mixer in accordance with 702.09 filled to a capacity recommended by the foam manufacturer. The foam concentrate shall then be added to the cement mix in the truck and mixed to a uniform consistency.

Grout mixed on site shall be batched in a deck mate or a similar device. Small batches of approximately 1 cubic meter (1 cubic yard) shall be mixed and pumped in a continuous operation.

For each day worked or for each 100 cubic meters (100 cubic yards) placed, four test cylinders measuring 75 mm by 150 mm (3 in. by 6 in.) shall be cast at the point of placement of the grout. The cylinders shall be prepared, cured, and transported in accordance with ASTM C 31.

The compressive strength shall be determined in accordance with ASTM C 39, except as modified herein. Initial curing shall be at room temperature and shall be from 2 to 5 days. After the initial curing, the test specimens shall be placed in a moist closet or moist room. All specimens shall be kept in their molds in the moist closet or moist room for the remainder of the curing period. The specimens shall be tested at 28 days. At that time the specimens shall be stripped, capped, and tested in compression as rapidly as possible to minimize drying. If more than one specimen is removed from the moist closet or moist room at the same time, these specimens shall be covered with a damp cloth until time of testing. The test results shall be submitted to the Engineer with a type D certification in accordance with 916.

## CONSTRUCTION REQUIREMENTS

**716.03 General Requirements.** Upon completion of the installation of the pipe, all excavated areas not occupied by the pipe shall be backfilled and compacted with suitable material in accordance with 203.

When ground water is known or anticipated, a dewatering system of sufficient capacity to handle the flow shall be maintained at the site until its operation can be safely halted. The dewatering system shall be equipped with screens or filter media sufficient to prevent the displacement of fines.

When the use of explosives is necessary for performing the work, their use shall be in accordance with 107.13.

Bentonite or other suitable lubricants, may be applied to the outside surface of the pipe to reduce frictional forces.

Joints in steel pipe shall be water tight. Where welded joints are utilized, they shall be welded in accordance with 711.32. Joints in concrete pipe shall be designed to withstand the additional forces that are created in the joints during the installation process. The joints in concrete pipe shall be protected with a resilient material around the circumference of the pipe. Resilient material shall also be used between the pipe and the thrust ring.

When installation is to be performed under railroads, highways, or streets, care shall be taken to prevent interference with the operations of the railroads, highways, or streets. The Contractor shall submit a QC plan of the installation process including, as a minimum, the chosen method of installation, the equipment to be used, and the materials to be utilized, for review and acceptance, at least seven calendar days prior to the start of the operations.

Pavement or ground surface heave or settlement above the installation will not be permitted. To confirm if heave or settlement is occurring, the Contractor shall undertake surface monitoring. The plan for monitoring the surface shall be included in the Contractor's QC plan.

Installations shall have a bored hole essentially the same diameter as the outside of the installed pipe. If voids develop or if the bored diameter is greater than the outside diameter of the pipe by more than 25 mm (1 in.), grouting shall be used to fill such voids. The Contractor's QC plan shall address the method of grouting.

When the installation is 100 mm (4 in.) or larger and the casing is used as the carrier pipe, a visual or a video inspection shall be performed using high resolution, high sensitivity color video camera/recording equipment. The pipe shall be cleaned of debris prior to the inspection. Cleaning shall be accomplished by water jetting or other approved methods.

The camera/recording equipment shall be specifically designed for continuous viewing/recording of detailed images of the interior wall of pipes and transitions of the specified sizes. The equipment shall include sufficient lighting to view the entire periphery of the pipe. The equipment shall have appropriate attachments to maintain a position in the center of the pipe and an electronic counter to continuously record the location of the equipment in the pipe. The recording equipment shall be a minimum four head industrial grade VHS recorder or a digital archiving and reviewing system. A color video printer shall be included in the equipment for printing observations during inspection. A copy of the video inspection shall be submitted to the Engineer.

All sections of pipe found to be damaged or where joint failure is evident shall be repaired as approved by the Engineer or removed and replaced.

For installations not utilizing tunnel shields or tunnel boring machines, if an obstruction is encountered during installation which stops the forward progress of the pipe, and it becomes evident that it is impossible to advance the pipe, and if ordered, operations shall cease and the pipe shall be abandoned in place and filled with grout or other approved materials.

When a gravity-flow carrier pipe is placed inside a casing pipe, the gravity-flow carrier pipe shall be shimmed to proper line, elevation, and grade and then the void between the two pipes shall be grouted.

**716.04 Method of Measurement.** Pipe installed by trenchless installation methods will be measured by the meter (linear foot) along the center line of the pipe installed.

**716.05 Basis of Payment.** Pipe installed by trenchless installation methods will be paid for by the meter (linear foot) for pipe, installation, trenchless of the size specified, complete and in place.

Payment will be made under:

| Pay Item | Pay Unit Symbol |
|---|---|
| Pipe Installation, Trenchless, _____ size | m (LFT) |

The cost of the QC plan, the excavating and backfilling of the entrance and receiving pits, video inspection, camera/recording equipment, bentonite or other lubricant, grout, and the casing when installed shall be included in the cost of pipe installation, trenchless.

If a partial installation has to be abandoned in place and filled with grout due to the encountering of an obstruction, the abandoned work will be paid for at 75% of the contract unit price of the pipe installed.

For installations where unknown obstructions such as boulders, concrete, and other unforeseen obstructions are encountered, and the crossing cannot be abandoned or where tunnel shields or tunnel boring machines are being utilized, the additional cost as a result of encountering the unforeseen conditions will be paid for as differing site conditions in accordance with 104.02(a)

## SECTION 717 – STRUCTURAL PLATE PIPE, PIPE-ARCHES, AND ARCHES

**717.01 Description**. This work shall consist of furnishing and placing structural plate pipe, pipe-arches, or arches in accordance with these specifications and in reasonably close conformance with the lines, grades, and details shown on the plans or as directed.

**717.02 Materials**. Materials shall be in accordance with the following:

| | |
|---|---|
| Bituminous Mastic Pipe Joint Sealer | 906.05 |
| Concrete, Class A | 702 |
| Flowable Backfill | 213 |
| Grouted Riprap | 904 |
| Reinforcing Steel | 910.01 |
| Structure Backfill | 904 |
| Structural Plate Arches | 908.09 |
| Structural Plate Pipe and Pipe-Arches | 908.09 |

Structural plate pipe and pipe-arches are part of the pipe classification system described in 715.02. The minimum material thickness and required protective treatments will be determined in accordance with 715.02.

### CONSTRUCTION REQUIREMENTS

**717.03 General Requirements**. Forming, punching, and assembling shall be in accordance with AASHTO Standard Specifications for Highway Bridges, Division II, Sections 23.2 and 23.3. The radius of the arc joining the top to the bottom shall be in accordance with 908.09(a)1. Excavation shall be in accordance with the applicable requirements of 715 for pipe and pipe-arches and 206 for arches. Concrete shall be placed in accordance with 702 and reinforcing steel shall be placed in accordance with 703.

Each side of an arch shall rest in a groove formed into the masonry or shall rest on a galvanized angle or channel securely anchored to or embedded in the substructure. Where the span of the arch is greater than 4.3 m (14 ft), or the skew angle is more than 20 degrees, a metal bearing surface having a width at least equal to the depth of the corrugations shall be provided.

Metal bearings may be either rolled structural or cold-formed galvanized angles or channels no less than 5 mm (3/16 in.) in thickness with the horizontal leg securely anchored to the substructure on 610 mm (24 in.) maximum centers. When the metal bearing is not embedded in a groove in the substructure, one vertical leg shall be punched to allow bolting to the bottom row of plates.

If shown on the plans, or otherwise required, the flowline of arches shall be paved with grouted riprap in accordance with 616.04 or paved with class A concrete.

If it is necessary to make a tee-connection to a structural plate pipe, pipe-arch, or arch, a stub-tee connection of the size and at the locations shown on the plans shall be furnished and placed, and its length shall be no less than 300 mm (12 in.) nor more than 610 mm (24 in.). The stub shall be connected in the field and the stub connection bituminous coated. The stub connection to the entering pipe shall be made by means of a connecting band of the required size or by means of concrete collars, as directed.

Structures on which the spelter coating has been bruised or broken either in the shop or in shipping, or which shows defective workmanship, shall be rejected unless it can be repaired satisfactorily. This requirement applies not only to the individual plates but to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship. The presence of defects in an individual culvert plate or in a shipment shall constitute sufficient cause for rejection.

(a) uneven laps;

(b) elliptical shaping, unless specified;

(c) variation from a straight centerline;

(d) ragged edges;

(e) loose, unevenly lined, or unevenly spaced bolts;

(f) illegible brand;

(g) bruised, scaled, or broken spelter coating;

(h) dents or bends in the metal itself; and

(i) twisted so that ends do not lay on bedding satisfactorily.

**717.04 Backfill**. Where shown on the plans or when directed, structure backfill or flowable backfill shall be used in backfilling around pipe and pipe-arch structures. Arch structure backfill shall be structure backfill. The amount of camber on the invert of the pipe or pipe-arch shall be varied to suit the height of fill and supporting soil, except the camber grade shall not be above level. The finished backfill grade shall be as shown on the plans.

After the pipe or pipe-arch has been assembled and is in place, backfill material shall be placed in accordance with 211.04 or 213.07.

An adequate earth cover shall be provided over the structure, as shown on the plans, before heavy construction equipment is driven over it. This earth cover shall be free of stones.

When backfilling at arches before headwalls are placed, the material shall first be placed midway between the ends of the arch, forming as narrow a ramp as possible, until the top of the arch is reached. The ramp shall be built up evenly on both sides and the backfilling material compacted as it is placed. After both ramps have been built to the top of the arch, the remainder of the backfill shall be deposited in both directions from the center to the ends and evenly on both sides of the arch.

If the headwalls are built before the arch is backfilled, the backfill material shall first be placed adjacent to one headwall until the top of the arch is reached, after which the fill material shall be placed from the top of the arch towards the other headwall. The material shall be deposited evenly on both sides of the arch.

In multiple installations the above procedure shall be followed. The backfill shall be brought up evenly on both sides of each arch so that unequal pressures are avoided.

Compaction by saturation will not be permitted, except below the free water table, then the provisions of 203.23 do not apply.

**717.05 Re-Laid Pipe and Pipe-Arch**. When required, any existing structural plate pipe or pipe-arch shall be taken up, re-laid, and extended. Removal shall be in accordance with 202.04 and the operations involved in its relaying shall be in accordance with similar operations contained herein for new structural plate pipe or pipe-arch.

**717.06 Blank**.

**717.07 Concrete Paved Inverts**. Structural plate pipe and pipe-arches with concrete field paved inverts shall be constructed in accordance with and at locations shown on the plans or where directed.

The paved inverts for these structures shall be reinforced with welded wire fabric and sealed with bituminous mastic pipe joint sealer as shown on the plans. The concrete for paving the invert shall not be placed until such time as the backfilling and embankment procedures have been completed satisfactorily.

**717.08 Method of Measurement**. Structural plate pipe and pipe-arch, both new and re-laid, will be measured in accordance with 715.11. Structural plate arches will be measured by the meter (linear foot), complete in place. Metal bearings and other hardware required to attach the structural plate arch to its substructure will not be measured for payment.

Concrete for headwalls and substructures will be measured in accordance with 702.27. Volumes occupied by a structural plate arch extending through the headwall will be deducted. Reinforcing steel used in substructures will be measured in accordance with 703.07. Concrete or grouted riprap paved flowline for structural plate arches will be measured by the square yard (square meter). Concrete anchors will be measured in accordance with 715.11. Reinforcing steel, straps, and hook bolts used in anchors will not be measured for payment.

Structure backfill will be measured in accordance with 211.09. Flowable backfill used for backfill will be measured in accordance with 213.08.

**717.09 Basis of Payment**. The accepted quantities of new, extended, or relaid structural plate pipe, or pipe-arch will be paid for in accordance with 715.12. Structural plate arches will be paid for at the contract unit price for arch, structural plate, of the size specified. Concrete, A, structures will be paid for in accordance with 714.07. Reinforcing steel in substructures will be paid for in accordance with 703.08. Concrete or grouted riprap paved flowline placed in structural plate arch structures will be paid for at the contract unit price per square meter (square yard) for concrete paved flowline, arch, structural plate; or riprap, grouted. Concrete anchors will be paid for in accordance with 715.12.

If a pipe or pipe-arch is lowered or relocated, or if rock or unsuitable material is encountered which requires additional excavation, such excavation will be paid for in accordance with 715.12. Structure backfill will be paid for in accordance with 211.10. Flowable backfill will be paid for in accordance with 213.09.

Stub-tee connections including the connecting bands, concrete collars, or cement mortar beads will be paid for in accordance with 715.12.

Payment will be made under:

| Pay Item | Pay Unit Symbol |
|---|---|
| Arch, Structural Plate, Min. Area _____ sq m | m |
| (Arch, Structural Plate, Min. Area _____ sq ft | LFT) |
| Concrete Paved Flowline, Arch, Structural Plate | m2 (SYS) |
| Riprap, Grouted | m2 (SYS) |

The cost of excavation, concrete field paved inverts, disposal of surplus materials, reinforcing steel, straps, and hook bolts used in anchors, and necessary incidentals shall be included in the cost of the pay items.

The cost of metal bearings and other hardware needed to attach the structural plate arch to its substructure shall be included in the cost of the arch.

## SECTION 718 – UNDERDRAINS

**718.01 Description.** This work shall consist of constructing underdrains using pipe, granular aggregates, outlet protectors, or geotextiles in accordance with 105.03.

## MATERIALS

**718.02 Materials.** Materials shall be in accordance with the following:

Coarse Aggregate, Class E or Higher, Size No. 8 or 9 .....904
Concrete, Class A.....702
Geotextile for Underdrains .....913.19
Reinforcing Steel .....910.01
Sod, including Nursery Sod .....621
Structure Backfill.....904
Underdrain Pipes.....715.02(d)
Underdrain Outlet Pipes .....907.24

Rodent screens shall be woven stainless steel wire mesh or galvanized hardware cloth. Coarse aggregate No. 8 or 9 shall be used for 150 mm (6 in.) underdrain installations. Coarse aggregate No. 9 shall be used for 100 mm (4 in.) underdrain installations.

The mixture for HMA for underdrains shall be Intermediate C19.0 mm in accordance with 401. An ESAL Category 5 in accordance with 401.04 and a PG Binder 76-22 shall be used. A MAF in accordance with 401.05 will not apply. Acceptance of the HMA for underdrains will be in accordance with 402.09.

## CONSTRUCTION REQUIREMENTS

**718.03 Pipe Installation.** Trenches shall be excavated to the dimensions and grade shown on the plans. Pipes shall be secured to ensure that the required grade and horizontal alignment of the pipe are maintained. Perforated pipe shall be placed with the perforations down. The pipe sections shall be joined securely with the appropriate couplings, fittings, or bands. Aggregate for underdrains shall be placed in a manner which minimizes aggregate contamination.

If plain end concrete pipe is being laid, no joint width shall not exceed 6 mm (1/4 in.).

**718.04 Geotextile.** Storage and handling of geotextiles shall be in accordance with the manufacturer's recommendations. Each geotextile roll shall be labeled or tagged. Damaged or defective geotextile shall be replaced as directed. The geotextile shall be placed loosely, but with no wrinkles or folds. The ends of subsequent rolls of geotextile shall be overlapped a minimum of 0.3 m (1.0 ft). The upstream geotextile shall overlap the downstream geotextile. Placement of aggregate shall proceed following placement of the geotextile.

**718.05 Underdrain Outlets.** After the outlet pipe installation, the trench shall be backfilled as shown on the plans. Structure backfill shall not extend into the limits of the underdrain trench. The trench outside the limits of structure backfill shall be filled with materials suitable for growing vegetation. Aggregate and stabilized materials removed from an existing shoulder shall not be used as backfill and shall be disposed of in accordance with 206.07. At the time of installation, a rodent screen shall be placed on the outlet pipe or the ends of the underdrain pipe when located in inlets or catch basins.

**718.06 Underdrain Outlet Protectors.** Underdrain outlet protectors shall be constructed as shown on the plans.

**718.07 Video Inspection.** Underdrains and outlets shall be inspected using high resolution, high sensitivity, waterproof color video camera/recording equipment.

The camera/recording equipment shall be specifically designed for continuous viewing/recording of detailed images of the interior wall of pipes and transitions of the specified sizes. The equipment shall have the capability of viewing a minimum of 140 m (450 ft) into the pipes and shall be designed to include sufficient lighting to view the entire periphery of the pipe. The equipment shall have appropriate attachments to maintain a position in the center of the pipe and an electronic counter to continuously record the location of the equipment in the pipe. The recording equipment shall be a minimum four head industrial grade VHS recorder or a digital archiving and reviewing system. A color video printer shall be included in the equipment for printing observations during inspection.

The Engineer will determine the runs of the underdrain installations to be inspected. Video inspection shall be conducted after guardrail, lighting, sign installation, and final seeding or sodding operations are completed.

Damage discovered by the video inspection shall be repaired. Damage shall include but is not limited to; crushed or partially crushed pipes that impedes the progress of the camera, blockages, vertical pipe sags filled with water to a depth of d/2 or greater, 90 degree connections, connector separations, cracks or splits in the pipes. All repaired sections shall be video reinspected prior to acceptance. A copy of the video inspection shall be submitted to the Engineer.

**718.08 Method of Measurement.** Underdrain and outlet pipe will be measured in accordance with 715.11. Outlet protectors will be measured by the number and type of units installed.

Structure backfill will be measured in accordance with 211.09. HMA for underdrains will be measured by the megagram (ton).

Aggregate for underdrains will be measured by the cubic meter (cubic yard), complete in place. The pay limits will not extend beyond the neat lines shown on the plans.

Geotextiles will be measured by the square meter (square yard) based on the neat line limits shown on the plans.

Video inspections for underdrains will be measured by the meter (linear foot) as determined by the electronic equipment.

Rodent screens, elbows, increaser or decreaser connections, and other incidentals will not be measured for payment.

Concrete, reinforcing steel, or sod for underdrain outlet protectors will not be measured for payment.

**718.09 Basis of Payment.** The accepted quantities of underdrains and underdrain outlet pipe will be paid for in accordance with 715.12. Aggregate for underdrains will be paid for at the contract unit price per cubic meter (cubic yard). Geotextile for underdrains will be paid for at the contract unit price per square meter (square yard). Outlet protectors will be paid for at the contract unit price per each of the type of unit installed, complete in place. The accepted quantities of HMA for underdrains will be paid for at the contract unit price per megagram (ton).

Structure backfill will be paid for in accordance with 211.10.

The final accepted quantity video inspection for underdrain will be paid for at the contract unit price per meter (linear foot).

Payment will be made under:

| **Metric Pay Item**<br>**(English Pay Item**<br>**Pay Item** | **Metric Pay Unit Symbol**<br>**English Pay Unit Symbol)**<br>**Pay Unit Symbol** |
|---|---|
| Aggregate for Underdrains | m3 (CYS) |
| Geotextile for Underdrains | m2 (SYS) |
| HMA for Underdrains | Mg (TON) |
| Outlet Protector, _____ type | EACH |
| Video Inspection for Underdrain | m (LFT) |

Geotextile for underdrains which has been rejected due to contamination or other reasons shall be replaced with no additional payment.

The costs of excavation, forming, reinforcing steel, concrete, curing materials, and sod shall be included in the cost of outlet protector.

The cost of providing the video inspection equipment, technician, videotapes, or computer disks shall be included in the cost of the underdrain video inspection. The cost of repair of underdrain pipes, aggregates, backfill, outlet protectors, geotextile fabric, etc. shall be included in the cost of the other pay items. The cost of providing video reinspection of the repairs shall be included in the cost of the other pay items.

The costs of disposal of unsuitable excavated materials, installation of pipe end caps, rodent screens, elbows, increaser or decreaser connections, and other incidentals shall be included in the cost of other pay items.

## SECTION 719 – TILE DRAINS

**719.01 Description.** This work shall consist of the installation of drain tile in accordance with these specifications and in reasonably close conformance with the lines and grades shown on the plans or as directed.

## MATERIALS

**719.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Concrete, Class A | 702 |
| Drain Tile Terminal Pipe | 907.24 |
| Flowable Backfill | 213 |
| Reinforcing Steel | 910.01 |
| Riprap | 904 |
| Rodent Screen | 718.02 |
| Structure Backfill | 904 |

Drain tile materials shall be in accordance with 715.02(d).

## CONSTRUCTION REQUIREMENTS

**719.03 Trench Excavation.** The trench excavation shall begin at the outlet end and proceed towards the upper end, true to the required line and grade. The trench shall be as shown on the plans. If no trench details are shown on the plans, the trench shall be of sufficient width to provide ample working space on each side of the drain tile to permit compaction of the backfill around the tile. Recesses shall be cut into the trench bottom to accommodate any projecting hubs or bells.

If excavation is made too deep, proper bearing shall be secured by backfilling to the required elevation with sand, clay, or other approved material which shall be tamped into place and shaped properly.

If a firm foundation is not encountered at the required trench bottom grade, the unstable material shall be removed to such depth that provides ample support after being backfilled, compacted, and shaped to the required elevation or the drain tile shall be laid on planking which is not less than 25 mm (1 in.) thick, 250 mm (10 in.) wide, and 3 m (10 ft) long.

If rock is encountered at or above the required trench bottom grade, the trench shall be excavated at least 200 mm (8 in.) below the pipe and backfilled, compacted, and shaped as described above.

Where excavation is made for installing drain tile across private property, the topsoil and sod, if present, shall be kept in separate stockpiles. After completion of the backfill operation, the topsoil and sod shall be placed so that the area is restored as closely as possible to its original condition.

**719.04 Laying Tile.** Tile shall not be laid on a frozen or muddy trench bottom. It shall be laid true to line and grade, starting at the outlet end. Each tile shall have a firm bearing for its entire length and joints left as tight as practicable by turning the individual sections until the ends fit closely. A joint which does not close to within 6 mm (1/4 in.) shall be covered with pieces of broken tile. If laid on planking, the joints shall be covered with pieces of broken tile and then entirely covered with clay and tamped.

Drain tile installed on private property shall be perforated pipe in accordance with 715.02(d).

When an existing tile drain is encountered on permanent right-of-way, it shall be replaced in the following manner. If the tile is intercepted by a side ditch prior to crossing proposed pavement, it shall be replaced between the right-of-way line and the ditch with non-perforated drain tile and a 3.0 m (10 ft) long terminal pipe section of drain tile with a rodent screen. If the tile is to outlet into a storm sewer, it shall be replaced between the right-of-way line and the storm sewer with pipe in accordance with 715.02(b). If the tile is to outlet at a side ditch after crossing proposed pavement, it shall be replaced between the right-of-way line and the ditch with pipe in accordance with 715.02(a) with a rodent screen. If the tile is to be maintained across the right-of-way, it shall be replaced from right-of-way line to right-of-way line with pipe in accordance with 715.02(a).

**719.05 Backfilling.** Pipe replacing drain tile shall be backfilled in accordance with 715.08.

**719.06 Blank.**

**719.07 Method of Measurement.** Drain tile and replacement pipe of the type and size specified will be measured in accordance with 715.11. Terminating pipe sections of the type and size specified will be measured per meter (linear foot). Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08. Riprap will be measured in accordance with 616.11.

Tee or wye branch connections will be measured per each along the centerline of the barrel. An additional allowance of 1.5 m (5 linear feet) of the smaller diameter pipe will be made for making such connections.

Elbow connections will be measured along the centerline of such connection. An additional allowance of 0.6 m (2 linear feet) of pipe of the same diameter as that of the elbow will be made for each such connection.

Increaser and reducer connections will be measured by the meter (linear foot) as the larger diameter pipe over the length of the connection.

**719.08 Basis of Payment.** The accepted quantities of drain tile and replacement pipe will be paid for in accordance with 715.12. Terminating pipe sections will be paid for at the contract unit price per meter (linear foot) for pipe, drain tile terminal section, of the size specified, complete in place. Structure backfill will be paid for in accordance with 211.10. Flowable backfill will be paid for in accordance with 213.09. Riprap will be paid for in accordance with 616.12.

Tee and wye connections will be paid for by means of the allowance of an additional 1.5 m (5 lft) of the smaller pipe at the connection. Elbow connections will be paid for by means of the allowance of an additional 0.6 m (2 lft) of the pipe at the connection.

If increaser or reducer connections are made, payment will be made on the basis of the larger diameter of the connection for the full length of the section forming such connections.

Payment will be made under:

| Metric Pay Item<br>(English Pay Item<br>Pay Item | Metric Pay Unit Symbol<br>English Pay Unit Symbol<br>Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Pipe, Drain Tile Terminal Section, _____ mm<br>diameter | m |
| (Pipe, Drain Tile Terminal Section, _____ in.<br>diameter | LFT) |

The costs of excavating, backfilling with suitable excavated material, disposal, planking, removal of existing tile, and necessary incidentals shall be included in the cost of this work.

## SECTION 720 – MANHOLES, INLETS, AND CATCH BASINS

**720.01 Description.** This work shall consist of the construction, reconstruction, or adjustment to grade of manholes, inlets, and catch basins in accordance with these specifications and in reasonably close conformance with the lines and grades shown on the plans or as directed.

**720.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Castings | 910.05 |
| Clay or Shale Brick | 905.01 |
| Clay Pipe | 907.08 |
| Concrete | 702 |
| Concrete Brick | 905.02 |
| Concrete Masonry Blocks | 905.03 |
| Hydrated Lime | 913.04 |
| Joint Filler | 906.01 |
| Joint Mortar | 913.17, 906.03 |
| Non-Reinforced Concrete Pipe | 907.01 |
| Precast Units | 907.04 |
| Reinforced Concrete Pipe | 907.02 |
| Reinforcing Steel | 910.01 |
| Water | 913.01 |

## CONSTRUCTION REQUIREMENTS

**720.03 General Requirements.** The construction of the items listed in this specification shall be in accordance with 203.14.

Excavation shall be to the established bottom of the foundations. The finished surface shall be firm and smooth. If soft or yielding spots are encountered at this elevation, they shall be removed, backfilled with suitable material, and tamped into place. If rock is encountered at the bottom elevation, the excavation shall be carried down 150 mm (6 in.) further and backfilled with approved material tamped to the required elevation.

Concrete construction shall be in accordance with the requirements for structural concrete. Masonry shall be in accordance with the requirements for the respective type. Exposed corners of concrete shall be rounded to a 6 mm (1/4 in.) radius. Air-entrained concrete will not be required in the precast portions of concrete manholes or catch basins.

Frames for castings and bearing plates for manholes shall be set in full mortar beds and secured as shown on the plans or as otherwise approved. The mortar shall be composed of one part cement to two parts No. 23 fine aggregate, by volume. Castings shall be set to the finished pavement elevation so that subsequent adjustments are not necessary.

Iron hood traps in catch basins shall be installed in walls as shown on the plans and so placed that a 150 mm (6 in.) seal is formed. Joints between hoods and walls shall be made gastight.

Mortar for laying brick and masonry units shall be composed of one part masonry cement and two parts mortar sand. Mortar for plastering may be the same or it may be composed of one part of a combination of portland cement and hydrated lime and two parts mortar sand. The lime shall not exceed 10% of the cement. In any case, proportioning shall be by volume. Ingredients, except water, shall be dry mixed, after which water shall be added to bring the mortar to a stiff paste and mixing continued until a uniform mixture results.

Required plaster coats on the inside and outside shall be at least 13 mm (1/2 in.) thick and shall be smooth, clean, and watertight.

Inlet and outlet pipes shall extend through walls a sufficient distance to allow for connections on the outside and the concrete or mortar carefully placed around them to prevent leakage around their outlet surfaces. Unless otherwise shown, the inside ends shall be flush with the inside walls. The pipe shall be of the same size and kind as that with which it connects on the outside.

Where castings are adjacent to or are surrounded by cement concrete construction, each casting shall be entirely separated from the concrete by a preformed joint filler not less than 10 mm (3/8 in.) thick. The cost of each joint, including the material, shall be included in the price for the structure. Grates shall be placed with the maximum dimension of the rectangular opening parallel to the direction of flow.

The surface of the grate shall be flush with the top edge of the frame, wingwall, and headwall. The frame shall be galvanized and anchored into concrete. The frame shall be factory assembled. All joints shall be fully welded. Where two frames butt together, they shall be welded on the top and bottom.

Adjusting slots for curb boxes shall be of the dimensions shown on the plans. One slot shall be located at each end of the curb box, and one slot shall be located at the approximate centerline on the back of the curb box. Galvanized or stainless steel M10 UNC x 90 mm (3.8 in. UNC x 3 1/2 in.) round head, square shoulder bolts with one flat washer, one lock washer, and one nut each shall be used in each slot to anchor the curb box to the frame such that the top of the curb box is flush with the top of the curb. Bolts shall be torqued to a minimum of 160 Nm (120 ft lb).

Steel grating type 12 shall be an approved, galvanized grating which shall be of sufficient strength to support a 5440 kg (12,000 lb) wheel load with a maximum fiber stress of 138 MPa (20,000 lb/in$^2$). The grating shall seat firmly in, but shall not be secured to, the frame. The length and width of the grating shall be so as to leave not more than 10 mm (3/8 in.) clearance on each side when in place in the frame. The grating shall be cut such that all riveted or welded connections are left intact.

If a manhole is constructed within the pavement area or within an area that may be paved at some future date, the height of the casting used shall be based on the depth of pavement constructed or proposed and a bearing plate for such casting will also be required. Adjusting rings or steps of alternate types to those shown on the plans may be used subject to approval.

If a manhole is constructed outside the proposed pavement area and outside an area that may be paved at some future date, the height of the casting used shall be at least 180 mm (7 in.) and a bearing plate for such casting will not be required.

The manhole bottom shall be constructed of a precast bottom section, or of class A concrete formed in place. A precast cover shall be placed on a manhole in which headroom is limited.

Only competent masons shall be employed in laying units. Brick or other masonry units shall be laid in courses with full and close joints of mortar and finished properly as the work progresses. No joint shall exceed 10 mm (3/8 in.) in width. All units shall be wetted thoroughly immediately prior to being laid. Broken or chipped units will not be permitted in the face of the structure. No spalls or bats shall be used except for shaping around irregular openings or where necessary to finish out a course. As nearly as practicable, adjoining courses shall break joints at a half unit. Courses shall be level except where otherwise necessary. If brick is used, at least one course in each seven shall be composed of headers.

The pipe used in pipe catch basins shall be of the bell-and-spigot type.

Reinforced concrete spring boxes shall be constructed of class A concrete to the dimensions and at locations shown on the plans or as otherwise specified.

If the completed structure is partially or completely under or at its nearest point is within 1.5 m (5 ft) of pavement, sidewalks, curbs, gutters, or similar miscellaneous existing or proposed structures, the excavated space not occupied by the newly completed structure shall be filled to the required subgrade elevation with material in accordance with 211.02. Placement of this material shall be in accordance with 211.04. If the completed structure is not located as set out above, the backfill shall be with approved material which, when compacted, shall meet the required subgrade density.

Material excavated for the structure shall, if suitable, be utilized as backfill. If, in excess for that purpose, the excess shall be used in embankment where locations are available or otherwise disposed of as directed. If the excavated material is unsuitable or is in excess for use in the work, it shall be disposed of in accordance with 201.03. When finally accepted, all structures shall be free from any accumulation of silt, debris, or other foreign matter.

The Contractor may precast inlets, catch basins, or manholes, subject to approval. If precast concrete inlets, catch basins, or manholes are used, a layer of structure backfill of minimum thickness of 100 mm (4 in.) shall be used under each unit for ease in positioning. If holes are formed or field cut in precast inlets or catch basins to receive the pipe structures, the pipes shall be connected directly to the precast unit, by means of a class A concrete collar of a minimum longitudinal and radial thickness of 150 mm (6 in.). Holes formed or cut in the wrong place shall be plugged satisfactorily with a class A concrete mixture.

Horizontal joints may be used in the construction of precast catch basins. A sketch of the type, location, and sealing material planned for each joint shall be submitted for approval. No joints shall be closer than 75 mm (3 in.) above standing water for those catch basins requiring hoods.

Grade and location adjustments to precast inlets and catch basins caused by unforeseen conditions shall be handled as if the units were being cast in place. All additional adjustments required due to precasting will not be paid for directly, but the cost thereof shall be included in the cost of the inlet or catch basin.

**720.04 Grade Adjustment of Existing Structures.** When grade adjustment of existing structures is specified, the frames, covers, and gratings shall be removed and the walls reconstructed as required. The cleaned frames shall be reset at the required elevation. If so specified or if it is determined that the existing casting and supporting walls are in good condition, an approved device may be used to adjust the manhole casting cover to the correct grade without reconstructing the walls or resetting the frame. Upon completion, each structure shall be cleaned of any accumulations of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

Excavation and backfill shall be done in accordance with 720.03.

If an existing casting is unfit for further use, a new casting shall be furnished with payment at the contract unit price per each for castings of the type specified, furnished, and adjusted to grade. This payment shall include and be full compensation for furnishing the new casting, placing and adjusting it to grade, including any necessary removal, construction, or reconstruction of not to exceed 300 mm (12 in.) average height of the upper portion of the masonry.

When catch basins and inlets are adjusted to grade and are to abut existing concrete construction, the castings shall be entirely separated from the adjacent concrete by a preformed expansion joint no less than 10 mm (3/8 in.) in thickness. The cost of furnishing and placing the preformed expansion joint material will not be paid for directly, but shall be included in the payment for reconstructed catch basin, or reconstructed inlet, or castings furnished and adjusted to grade. The preformed expansion joint material shall be in accordance with 906.01.

On resurface contracts the castings shall, unless otherwise permitted or directed, be adjusted to grade after the last binder course has been laid and before placing the surface course.

**720.05 Method of Measurement.** Manholes, inlets, spring boxes, and catch basins, both new and reconstructed as applicable, will be measured per each unit, complete in place.

Castings adjusted to grade and castings furnished and adjusted to grade will be measured per each unit complete in place, if the average adjustment height does not exceed 300 mm (12 in.). If corrections to the structure involve portions exceeding an average adjustment height of 300 mm (12 in.), the additional work will be measured by the meter (linear foot) for the type of structure involved.

**720.06 Basis of Payment.** The accepted quantities of manholes, inlets, spring boxes, catch basins, castings adjusted to grade not exceeding 300 mm (12 in.), and castings furnished and adjusted to grade not exceeding 300 mm (12 in.) will be paid for at the contract unit price per each, complete in place.

That portion of a reconstructed structure which exceeds 300 mm (12 in.) in average height will be paid for at the contract unit price per meter (linear foot), for structure, of the type specified, reconstruct, complete in place.

Payment will be made under:

| **Metric Pay Item (English Pay Item Pay Item** | **Metric Pay Unit Symbol English Pay Unit Symbol) Pay Unit Symbol (English Pay Unit Symbol)** |
|---|---|
| Casting, _____, Adjust to Grade (type) | EACH |
| Casting, _____, Furnish and Adjust to Grade (type) | EACH |
| Catch Basin, _____ (type) | EACH |
| Inlet, _____ (type) | EACH |
| Inlet, type H, with Slotted Drains | EACH |
| Inlet, type HA, with Slotted Drains | EACH |
| Manhole, _____ (type) | EACH |
| Pipe Catch Basin, _____ mm (size) | EACH |
| (Pipe Catch Basin, _____ in (size) | EACH) |
| Spring Box | EACH |
| Structure, _____, Reconstruct (type) | m (LFT) |

The cost of both inlets, the 300 mm (12 in.) pipe connecting the two inlets, the type 5 castings, the concrete filler between the barrier wall and the inlet, and other miscellaneous materials shall be included in the cost of the inlet, type H. The cost of the inlet, the type 5 casting, the concrete filler between the barrier wall and the inlet, and other miscellaneous materials shall be included in the cost of the inlet, type HA.

The cost of both inlets, the 300 mm (12 in.) pipe connecting the two inlets, the type 5 castings, the concrete filler between the barrier wall and the inlets, the slotted drain pipe, the concrete collar around the slotted drain pipe, and other miscellaneous materials shall be included in the cost of the inlet, type H, with slotted drains. The cost of the inlet, the type 5 casting, the concrete filler between the barrier wall and the inlet, the slotted drain pipe, the concrete collar around the slotted drain pipe, and other miscellaneous materials will be included in the cost of the inlet, type HA, with slotted drains.

The costs of excavation, backfill, reinforcing steel, structure backfill, concrete collar required for pipe connection to structures, removal, disposal and replacement of pavement, or surface material, and necessary incidentals shall be included in the costs of the pay items.

## SECTION 721 – AUTOMATIC DRAINAGE GATES

**721.01 Description.** This work shall consist of furnishing and placing cast-iron, automatic, hinged, flap-gate valves to the outlet ends of pipe or headwalls in accordance with these specifications and in reasonably close conformance with the plans or as directed.

**721.02 Materials.** The cast-iron flap and seat shall be machined accurately to ensure watertightness. They shall be in accordance with the applicable requirements of 910.05(b).

**721.03 Construction Requirements.** The gate shall be constructed to offer minimum resistance to water flowing through it. When the water elevation in the outlet stream is 13 mm (1/2 in.) or more above or below the bottom of the valve, the valve shall close or open, as the case may be. The valve shall be able to resist a head of at least 3 m (10 ft).

The end of the pipe, or headwall, to which the flange is attached shall be vertical and the flange attached thereto either with rivets, bolts, or other approved means.

**721.04 Method of Measurement.** Automatic drainage gates will be measured by the number of units installed.

**721.05 Basis of Payment.** The accepted quantities of this work will be paid for at the contract unit price per each for automatic drainage gate, of the size specified, complete in place.

Payment will be made under:

| **Metric Pay Item (English Pay Unit** | **Metric Pay Unit Symbol English Pay Unit Symbol)** |
|---|---|
| Automatic Drainage Gate, _____ mm x _____ mm (width, height) | EACH |
| (Automatic Drainage Gate, _____ in. x _____ in (width, height) | EACH) |

If the gate is fastened to the end of a pipe, no additional payment will be allowed for that portion of pipe extending beyond the outside face of the headwall.

## SECTION 722 – LATEX MODIFIED CONCRETE BRIDGE DECK OVERLAYS

**722.01 Description.** This work shall consist of the construction of a latex modified portland cement concrete overlay on an existing or new bridge deck, or it shall consist of patching an existing latex modified portland cement concrete overlay on a bridge deck in conformance with the lines, grades and at locations shown on the plans or as directed.

**722.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Admixtures | 912.03 |
| Coarse Aggregate, Class A or Higher, Size No. 11 | 904 |
| Epoxy Penetrating Sealer | 909.09 |
| Epoxy Resin Adhesive | 909.11 |
| Fine Aggregate | 904.01 |
| Fly Ash | 901.02 |
| Latex Modifier | 912.04 |
| PCC Sealer/Healer | 901.06 |
| Portland Cement | 901.01(b) |
| Water | 913.01 |

* Crushed stone only

**722.03 Storage and Handling of Materials.** Fine and coarse aggregates shall be stored and handled avoiding contamination and maintaining uniform moisture content. Fine and coarse aggregates which are stored in piles or bins shall remain separated and shall be covered with a moisture proof material which prevents variations in moisture content of the aggregates. The maximum variation of moisture content in successive concrete batches shall be 0.5%.

Cement shall be stored in weatherproof enclosures which protect the cement from dampness. Cement shall not have developed lumps.

The latex modifier shall be stored in accordance with the manufacturer's recommendations. Latex modifier shall be strained to remove solid particles during transfer of the material from storage drums to the mobile mixer tank.

**722.04 Proportioning.** The amount of fine aggregate shall be 60% ± 5% by dry weight of the total aggregate and shall be considered as the amount of aggregate blend passing the 4.75 mm (No. 4) sieve. The coarse aggregate shall be size No. 11, class A crushed stone. The cement content shall be a minimum of 391 kg/m$^3$ (658 lb/cu yd) of concrete. The same brand of cement shall be used throughout a bridge structure. The amount of latex modifier shall be 13.3 L per 43 kg (3.5 gal. per 94 lb) of cement. The net water added shall produce a slump of 125 mm (5 in.) ± 25 mm (1 in.) at 4 to 5 min after discharge from the mixer. The moisture content of the aggregates shall be controlled such that the slump is within the specified limits. The air content shall be a maximum of 6%, by volume, of the plastic mix.

The yield will be checked using the 0.2 m$^3$ (1/4 cu yd) box method as follows. The chute shall be cleaned and the box shall be positioned to receive the discharged concrete. The mixer shall be operated until the cement counter indicates that 0.2 m$^3$ (1/4 cu yd) of concrete has been produced. The contents of the box shall be consolidated and struck off. If the box is not essentially full, the gates shall be adjusted and the procedure shall be repeated until the actual and calculated volumes of concrete agree. Yield tests shall be run on the first load of each truck and every third load per truck thereafter. Additional tests will be required after making any adjustments.

Slump and air content tests will be performed after each acceptable yield test. The slump test shall be in accordance with AASHTO T 119 and will be performed 4 to 5 min after the concrete is discharged from the mixer. The water flow meter reading will be recorded at the time the slump test is taken. The concrete shall not be disturbed during the waiting period for the slump test. The air content test shall be in accordance with 505. Any concrete mixture which is not properly proportioned or does not conform to the specified slump will be rejected.

Class F or class C fly ash may be used in the latex modified portland cement concrete. The maximum cement reduction shall be 15% and the minimum replacement ratio by weight of fly ash to cement shall be 1.25:1. A concrete mix design shall be submitted in accordance with 702.05. If portland pozzolan cement, type IP is to be used in the concrete mix design, the cement content shall be increased by a multiplier of 1.06 times the specified cement content.

Bridge deck patching concrete shall be composed of the following:

(a) Fine aggregate shall be 35% to 45% of the total weight of aggregate used.

(b) The cement shall be 335 kg/m$^3$ (564 lbs/cu yd) of portland cement type III or type IIIA, or 503 kg/m$^3$ (846 lbs/cu yd) of portland cement type I or type IA.

(c) Air entraining admixture shall be added to produce 5% to 8% entrained air.

(d) The net water added shall produce a slump of no more than 100 mm (4 in.).

### 722.05 Preparation of the Bridge Floor.

#### (a) Concrete Removal.

**1. Deck Surface.** The top 6 mm (1/4 in.) of the entire bridge deck surface shall be removed if the overlay is to be placed on a bridge deck constructed under a previous contract. The surface removal operation shall be limited to that portion of the bridge deck that is closed to traffic at any one time. After this initial surface removal, an additional 6 mm (1/4 in.) of surface removal may be required on part or all of the bridge deck as directed.

Surface removal shall be performed with a power operated mechanical milling machine. The equipment shall uniformly remove the required depth of concrete surface in a satisfactory manner. Surface removal, which is in areas adjacent to the curb that are inaccessible to milling, shall be done by handchipping. All surface removal residue, including water, dust and concrete, shall be immediately removed.

**2. Bridge Floor.** Following the clean up from the surface removal operation, areas of unsound concrete to be removed will be marked. Removal of the unsound concrete shall be performed by handchipping or hydrodemolition. Handchipping tools may be hand or mechanically driven. Jack hammers shall not be heavier than nominal 20.5 kg (45 lb) class and chipping hammers shall not be heavier than nominal 6.8 kg (15 lb) class. Only handchipping tools shall be used when removing concrete within 25 mm (1 in.) of reinforcing steel. Mechanically driven tools shall be operated at a maximum angle of 45 degrees from the bridge floor surface.

The hydrodemolition machine shall utilize a high pressure water jet system and shall be approved prior to use. Hydrodemolition equipment shall be calibrated to remove only unsound concrete. The pressure of the water jet shall be calibrated for each structure prior to use. All water used in the hydrodemolition operation shall be potable, and stream or lake water will not be permitted. Precautions shall be taken, during the hydrodemolition operations, to prevent damage to surrounding property and traffic. Waste water shall not be discharged into a stream.

Regardless of the method of removal, the removal operation shall be stopped if it is determined that sound concrete is being removed. Appropriate recalibration, or changes in equipment and methods shall be performed prior to resuming the removal operation.

Where the bond between the existing concrete and reinforcing steel has been destroyed, the concrete adjacent to the steel shall be removed to a minimum clearance of 25 mm (1 in.) around the entire periphery of the exposed steel. If the concrete is unsound down to the top layer of bottom reinforcing steel, all of the concrete within the marked area shall be removed and the cavity shall require full depth patching in accordance with 722.06(a). Prepared cavities which are deeper than the level of the

adjacent prepared deck surface, but are not full depth, shall require partial depth patching in accordance with 722.06(b). Prepared partial depth cavities shall be made full depth when directed. Exposed reinforcing steel shall not be damaged by the removal operation. Any damaged reinforcing steel shall be repaired as directed with no additional payment.

The removal areas shall be thoroughly cleaned of all dirt, foreign materials and loose concrete to the extent necessary to produce a firm solid surface for adherence of the new concrete. A minimum 25 mm (1 in.) vertical surface shall remain, or be cut, one inch outside and around the entire periphery of each removal area after removal of all loose and unsound concrete.

**(b) Cleaning.** After the concrete removal operation is completed and just prior to placing the overlay, the entire deck shall be heavily sandblasted to expose fine and coarse aggregates and to remove unsound concrete or laitance layers from the surface. Exposed reinforcing steel and the concrete under and around the exposed steel shall be thoroughly cleaned by sandblasting. The surface shall be then cleaned free of all dust, chips and water. The final surface shall be free of oil, grease and water. The air lines for sandblasting and air cleaning shall be equipped with oil traps.

**722.06 Patching of the Bridge Floor.** A vacuum device shall be used to remove all water from the prepared cavities.

**(a) Full Depth Patching.** The material used for full depth patching shall be either bridge deck patching concrete or latex modified concrete. Full depth patching shall be performed prior to the overlay operation unless otherwise permitted. The patching material shall be consolidated by internal vibration at the time of placement. Equipment shall not be operated on the repaired deck areas until the test beams indicate a minimum modulus of rupture of 3800 kPa (550 psi). Curing of the patch shall be as directed.

**1. Patching with Bridge Deck Patching Concrete.** Epoxy resin adhesive, in accordance with 909.11, shall be used to coat the surfaces of the prepared cavities and all the exposed reinforcing steel within the cavities. The epoxy coating shall be tacky at the time that the patching concrete is placed. If the epoxy coating has cured beyond the obvious tacky condition, it shall be re-applied prior to patching. The coated cavities shall then be filled with the patching concrete to the level of the adjacent deck surface.

**2. Patching with Latex Modified Concrete.** The surfaces of the prepared cavities shall be coated with a bond coat in accordance with 722.08. The cavities shall then be filled with the latex modified concrete to the level of the adjacent deck surface.

**(b) Partial Depth Patching.** The material used for partial depth patching shall be either bridge deck patching concrete or latex modified concrete. The patching material shall be consolidated by internal vibration at the time of placement. Curing of the patch shall be as directed.

**1. Patching with Bridge Deck Patching Concrete.** Partial depth patching with bridge deck patching concrete shall be in accordance with 722.06(a) and 722.06(a)1.

**2. Patching with Latex Modified Concrete.** The surfaces of the prepared cavities shall be coated with a bond coat in accordance with 722.08. The cavities shall then be filled with the latex modified concrete at the time that the overlay is placed.

**722.06.1 Overlay Dam.** An overlay dam shall consist of the removal of existing concrete from the bridge floor and replacing it with new concrete as shown on the plans or as otherwise directed. Overlay dam material shall be in accordance with 722.05.

The existing concrete shall be removed as required in accordance with 722.05(a). Exposed reinforcing steel shall not be cut or otherwise damaged.

Power driven hand tools for removal by handchipping will be permitted. Pneumatic hammers with a maximum weight of 31 kg (69 lb) may be used for the tops of mudwalls. If, during the removal process, the tools or methods being used appear to cause damage such as cracks or spalling on the concrete which is to remain, the work shall cease immediately and shall not resume until the Engineer is assured the tools or methods being used will not cause further damage.

The surface to be repaired, the reinforcing steel, and the concrete under and around the steel shall be thoroughly cleaned in accordance with 722.05(b). The cavity shall be epoxy coated in accordance with 722.06(a)1 then filled with class A concrete in accordance with 702.

**722.07 Mixing.** Proportioning and mixing of the latex modified concrete shall be performed in a self-contained, self-propelled continuous mixer. The mixer shall be calibrated to accurately proportion the specified mix prior to starting the work. The calibration shall be in accordance with 722.11. Sufficient mixing capacity or mixers shall be provided to permit the intended pour to be placed without interruption. The mixer shall carry sufficient quantities of unmixed ingredients to produce at least 4.6 $m^3$ (6 cu yd) of latex modified concrete at the site.

The mixer shall measure and control the flow of ingredients being introduced into the mix and shall record these quantities on an approved visible recording meter equipped with a ticket printer. Water flow shall be readily adjustable to compensate for minor variations in aggregate moisture content, and shall be displayed by an approved flow meter. The flow of the latex modifier shall also be displayed by an approved flow meter. The manufacturer's inspection plate shall clearly show the serial number, proper operating revolutions per minute, and the approximate number of counts on the cement meter to deliver 43 kg (94 lb) of cement.

The mixer shall automatically proportion and blend simultaneously all the ingredients of the specified mix on a continuous or intermittent basis as required by the finishing operation. The latex modified concrete shall be discharged through a conventional chute directly in front of the finishing machine. The surface ahead of the deposited mixture shall be kept damp by spraying it with water. If the water is applied by the mixer, it shall be dispensed ahead of the water flow meter.

**722.08 Placing and Finishing.** Existing expansion joints shall be maintained throughout the overlayment. A bulkhead, equal in thickness to the joint width, shall be installed to the required grade and profile prior to placing the overlay. Screed rails for the finishing machine shall be placed to the required profile, and stably anchored vertically and horizontally. Screed rails shall not be treated with a bond breaking compound.

The overlay shall not be placed unless the ambient temperature is 7°C (45°F) and rising, unless otherwise approved in writing. Placement may be required during early morning hours, at night, or during other limited work periods if the prevailing daytime temperature exceeds 29°C (85°F). The overlay shall not be placed if rain is expected. Adequate precautions shall be taken to protect freshly placed overlay material from sudden or unexpected rain. Damaged material shall be removed and replaced with no additional payment. A construction dam or bulkhead shall be installed in case of a delay in placement of 1 h or more. During delays of less than 1 h, the end of the placed overlay material shall be protected from drying with layers of wet burlap.

After the surface has been cleaned, and immediately before placing the overlay material, the surface shall be thoroughly soaked for a period of 1 h. The surface shall not be allowed to dry before placing the overlay material and there shall be no standing water at the time of placement. The surface shall then be thoroughly and evenly coated with a brush applied bond coat of latex modified concrete. The progress of the bond coat application shall be controlled to ensure that the bond coat does not dry before the overlay is placed to the required grade. Aggregate segregated in the brush application of the bond coat shall be removed before the overlay is placed. Surface irregularities shall be filled to approximately 3/4 of their depth sufficiently ahead of the overlay operation to allow the material to stiffen and resist rolling back during the finishing.

Following the bond coat application and partial filling of any surface irregularities, the latex modified concrete overlay shall be placed to an elevation approximately 13 mm (1/2 in.) above final grade. The mix shall then be consolidated and machine finished to the required grade. The machine finishing shall be to within 300 mm (12 in.) of the curb line or coping line unless otherwise directed. Supplemental hand finishing with a wood float shall be performed as needed to produce the required tight, uniform surface.

The finishing machine shall be self-propelled and capable of positively controlled forward and reverse motion. The machine shall be equipped with at least two finishing devices. The first finishing device shall be a vibrating mechanism, such as a vibrating pan, for consolidating the deposited mix. The vibrating pan shall be metal and of sufficient dimensions to ensure proper consolidation. The second finishing device

shall be either a rotating cylindrical drum, at least 1.1 m (45 in.) in length, or a vibrating oscillating metal faced screed of 100 mm (4 in.) minimum in width. The vertical position of the finishing devices shall be positively controlled and the devices shall be raised clear of the finished surface when the machine is operated in the reverse direction. The vibration frequency of any vibrating finishing device shall be variable, with positive control between 3,000 and 6,000 vibrations per minute. Alternate finishing machines may be considered for approval subject to a written request.

Screed rails and construction dams shall be separated from the newly finished overlay by passing a pointing trowel along the rail-to-overlay and dam-to-overlay interfaces after the overlay has sufficiently set such that it does not flow back. This trowel cut shall be made for the entire length and depth of the rail or dam. The rails may be removed anytime after the overlay has initially set. Adequate precautions shall be taken during and subsequent to the rail removal to protect the edge of the new overlay from damage. The finished surface shall be in accordance with 504.03.

**722.09 Texturing.** Immediately after the finishing is complete and before the surface film has formed, the surface of the overlay shall be textured by transverse grooving. The grooves may be formed by mechanized equipment using a vibrating beam roller, a series of discs or other approved device. Manual tools such as fluted floats, spring steel tined rakes, or finned floats with a single row of fins may be used. The grooves shall be relatively uniform and smooth and shall be formed without tearing the surface or bringing coarse aggregate to the top. The grooves shall be in accordance with 504.03. The grooves shall be terminated approximately 450 mm (18 in.) from vertical faces such as curbs and concrete railing.

All areas of hardened grooved overlay which do not conform to these requirements due to either a deficiency in the grooving or a rough open textured surface shall be corrected with no additional payment. Corrections shall be made by cutting transverse grooves in the hardened overlay with an approved cutting machine or by sealing with an approved mixture and retexturing to a satisfactory finish as directed.

**722.10 Curing.** When fly ash is used, the requirement for additional wet and/or dry curing time will be determined based on the relative initial, and final time of set and a comparison of strength versus age using control concrete strengths at conventional cure period ages as the reference. Unless otherwise directed, 702.21 shall apply except that the membrane forming curing compound shall not be used to cure the bridge deck overlay.

The minimum curing shall be 24 h of wet cure followed by 72 h of dry cure. An overlaid bridge deck may be opened to traffic during the minimum curing duration when the compressive strength of test cylinders is 27 500 kPa (4,000 psi) or greater. The strength requirements, and the making and curing of the cylinders, shall be in accordance with 702.23. After texturing, the plastic film which forms on the surface of the overlay shall be protected from shrinkage cracking with a single layer of well drained wet burlap. This layer of wet burlap shall be placed as soon as the overlay surface will support it without deformation. Approximately 1 h after placing the first layer of wet burlap, a second layer shall be placed and the entire covering shall be

maintained in a wet condition for a minimum of 24 h. Polyethylene film may be used in lieu of the second layer of wet burlap. If the polyethylene film is used for the second covering, then the burlap already in place shall be wetted just before placing the polyethylene film and shall be maintained in a wet condition. After the 24 h elapse, all layers of covering material shall be removed.

If the ambient temperature falls below 10°C (50°F) during either the wet or dry curing periods, the time that the temperature is below 10°C (50°F) shall not be considered as part of the total 96 h curing period. If there is sufficient rain to wet the surface of the overlay for 1 h or more during the dry cure period, this number of hours shall not be considered as part of the 72 h dry cure period.

Immediately upon the start of the dry cure period, the surface shall be checked for cracks. If cracks exist, a thorough investigation will be conducted prior to sealing cracks. Cores may be required to determine the actual crack depth. Surface cracks not exceeding 10 mm (3/8 in.) in depth shall be sealed with an epoxy penetrating sealer followed by an application of an approved sand. The sealing and sand application shall be repeated as needed to ensure that the voids remain completely filled. Alternate methods of surface crack sealing may be used if approved. Cracks exceeding 10 mm (3/8 in.) in depth shall not be sealed at this time. Corrective procedures for repairing cracks exceeding 10 mm (3/8 in.) in depth will be determined after further investigation which may include additional cores. The method of repair shall be as directed in writing and may include removal and replacement or complete filling with an approved sealer/healer and a sand application on the surface. The Department will maintain a list of approved sealer/healers.

If it is determined by sounding or coring that adequate bonding between the overlay and the bridge deck has not been attained, the deficient areas shall be removed and replaced as directed.

### 722.11 Calibration of Continuous Mixers.

**(a) Frequency.** A complete calibration shall be performed for each mixer prior to each pour unless the initial calibration was made within the previous 10 calendar days. A mixer that has been calibrated within the previous 10 calendar days may be approved for use providing that the mixer operator is in possession of the completed, signed, certified and dated Department calibration form for that mixer. A complete calibration of a mixer may be required at any time as directed. All mixers which are calibrated within the 10 day limit but are changing aggregate sources shall have an aggregate blend test performed.

**(b) Equipment.** All special equipment required for calibration shall be furnished. It shall include but not be limited to suitable material containers, buckets, stop watches and a set of balance beam platform scales graduated in at least 0.10 kg (1/4 lb) intervals with a minimum capacity of 230 kg (500 lb). Samples shall be obtained and handled by the Contractor. Normal testing equipment such as aggregate sieves and containers shall also be furnished.

**(c) Pre-calibration.** The aggregate bin shall be clean and the bin vibrators shall be in good working order. The mixer shall be equipped with a grounding strap. The cement meter feeder, the fins and all pockets shall be clean and free of any accumulated cement. The aeration system shall be equipped with a gauge or indicator to verify that the system is operating. The main belts and the latex strainer shall be clean and free of any accumulated material.

**(d) Calibration.**

**1. Cement Meter.** The mixer manufacturer's mix setting chart shall determine the specified operating revolutions per minute and the approximate number of counts required on the cement meter to deliver 43 kg (94 lb) of cement. At least 1700 kg (3760 lb) of cement shall be placed in the cement bin.

The mixing unit shall rest on a level surface. The engine throttle shall be adjusted to obtain the required revolutions per minute. The unit discharging the cement shall be operated until the belt has made one complete revolution. It shall then be stopped and the cement meter shall be reset to zero.

A suitable container shall be positioned to catch the cement and at least 41 kg (90 lb) of cement shall be discharged. The time required to discharge the cement shall be measured with a stop watch, the number of counts on the cement meter shall be recorded, and the weight of the discharged cement shall be determined. This process shall be repeated a total of three times. The cement counter shall be reset to zero before each repetition.

The following formulas shall be used to calculate the number of counts per 43 kg (94 lb) of cement and the time required to discharge 43 kg (94 lb) of cement.

$$43\ (94) \div \frac{A}{B} = \text{Counts per 94 lb (43 kg) of cement}$$

$$43\ (94) \div \frac{A}{C} = \text{Time in seconds per 94 lb (43 kg) of cement}$$

A = Total mass (weight) of cement in kilograms (pounds) for three trials
B = Total number of counts on the cement meter for three trials
C = Total time in seconds for three trials

**2. Water Flow Meter.** The accuracy of the water flow meter shall be verified by adjusting the flow to 7.6 L (2 gal.) per minute. With the equipment operating at the required revolutions per minute, the water discharged during a one minute interval shall be collected and weighed. The mass in kilograms (weight in pounds) of the discharged water shall be divided by 1.0 (8.33) to determine the number of liters (gallons). This procedure shall be repeated with the flow meter adjusted to 11.4 L (3 gal.) per minute.

**3. Aggregate Bin Gates.** The gate opening shall be adjusted to provide the required amount of aggregate to produce a cubic meter (cubic yard) of the designated mix. The ratio of fine aggregate to total aggregate shall be verified by stopping the cement discharge and collecting the aggregate discharged in a container. A representative sample of the discharged aggregate shall be selected and separated on a 4.75 mm (No. 4) sieve. The fine aggregate will be considered as the amount passing the 4.75 mm (No. 4) sieve. The percentage shall be computed on a dry weight basis.

**4. Latex Throttling Valve.** The latex strainer shall be unobstructed. The latex throttling valve shall be adjusted to deliver the required amount of latex emulsion admixture for each 43 kg (94 lb) of cement. With the unit operating at the required revolutions per minute for the calculated time in seconds per 43 kg (94 lb) of cement, the latex shall be discharged into a container. The weight of the latex shall be determined and, if necessary, the valve shall be adjusted such that the amount of latex discharged is within 0.23 kg (1/2 lb) of the amount required for each 43 kg (94 lb) of cement. One verification shall be performed to check the accuracy of the valve setting.

**5. Admixture Dispensers.** This equipment shall be calibrated in accordance with the manufacturer's instructions for the specific materials and quantities involved.

### 722.12 Patching an Existing Bridge Deck Overlay.

**(a) Materials.** Materials shall be in accordance with 722.02.

**(b) Storage and Handling of Materials.** Storage and handling of materials shall be in accordance with 722.03.

**(c) Proportioning.** Proportioning shall be in accordance with 722.04.

**(d) Preparation of the Bridge Floor.** Preparation of the bridge floor shall be in accordance with the applicable provisions of 722.05.

**(e) Patching.** Patching shall be in accordance with 722.06 except as modified herein. If no new overlay is planned, bridge deck patching concrete used in patching the bridge floor shall be placed to the level of the original deck. The remainder of each cavity shall be patched with the same material as the existing overlay.

**(f) Mixing.** Mixing shall be in accordance with the applicable provisions of 722.07.

**(g) Placing and Finishing.** Placing and finishing shall be in accordance with the applicable provisions of 722.08. Machine finishing shall be required when directed.

**(h) Texturing.** Texturing shall be in accordance with 722.09. In addition, the surface texturing shall match the pattern of the adjacent overlay.

**(i) Curing.** Curing shall be in accordance with 722.10.

**(j) Calibration of Continuous Mixers.** Calibration shall be in accordance with 722.11.

**722.13 Method of Measurement.** Surface milling will be measured by the square meter (square yard) for the initial 6 mm (1/4 in.) depth. Additional surface removal required below the initial 6 mm (1/4 in.) depth will be measured by the square meter (square yard) for each required 6 mm (1/4 in.) depth. Only the portion of the bridge deck which is to remain in place will be measured for payment. The undefined areas requiring full depth deck removal will be measured for payment. The areas of the bridge floor which are shown on the plans to be removed will not be measured for payment.

Full depth patching will be measured by the square meter (square yard). The patching material used in full depth patching will not be measured for payment.

Partial depth patching will be measured by the square meter (square yard). The measurement of bridge deck patching concrete used in partial depth patching will be based on a theoretical quantity determined by multiplying the area of the appropriate partial depth patches by an assumed average depth of 50 mm (2 in.) and converting the resulting volume into cubic meters (cubic yards). Overlay material used in partial depth patching will be measured by the cubic meter (cubic yard). The quantities of patching material used in partial depth patching will be included in the measurement of additional bridge deck overlay.

Overlay material used to fill surface irregularities will be measured by the cubic meter (cubic yard). Such quantity will be included in the measurement of additional bridge deck overlay.

Bridge deck overlay will be measured by the square meter (square yard) for the specified thickness. If there is no specified thickness shown on the plans, the specified thickness shall be 45 mm (1 3/4 in.).

Overlay dams and patching an existing overlay will be measured by the square meter (square foot).

Epoxy resin adhesive and bond coat will not be measured for payment. Blasting, cleaning, finishing, texturing, and curing will not be measured for payment.

**722.14 Basis of Payment.** Milling of the initial 6 mm (1/4 in.) depth of surface will be paid for at the contract unit price per square meter (square yard) for surface milling. Additional surface removal below the initial 6 mm (1/4 in.) depth will be paid for at the contract unit price per square meter (square yard) for surface milling for each required 6 mm (1/4 in.) depth.

Full depth patching will be paid for at the contract unit price per square meter (square foot) for bridge deck patching, full depth.

Partial depth patching will be paid for at the contract unit price per square meter (square foot) for bridge deck patching, partial depth.

Prepared partial depth cavities exceeding 50 mm (2 in.) in average depth, which are subsequently directed to be made full depth, will be paid for at the contract unit price per square meter (square foot) for bridge deck patching, partial depth. Additional payment will be made at 80% of the contract unit price per square meter (square foot) for bridge deck patching, full depth.

Prepared partial depth cavities of 50 mm (2 in.) or less in average depth, which are subsequently directed to be made full depth, will be paid for at the contract unit price per square meter (square foot) for bridge deck patching, full depth.

Patching material used for partial depth patching will be paid for at the contract unit price of $434.50 per cubic meter ($330 per cubic yard) for bridge deck overlay, additional.

Overlay material used to fill surface irregularities will be paid for at the contract unit price of $434.50 per cubic meter ($330 per cubic yard) for bridge deck overlay, additional.

Bridge deck overlay will be paid for at the contract unit price per square meter (square yard).

Patching an existing bridge deck overlay will be paid for at the contract unit price per square meter (square foot) for bridge deck overlay patching.

Overlay dam will be paid for at the contract unit price per square meter (square foot), complete in place.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Bridge Deck Overlay | m2 (SYS) |
| Bridge Deck Overlay, Additional | m3 (CYS) |
| Bridge Deck Overlay Patching | m2 (SFT) |
| Bridge Deck Patching, Full Depth | m2 (SFT) |
| Bridge Deck Patching, Partial Depth | m2 (SFT) |
| Overlay Dam | m2 (SFT) |
| Surface Milling | m2 (SYS) |

The cost of milling, handchipping, removing debris and water, and necessary incidentals shall be included in the cost of surface milling.

The cost of removal of unsound concrete, preparation of cavity surfaces, furnishing and applying bond coat or epoxy resin adhesive as required, furnishing and placing patching material, and necessary incidentals shall be included in the cost of bridge deck patching, full depth, or bridge deck patching, partial depth.

The cost of patching material used for full depth patching shall be included in the cost of bridge deck patching, full depth.

The cost of furnishing and placing patching material and necessary incidentals shall be included in the cost of bridge deck overlay, additional.

The cost of removing the existing concrete; furnishing, hauling, and placing all materials including the epoxy; preparing the surface; and all necessary incidentals shall be included in the cost of overlay dam.

The cost of blasting, cleaning, furnishing, and applying epoxy resin adhesive or bond coat shall be included in the cost of other pay items.

Coring of the bridge deck, patching core holes, and all corrective measures required in accordance with 722.10 shall be performed with no additional payment.

The cost of bond coat, furnishing and placing the overlay material, and necessary incidentals shall be included in the cost of bridge deck overlay or bridge deck overlay patching.

## SECTION 723 – Blank

## SECTION 724 – STRUCTURAL EXPANSION JOINTS

### 724.01 Description.

**(a) Structural Expansion Joint.** This work shall consist of furnishing and placing, for new construction, structural expansion joints of the type specified, in accordance with the plans and these requirements.

**(b) Replacement of Existing Structural Expansion Joint.** This work shall consist of the removal and replacement of an existing structural expansion joint with a joint of the type shown on the plans and in accordance with these requirements.

**(c) Replacement of Existing Structural Expansion Joint Seal.** This work shall consist of the replacement of the joint seal in an existing structural expansion joint of the type shown on the plans.

**724.02 Materials.** Materials shall be in accordance with the following:

| | |
|---|---|
| Expansion Joint BS | 906.06(b) |
| Expansion Joint M | 906.06(c) |
| Expansion Joint SS | 906.06(a) |
| Inorganic Zinc Primer | 909.02(a)1 |
| Structural Steel | 910.02 |

**(a) Expansion Joint SS.** The sliding cover plate required over that portion of expansion joint SS located in a sidewalk shall be the same material as the extrusion and shall be galvanized in accordance with ASTM A 123.

**(b) Expansion Joint M.** This joint shall consist of prefabricated, multiple elastomeric seals, separator beams, and support bars. The structural design of expansion joint M shall be in accordance with the current AASHTO Standard Specifications for Highway Bridges and shall be for the same design loading as the bridge structure at which it is installed, but in no case less than HS 20 - 44 truck loading and impact. The joint shall be designed to accommodate the movement shown on the plans. The sliding cover plate required over that portion of expansion joint M located in a sidewalk or concrete rail shall be the same material as the extrusion and shall be galvanized in accordance with ASTM A 123.

## CONSTRUCTION REQUIREMENTS

**724.03 General Requirements.** The manufacturer shall prepare and submit four sets of detailed shop drawings for approval, prior to the manufacture of joint assemblies SS and M. The shop drawings shall be a minimum of 560 mm by 860 mm (22 in. by 34 in.) in overall size. Expansion joints SS and M shall not be fabricated until the shop drawings are approved. Joint installation and the replacement of existing joints shall be in accordance with the manufacturer's recommendations, the plans, and the approved shop drawings. If there is a dispute between the plans and the approved shop drawings, the approved shop drawings shall govern. The manufacturer shall furnish a copy of the installation instructions prior to the placement of these joints.

The fabrication and installation of the joint assembly, where changes in joint direction are required, shall be in accordance with the plans and the approved shop drawings. All welding shall be in accordance with 711.32. All splice welds shall develop full strength. All welds which come in contact with the seals shall be ground smooth. All metal surfaces in direct contact with the seal shall be cleaned and properly treated in accordance with the manufacturer's recommendations. All exposed structural steel surfaces, except for polytetrafluoroethylene coated surfaces and stainless steel, shall be shop painted in accordance with 619.11. Lubricants and adhesives shall be used in accordance with the joint manufacturer's recommendations. All excess lubricant and adhesive shall be removed before it has set.

**(a) Expansion Joint SS.** The joint assembly shall consist of one of the allowable alternates for this type of joint as shown on the plans. A sliding cover plate shall be required over that portion of expansion joint SS located in a sidewalk. The strip seal shall be sized to accommodate a minimum of four inches of movement.

The strip seal shall be furnished in one continuous length for the entire limits of the installed joint. Field splicing of the strip seal will not be permitted. Miter cut, vulcanized shop splices will be required in the strip seal as shown on the plans. The shop vulcanizing of the strip seal splice may be either a hot or cold process so long as the process produces a splice of equal or greater strength than the elastomer.

The extrusion and plate assemblies with anchors shall be shop fabricated, delivered, and installed in one continuous length except as otherwise permitted for crown breaks in the roadway, stage construction, or impractical shipping lengths exceeding 14 m (46 ft). Extrusion and plate assemblies with anchors, permitted to be furnished in sections, shall have shop prepared ends for field welding. This work shall be in accordance with 711.03.

**(b) Expansion Joint BS.** This type of joint shall be in accordance with the details shown on the plans for the size specified. The joint seal shall be furnished in one continuous length for the limits as shown on the plans. Miter cut, vulcanized shop splices will be required in the joint seal at those locations where a change in direction is required as shown on the plans. Field splicing of the joint seal will not be permitted. The distance from the top of the bridge deck to the joint seal, as shown on the plans, shall be in accordance with the joint manufacturer's recommendations. The distance from the top of the bridge deck to the top of the joint seal, when the joint is at its minimum width, shall be as shown on the plans.

**(c) Expansion Joint M.** The joint manufacturer shall submit the material specifications and joint setting data with the shop drawings as required elsewhere herein. This joint setting data shall be applicable to the particular bridge structure at which the joint is to be installed. The joint and anchor assembly shall be prefabricated and preset by the manufacturer in accordance with the approved shop drawings, joint setting data and the manufacturer's specifications. The assembly shall contain provisions for final field adjustment at the time of installation. All movements due to such factors as shrinkage, creep, and midslab deflection shall be properly accounted for prior to this final adjustment. Final adjustment of the assembly shall be made as directed at the time of installation.

The joint and anchor assembly shall be delivered and installed as a continuous unit for lengths up through 14 m (46 ft). Joints longer than 14 m (46 ft) shall be furnished in continuous units or in appropriate shorter sections as shown on the shop drawings and as approved. Joints used in stage construction shall be furnished in sections appropriate to accommodate the work. All joints furnished in sections shall have shop prepared ends for field splice welds. All work, both shop and field, shall be in accordance with 711.03. A sliding cover plate shall be required over that portion of expansion joint M located in a sidewalk or concrete rail.

**(d) Replacement of Existing Structural Expansion Joint.** The existing joint and adjacent concrete shall be removed to the limits shown on the plans. Additional removal, as directed, may be required to encounter sound concrete adjacent to the joint area. The replacement joint shall be in accordance with the requirements contained herein for the specified type.

**(e) Replacement of Existing Structural Expansion Joint Seal.** The existing seal shall be removed in its entirety. The new seal shall be installed in accordance with the requirements contained herein for the specified joint type.

**724.04 Method of Measurement.** Structural expansion joints will be measured by the meter (linear foot) along and parallel to the plane of the finished joint surface. Replacement of existing structural expansion joints will be measured by the meter (linear foot) along and parallel to the plane of the finished joint surface. Concrete removal and new concrete required for the replacement of existing structural expansion joints will not be measured for payment. Sliding cover plates will not be measured for payment. Replacement of existing structural expansion joint seals will be measured by the meter (linear foot) along and parallel to the plane of the finished seal installation.

**724.05 Basis of Payment.** Structural expansion joint will be paid for at the contract unit price per meter (linear foot) of the type specified, complete in place. Replacement of existing structural expansion joint will be paid for at the contract unit price per meter (linear foot) for structural expansion joint, of the type specified, replace, complete in place. Replacement of existing structural expansion joint seal will be paid for at the contract unit price per meter (linear foot) for structural expansion joint seal, of the joint type specified, replace.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Structural Expansion Joint, _____ (type) | m (LFT) |
| Structural Expansion Joint, _____ (type), Replace | m (LFT) |
| Structural Expansion Joint Seal, _____ (type), Replace | m (LFT) |

The cost of sliding cover plates shall be included in the cost of structural expansion joint or structural expansion joint, replace, as applicable. The cost of concrete removal and new concrete for the replacement of existing structural expansion joint shall be included in the cost of structural expansion joint, replace.

## SECTION 725 – SLIP LINING OF EXISTING PIPE

**725.01 Description.** This work shall include installing a thermoplastic liner into an existing pipe and filling the space between the liner and the existing pipe with cellular concrete grout all in accordance with 105.03.

## MATERIALS

**725.02 Materials.** Materials shall be in accordance with the following.

| | |
|---|---|
| Cement | 901.01(b) |
| Fine Aggregate | 904 |
| Fly Ash | 901.02 |
| Flowable Backfill | 213 |
| Foam Concentrate | ASTM C 869 |
| Profile Wall HDPE Pipe Liner | 907.24.1(b) |
| Profile Wall PVC Pipe Liner | 907.24.1(c) |
| Solid Wall HDPE Pipe Liner | 907.24.1(a) |
| Water | 913.01 |

Individual liner section lengths shall be a minimum of 5.8 m (19 ft), but shall not exceed 16.7 m (55 ft) unless approved.

Liner joints shall be bell and spigot, screw type, or thermal welded. Grooved press-on joints shall be used only when approved by the Engineer. All joints shall have sufficient mechanical strength to withstand the liner installation and grouting operations. Joints shall not reduce the hydraulic capacity of the liner.

Only pipe liners selected from the Department's list of approved thermoplastic pipe liners shall be used.

The cellular concrete grout shall be designed and produced in accordance with ASTM C 796 except as herein modified.

The admixtures, retarders, and plasticizers used in the grout shall be in accordance with the foam concentrate supplier's specifications.

The grout shall be made using the preformed foam process using foam generating equipment calibrated daily by the foam manufacturer to produce a precise and predictable volume of foam. The foam concentrate shall be certified by the manufacturer to have specific liquid/foam expansion ratio at a constant dilution ratio with water.

The specific job mix shall be submitted to the Engineer by the foam concentrate supplier certified or licensed grouting contractor for approval prior to use on the contract. The mix shall have a minimum 28 day compressive strength of 1040 kPa (150 psi). The mix shall be tested and verified in accordance with these specifications or shall be approved based on prior acceptable performance on Department contracts.

Grout mixed off site shall be delivered to the job site in a truck mixer in accordance with 702.09 filled to half its capacity. The foam concentrate shall then be added to the cement mix in the truck and mixed to a uniform consistency.

Grout mixed on site shall be batched in a deck mate or similar device. Small batches of approximately 1 cubic meter (1 cubic yard) shall be mixed and pumped in a continuous operation.

For each day worked or for each 100 cubic meters (100 cubic yards) placed, four test cylinders measuring 75 mm by 150 mm (3 in. by 6 in.) shall be cast at the point of placement of the grout. The cylinders shall be prepared, cured, and transported in accordance with ASTM C 31, except as modified herein.

The compressive strength shall be determined in accordance with ASTM C 39, except as modified herein. Initial curing shall be at room temperature and shall be from 2 to 5 days. After the initial curing, the test specimens shall be placed in a moist closet or moist room or stored in an enclosed curing tank above the water level. All specimens shall be kept in their molds in the moist storage for the remainder of the curing period. The specimens shall be tested at 28 days. At that time the specimens shall be stripped, capped, and tested in compression as rapidly as possible to minimize drying. If more than one specimen is removed from the moist storage at the same time, these specimens shall be covered with a damp cloth until time of testing.

Existing circular pipe structures shall be lined with solid wall high density polyethylene, HDPE, pipe liner; profile wall HDPE pipe liner; or profile wall polyvinyl chloride, PVC, pipe liner. Existing deformed pipe structures shall be lined with solid wall HDPE pipe liner.

## CONSTRUCTION REQUIREMENTS

### 725.03 Construction Requirements.

(a) **Right-of-Entry Areas**. If the right-of-way does not provide sufficient room for performance of the work, rights-of-entry from all necessary adjacent property owners shall be obtained in accordance with 107.14. A temporary fence shall be installed as required to prevent encroachment of the public or livestock into the work area. Upon completion of the work, disturbed areas on private property shall be restored in accordance with 107.14.

**(b) Filling of Cavities Outside the Existing Pipe**. All obvious cavities outside the existing pipe shall be filled with flowable backfill in accordance with 213 prior to the liner installation or with grout placed in conjunction with the grouting operation after the liner is installed.

**(c) Liner Installation**. Prior to commencing the liner installation, all jagged existing pipe edges or other deformities shall be repaired. All foreign material shall be removed from the existing pipe.

The inside diameter of the liner shall be in accordance with the following:

| EXISTING CIRCULAR CMP STRUCTURES | |
|---|---|
| PAY ITEM DIAMETER mm (in.) | MINIMUM LINER INSIDE DIAMETER mm (in.) |
| 300 (12) | 250 (10.0) |
| 375 (15) | 290 (11.7) |
| 450 (18) | 355 (14.3) |
| 525 (21) | 420 (16.8) |
| 600 (24) | 460 (18.5) |
| 675 (27) | 515 (20.7) |
| 750 (30) | 585 (23.5) |
| 825 (33) | 650 (26.1) |
| 900 (36) | 735 (29.5) |
| 1050 (42) | 840 (33.6) |
| 1200 (48) | 980 (39.2) |
| 1350 (54 ) | 1050 (42.0) |
| 1500 (60) | 1200 (48.0) |
| 1650 (66) | 1350 (51.6) |
| 1800 (72) | 1475 (59.1) |
| 1950 (78) | 1500 (60.0) |
| 2100 (84) | 1650 (66.0) |
| 2250 (90) | 1800 (72.0) |
| 2400 (96) | 1950 (78.0) |
| 2550 (102) | 1950 (78.0) |
| 2700 (108) | 2100 (84.0) |
| 2850 (114) | 2250 (90.0) |
| 3000 (120) | 2400 (96.0) |
| 3150 (126) | 2400 (96.0) |
| 3300 (132) | 2700 (108.0) |
| 3450 (138) | 2700 (108.0) |
| 3600 (144) | 3000 (120.0) |

| EXISTING CIRCULAR STRUCTURAL PLATE PIPE STRUCTURES | |
|---|---|
| PAY ITEM DIAMETER mm (ft - in.) | MINIMUM LINER INSIDE DIAMETER mm (in.) |
| 1500 (5 - 0) | 1200 (48.0) |
| 1655 (5 - 6) | 1290 (51.7) |
| 1810 (6 - 0) | 1475 (59.1) |
| 1965 (6 - 6) | 1475 (59.1) |
| 2120 (7 - 0) | 1475 (59.1) |
| 2275 (7 - 6) | 1800 (72.0) |
| 2430 (8 - 0) | 1950 (78.0) |
| 2585 (8 - 6) | 2100 (84.0) |
| 2740 (9 - 0) | 2250 (90.0) |
| 2895 (9 - 6) | 2400 (96.0) |
| 3050 (10 - 0) | 2400 (96.0) |
| 3205 (10 - 6) | 2400 (96.0) |
| 3360 (11 - 0) | 2700 (108.0) |
| 3515 (11 - 6) | 2700 (108.0) |
| 3670 (12 - 0) | 3000 (120.0) |

| EXISTING DEFORMED PIPE STRUCTURES | |
|---|---|
| PAY ITEM END AREA $m^2$ ($ft^2$) | MINIMUM LINER INSIDE DIAMETER mm (in.) |
| CORRUGATED METAL PIPE-ARCH | |
| 68 mm x 13 mm (2 2/3" x 1/2") Corrugations | |
| 0.10 (1.1) | 300 (12.0) |
| 0.15 (1.6) | 370 (14.9) |
| 0.20 (2.2) | 420 (16.8) |
| 0.27 (2.9) | 460 (18.5) |
| 0.42 (4.5) | 600 (24.0) |
| 0.60 (6.5) | 735 (29.5) |
| 0.83 (8.9) | 840 (33.6) |
| 1.08 (11.6) | 980 (39.2) |
| 1.37 (14.7) | 1050 (42.0) |
| 1.68 (18.1) | 1200 (48.0) |
| 2.03 (21.9) | 1290 (51.6) |
| 2.42 (26.0) | 1475 (59.1) |
| 75 mm x 25 mm (3" x 1") Corrugations | |
| 1.45 (15.6) | 1050 (42.0) |
| 1.79 (19.3) | 1200(48.0) |
| 2.16 (23.2) | 1290 (51.6) |
| 2.55 (27.4) | 1475 (59.1) |
| 2.98 (32.1) | 1500 (60.0) |
| 3.44 (37.0) | 1650 (66.0) |
| 3.94 (42.4) | 1800 (72.0) |

| | |
|---|---|
| 4.46 (48.0) | 1950 (78.0) |
| 5.04 (59.2) | 1950 (78.0) |
| 5.62 (60.5) | 2100 (84.0) |
| 6.26 (67.4) | 2250 (90.0) |
| 6.92 (74.5) | 2400 (96.0) |
| | |
| STRUCTURAL PLATE STEEL PIPE-ARCH | |
| 2.0 (22) | 1200 (48.0) |
| 2.2 (24) | 1290 (51.7) |
| 2.4 (26) | 1290 (51.7) |
| 2.6 (28) | 1475 (59.1) |
| 2.9 (31) | 1475 (59.1) |
| 3.1 (33) | 1475 (59.1) |
| 3.3 (35) | 1475 (59.1) |
| 3.5 (38) | 1475 (59.1) |
| 3.7 (40) | 1475 (59.1) |
| 4.0 (43) | 1475 (59.1) |
| 4.3 (46) | 1800 (72.0) |
| 4.6 (49) | 1800 (72.0) |
| 4.8 (52) | 1950 (78.0) |
| 5.1 (55) | 2100 (84.0) |
| 5.4 (58) | 2100 (84.0) |
| 5.7 (61) | 2250 (90.0) |
| 5.9 (64) | 2250 (90.0) |
| 6.2 (67) | 2400 (96.0) |
| 6.6 (71) | 2400 (96.0) |
| 6.9 (74) | 2400 (96.0) |
| 7.2 (78) | 2400 (96.0) |
| 7.5 (81) | 2400 (96.0) |
| 7.9 (85) | 2400 (96.0) |
| 9.0 (97) | 2700 (108.0) |
| 9.5 (102) | 2700 (108.0) |
| 9.8 (105) | 2700 (108.0) |
| 10.1 (109) | 3000 (120.0) |

Prior to commencing the liner installation operation, steps shall be taken to verify that a liner meeting the minimum inside diameter requirements can be successfully placed inside the existing pipe. If it is discovered prior to installation that a liner with the required inside diameter cannot fit, the inside and outside diameters of a substitute liner shall be submitted to the Engineer for approval. If this discovery is not made until after the liner installation has begun, the partially installed liner shall be removed. Inside and outside diameters for a substitute liner shall then be submitted to the Engineer for approval.

After the liner installation is complete and the liner has cooled to approximately the temperature of the existing pipe, the liner shall be cut so that each end is no more than 75 mm (3 in.) outside the end of the existing pipe.

Grout shall be injected into the space between the existing pipe and the liner. The injection operation shall provide sufficient grout to fill all voids between the existing pipe and the liner over the entire structure length, but shall also be performed in a manner that does not distort the liner. The pressure developed in the space between the liner and the existing pipe shall not exceed the liner manufacturer's recommended maximum value.

All existing culverts, storm drains, underdrain pipes, drain tile, or other pipes that are directly connected to the lined structure shall be perpetuated. Grout shall not leak through the liner at these connections.

**725.04 Method of Measurement**. Thermoplastic liner will be measured by the meter (linear foot), complete in place. An allowance of 1.5 m (5 ft) of liner will be made for the perpetuation of an existing pipe through the liner.

**725.05 Basis of Payment.** The accepted quantities of pipe liner, thermoplastic, will be paid for at the contract unit price per meter (linear foot) for the size of the existing pipe in which the liner is installed, complete in place. Perpetuating the direct connection of an existing pipe through the liner will be paid for by means of an allowance of 1.5 m (5 ft) of liner for each such connection.

Payment will be made under:

| Pay Item | Metric Pay Unit Symbol (English Pay Unit Symbol) |
|---|---|
| Pipe Liner, Thermoplastic, _____ mm diameter | m |
| (Pipe Liner, Thermoplastic, _____ in. diameter | LFT) |
| Pipe Liner, Thermoplastic, _____ $m^2$ area | m |
| (Pipe Liner, Thermoplastic, _____ sft area | LFT) |

The cost of repairing jagged edges or deformities to existing pipe, filling cavities around the existing pipe with flowable backfill or grout, acquisition and restoration of required right-of-entry areas, erection, maintenance, and removal of temporary fence, removing foreign material from the existing pipe, grouting the space between the existing pipe and the liner, and other incidentals will not be paid for separately, but shall be included in the cost of the pay items in this section.

In situations where the condition of the existing pipe requires that a substitute liner be utilized, there will be no reduction in payment for the installation of the substitute liner. There will be no additional payment for the additional grout required to fill the larger void between the existing pipe and the smaller liner.

There will be no payment for the installation or removal of any liner that cannot be successfully installed due to the condition of the existing pipe.

If the existing pipe or any other object not designated for removal is damaged while performing this work, it shall be considered unauthorized work and repaired or replaced in accordance with 105.11.