SECTION 700 – STRUCTURES

SECTION 701 – DRIVEN PILING

701.01 Description

This work shall consist of furnishing and driving foundation piles of the type and dimensions specified including cutting off or building up foundation piles when required. This work shall also consist of providing test piles and performing loading tests when required. Piling shall be installed at the location and to the tip elevation, the penetration depth, and nominal driving resistance shown on the plans in accordance with 105.03.

MATERIALS

701.02 Materials

Materials shall be in accordance with the following:

B Borrow	211
Bentonite Grout	913.06
Concrete Piles	707
Conical Pile Tips	915.01(a)2
End Plates	915.01(a)1
Epoxy Coating for Piles	915.01(d)
Pile Shoes	915.03
Reinforcing Bars	910.01
Steel H Piles	915.02
Steel Pipe Piles	915.01
Structural Concrete	702
Timber Piling, Treated	911.02(c)
Timber Piling, Untreated	911.01(e)

Unless otherwise specified, reinforcing bars may be either plain or epoxy coated.

Steel pipe piles shall consist of a steel pipe which is driven into place and filled with class A concrete.

The Contractor may furnish and drive steel pipe piles with thicker walls than specified.

701.03 Handling of Epoxy Coated Piles

Epoxy coated piles shall be protected at all times from damage to the epoxy coating. 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, including the pile driving hammer, hammer cushion, helmet or pile drive head, pile cushion, and other appurtenances furnished by the Contractor shall be in working condition and approved in writing by the Engineer prior to delivery of the pile driving equipment to the job site. All pile driving equipment shall be sized such that the piles can be driven to the length required without damage. Approval of pile driving equipment does not relieve the Contractor of the responsibility to drive piles, free of damage, to the required nominal driving resistance and, if specified, the minimum tip elevation shown on the plans. Pile driving equipment will be subject to satisfactory performance during production.

The Contractor shall submit to the Office of Geotechnical Services, a completed pile and driving equipment data form at least 15 calendar days prior to driving piles. A copy shall also be furnished to the Engineer. The pile and driving equipment data form is available on the Department's website. 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. Acceptance of pile and driving equipment does not relieve the Contractor of the responsibility to provide equipment suitable for driving the specified piling to the required bearing without damage.

If the method of pile driving approval is in accordance with the dynamic formula shown in 701.05(a) the dynamic formula method will be used to determine if the pile driving equipment is acceptable for use. To be considered for approval, the proposed driving system shall obtain the nominal driving resistance between the specified blow count range of 30 and 120 blows per foot.

If the nominal driving resistance is to be determined by dynamic pile load test in accordance with 701.05(b) or static load test in accordance with 701.05(c), the Engineer will use the wave equation analysis method for driving system approval. To be approved, the proposed driving system shall obtain the nominal driving resistance between the specified blow count range of 30 and 120 blows per foot, and shall maintain driving stresses below the specified driving stress limits for the pile type being driven. If wave equation predicted driving stresses are greater than specification limits or the wave equation blow count for the nominal driving resistance is outside the specified blow count range, the Contractor shall modify or replace the proposed equipment until subsequent wave equation analyses indicate the piles can be driven to the nominal driving resistance within the allowable blow count range and within driving stress limits.

If the driving system requires revision, the Contractor will be notified of the acceptance of the revised driving system within seven calendar days of receipt of a revised pile and driving equipment data form.

The Contractor shall use the approved pile driving system. No changes shall be made without prior written approval from the Engineer, with the exception that the concrete pile cushion thickness may be increased to control driving stresses. A change 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 a proposed change in driving equipment within three work days of receipt of the pile and driving equipment data form. If the Engineer determines the Contractor's hammer is not functioning properly and is unable to drive the piles to the required penetration depth or nominal driving resistance, the hammer shall be removed from service.

1. Dynamic Formula Method

If the dynamic formula 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 nominal driving resistance as shown in the table below. The table below will be used as the basis of approval of pile driving equipment for the dynamic formula method.

DYNAMIC FORMULA METHOD
MINIMUM PILE HAMMER REQUIREMENTS

Nominal Driving Resistance	Minimum Manufacturer's Rated Energy
kips	ft·lbs
≤ 180	12,000
181 - 300	21,000
301 - 400	28,800
> 400	Wave Equation Analysis required

The minimum rated energies do not account for losses and inefficiencies in the pile driving system. If the hammer selected cannot satisfy all of the criteria, a wave equation analysis shall be submitted by the Contractor for approval.

2. 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 shall be calculated as follows:

a. The maximum compressive and tensile driving stresses for steel piles = $0.9F_y$.

b. The maximum compressive driving stress for prestressed concrete piles = $(0.85f'_c - f_{pe})$, where f_{pe} is the effective prestress value.

c. The maximum tensile driving stress, psi, for prestressed concrete piles = $3\sqrt{f'_c} + f_{pe}$, where f'_c and f_{pe} are expressed in psi.

d. The effective prestress, f_{pe}, shall be obtained from the approved working drawings.

e. The maximum driving stress, psi for timber piles shall not exceed $3F_{co}$, where F_{co} is the base resistance of wood in compression parallel to the grain, in psi.

(b) Pile Hammers

Piles may be driven with air, steam, diesel, or hydraulic hammers. Gravity hammers, vibratory hammers, and other pile driving methods shall be used only if specified or approved in writing by the Engineer.

1. Gravity Hammers

Gravity or drop hammers shall be used to drive timber piles only. The ram shall have a weight of between 2,000 and 3,500 lbs. The height of drop shall not exceed 12 ft. The weight of gravity hammers shall not be less than the combined weight of the helmet and pile. All gravity hammers shall be equipped with hammer guides and helmet to ensure concentric impact on the drive head.

2. Single or Double Acting 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 hose connecting the air compressor to the hammer shall be at least the minimum size recommended by the manufacturer. The plant and equipment shall be equipped with accurate chamber pressure gauges which are easily accessible to the Engineer. If 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 combined weights of the drive head and pile being driven. The striking parts shall not weigh less than 2,800 lbs. Proximity switches and an electronic readout device shall be provided prior to driving piling.

3. Diesel Hammers

Open-end or single acting diesel hammers shall be equipped with a device such as graduated rings or grooves on the ram to enable 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 approved open-end diesel hammer. The Contractor shall also provide and maintain in working order an approved device that automatically measures and displays the ram stroke for open-end diesel hammers.

Closed-end double acting diesel hammers shall be equipped with an accurate bounce chamber pressure gauge, easily accessible to the Engineer. The Contractor shall provide the Engineer a calibrated chart equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used. Calibration of actual hammer performance shall be performed no more than 90 days prior to the beginning of the work.

4. Hydraulic Hammers

The power plant furnished for hydraulic hammers shall have sufficient capacity to maintain at the hammer, under working conditions, the volume and pressure specified by the manufacturer of the hammer. Hydraulic hammers shall also be equipped with a controlled variable stroke system and a readout device to measure ram energy. The plant and equipment shall be equipped with accurate pressure and velocity gauges and an energy readout device which are easily accessible to the Engineer.

5. Vibratory Hammers

Except for pile lengths which have been evaluated from load test piles, the nominal driving resistance of the piles driven with vibratory hammers shall be verified by redriving the first pile driven in each group of 10 or fewer piles with an impact hammer of suitable energy to measure the nominal driving resistance before driving the remaining piles in the group. All piles which rely on point bearing capacity shall be redriven with an impact hammer.

(c) Pile Driving Aids

Pile driving aids such as jets and followers, shall not be used unless specified or approved in writing by the Engineer. If specified or approved, pile driving aids shall be used for installing production piles only after the minimum pile tip elevation is established by means of load testing or indicator test piles conventionally driven in accordance with 701.05. The Contractor shall perform all extra load tests or extra work required to drive indicator test piles as determined by the Engineer.

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. Impact hammers designed such that a hammer cushion is not required are excluded from this requirement. Hammer cushions shall be made of durable, manufactured materials, provided in accordance with the hammer manufacturer's guidelines. Wood, wire rope, or asbestos hammer cushions shall not be used. 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 when beginning pile driving at each structure or after each 100 h of pile driving, whichever is less. A hammer cushion whose thickness has been reduced to less than 75% of the original thickness shall be replaced.

2. Helmet

Piles driven with impact hammers shall have an adequate helmet that adequately distributes the hammer blow uniformly and concentrically to the pile head. The helmet shall be axially aligned with the hammer and the pile shall be guided by the leads and not be free-swinging. The helmet 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. For timber piles, the least inside helmet horizontal dimension or hammer base horizontal dimension shall not exceed the pile head diameter by more than 2 in. If the timber pile diameter slightly exceeds the least helmet or hammer base dimension, the pile head shall be trimmed to fit the helmet.

A helmet 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 each be protected with a pile cushion made of plywood, hardwood, or composite plywood and hardwood materials. The use of manufactured pile cushion materials shall be by the hammer manufacturer's recommendation. 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. The minimum pile cushion thickness placed on the pile head prior to driving shall be either as recommended by wave equation analysis or not less than 4 in. if the dynamic formula is used. 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 smolder or burn. Pile cushions shall be protected from weather and kept dry prior to use. Pile cushions shall not be soaked in liquid unless approved by the Engineer.

A used pile cushion in acceptable condition shall be used for restrike tests. The used pile cushion shall be the same pile cushion from the end of initial driving on that pile unless the condition of that pile cushion is no longer within specification limits. If the original pile cushion is not within specification limits, a used cushion of similar thickness as the end of drive pile cushion shall be used.

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. The leads shall be of sufficient length to make the use of a follower unnecessary, and shall be designed as to enable proper alignment of battered piles.

5. Followers

Followers shall only be used if specified or approved in writing by the Engineer. If a follower is allowed, 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 nominal driving resistance. 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 enable the piles to be driven to the required penetration depth 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 3 in. from the locations shown on the plans before additional piles are installed.

6. Jets

Jetting shall only be allowed if specified or approved in writing by the Engineer. 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 unapproved or improper jetting operations. If jetting is specified, the jetting plant shall have sufficient capacity to enable installation to the required elevation, location, and alignment in accordance with 701.09(b). Unless otherwise directed, external jet pipes shall be removed once the pile tip is 5 ft above the prescribed tip elevation, depending on soil conditions. The pile shall then be driven to the nominal driving resistance with an impact hammer. The Contractor shall provide suitable sediment control measures for jet water in accordance with the specifications. Where practical, all piles in a pile group shall be jetted to the required penetration depth before beginning pile driving. Where large pile groups or pile spacing and batter make this impractical, restrike tests on a select number of previously driven piles shall be performed to check nominal driving resistance after jetting operations are completed.

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

7. Collars

Where timber piles are used, collars, bands, or other devices shall be provided to protect piles against splitting and brooming.

8. Pile Shoes, End Plates, and Conical Pile Tips

Pile shoes shall be used when specified. End plates or conical pile tips shall be used on pipe piles. Steel pile shoes shall be used on H piles if specified.

If shoes are required on timber piles, the tips of timber piles shall conform to the approved steel shoes to ensure a firm uniform contact and prevent local stresses concentrations in the timber.

701.05 Nominal Driving Resistance of a Driven Pile

The Engineer will use one of the following methods as specified to determine the nominal driving resistance of a driven pile.

(a) Dynamic Formula

The nominal driving resistance will be determined by means of a dynamic formula. Piles shall be driven to the penetration depth necessary to obtain the nominal driving resistance. The nominal driving resistance, as shown on the plans, can be calculated from the formula as follows:

$$R_{ndr} = 1.75\sqrt{E} \text{ x } (\log 10N) - 100$$

where:

R_{ndr} = nominal driving resistance in kips

E = manufacturer's rated energy in foot·pounds at the field observed ram stroke 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 1 in. at final penetration.

An indicator test pile shall be the first pile driven at each bent and pier and shall be driven to the plan tip elevation or to the nominal driving resistance whichever occurs first. All indicator test piles shall be driven with impact hammers unless otherwise directed. The length of indicator 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 10 ft longer than the estimated length of piling shown on the plans. Steel piles shall be provided such that additional 10 ft of driving will not require an additional splice.

The driving equipment used for driving indicator 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 indicator test pile location to the elevation of the bottom of the footing before the pile is driven, unless otherwise shown on the plans.

To assess the effects of relaxation and setup, each indicator test pile shall be restruck after number of hours specified unless otherwise approved. The hammer shall be warmed up before driving begins by applying at least 20 blows to another fixed object. The maximum amount of penetration required during restrike shall be 3 in., or the total number of hammer blows shall be 20, whichever occurs first. If the

indicator test pile does attain the nominal driving resistance upon restriking, the penetration resistance attained during initial driving shall be used to establish the adequacy of production piles. If the nominal driving resistance is not attained upon restriking, the Contractor shall redrive the indicator test pile until it achieves the nominal driving resistance and repeat the restrike procedure described above. If the nominal driving resistance is still not obtained, pile driving shall stop immediately and the Office of Geotechnical Services shall be notified.

A record of driving indicator test piles, which includes the number of hammer blows per 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 penetration resistance at various hammer strokes versus nominal driving resistance relationship will be determined based on the driving of representative indicator test piles.

If indicator piles are not shown on the plans, all piles shall be driven to the nominal driving resistance and restriking is not required.

(b) Dynamic Pile Load Test

Dynamic monitoring will be performed for the purpose of obtaining the nominal driving resistance, pile driving stresses, pile integrity, and pile driving system performance. Dynamic monitoring will be conducted by PDA in accordance with ASTM D 4945. PDA will be performed on the first pile driven. The length of the pile used in the dynamic pile load test shall be a minimum of 10 ft greater than the estimated length of production piles in order to provide for variation in soil conditions. The Contractor shall assist the Department in obtaining dynamic measurements with the PDA during initial pile driving and during pile restrikes. If a static load test is required, the dynamic pile load test shall be performed on the same pile as the pile used in the static load test. The restrike for the dynamic pile load test on a static load test pile shall be performed within 48 h of completion of the static load test.

1. Scheduling

The Contractor shall notify the Engineer at least seven calendar days before the scheduled date of driving piles to be monitored by PDA. The Contractor shall confirm the driving date three calendar days prior to the scheduled driving date. The Contractor shall indicate at which foundation production pile driving is to begin. The Engineer will provide final driving criteria for the indicated foundation first.

2. Dynamic Monitoring

The Contractor shall make the steel piles available so that the Engineer can predrill the required instrument attachment holes prior to the Contractor placing the pile in the leads. Each pile to be tested shall be instrumented with force and acceleration transducers provided by the Department. The Contractor shall install the transducers before striking the pile. The pile driving may have to be temporarily

interrupted for the transducers to be adjusted or replaced, or for the monitoring results assessed.

Prior to placement in the leads, the Contractor shall make each designated concrete or timber pile available for taking of wave speed measurements and for predrilling the required instrument attachment holes. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling. Predriving wave speed measurements will not be required for steel piles. The Contractor shall mount the instruments near the head of the pile after the pile is placed in the leads.

The Contractor shall drive the test pile to the minimum tip elevation and to the penetration depth at which the dynamic test equipment indicates that the nominal driving resistance shown on the plans and in accordance with 701.04(a) has been achieved. 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)1. If non-axial driving is indicated by the dynamic test equipment measurements, the Contractor shall immediately realign the hammer system. Upon determination by the Engineer that valid data have been secured, the Contractor shall assist the Engineer with the removal of the instrumentation from the pile.

3. Restrike

The Contractor shall wait the specified minimum time period prior to the restriking of a dynamic load test pile. The Contractor shall assist the Engineer with reattachment of dynamic test 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 restrike will be 3 in., or the total number of hammer blows will be 20, whichever occurs first. If the pile does not achieve the required nominal driving resistance during restrike, the Engineer will either accept the tip elevation or specify additional pile penetration and testing.

Once the restrike test for the test pile is complete, the Engineer will run CAPWAP analyses and will provide the final driving criteria within two business days of the restrike test. Production piles driven prior to receipt of the final driving criteria shall be done at the Contractor's risk. Final driving criteria for additional structures will be provided within two business days of the restrike test or, when multiple test piles are restruck the same day, at a rate of one substructure location per business day in the order requested by the Contractor.

4. PDA on Local Public Agency Contract

The Contractor shall perform the PDA in accordance with ASTM D 4945. The firm conducting the PDA shall have at least one geotechnical engineer who shall have achieved one of the following certification levels: intermediate, advanced, master, or expert, within the last three years through the Dynamic Measurement and Analyses Proficiency Test conducted by Pile Dynamics, Inc., and the Pile Driving

Contractors Association. An engineer with a lower certification level can provide services so long as this individual is under the direct supervision of an engineer with intermediate certification level or higher. The Case Pile Wave Analysis Program, CAPWAP, shall be utilized to determine the as-built pile capacity from the PDA data. The first pile driven for each substructure unit shall be a PDA test pile. The pile driving criteria with the PDA and CAPWAP results shall be submitted to the Department's Office of Geotechnical Services for approval.

(c) Static Load Test

A static load test shall be conducted on a non-production test pile at the location shown on the plans. The test pile axial deflection in compression shall be verified by performing actual loading tests of the designated static load test pile in accordance with ASTM D 1143, Quick Load Test Method, with loads applied by hydraulic jack. The test shall be continued until either plunging failure is achieved or the capacity of the loading system is reached. The nominal pile resistance will be determined from the settlement versus load curve generated by the incremental loading in accordance with 701.05(c)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 1/4 in. shall be redriven, or jacked, to the original elevation prior to testing. The Contractor shall wait 36 h between the driving of a load test pile and the commencement of the load testing unless otherwise specified.

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 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. Reaction piles shall be driven prior to driving the static load test pile.

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 2,000 kips or 150% of the nominal driving resistance, whichever is less. A minimum of seven days prior to driving the static load test pile or construction of the reaction frame or load platform, the Contractor shall submit, for review and approval, detailed working drawings to scale for the reaction frame or load platform and loading apparatus including the distances between the load test pile and all reaction piles and reference beam supports. The submittal shall also include a proposed load test and reaction pile driving sequence, a scaled profile drawing of the loading apparatus detailing the ground surface elevation, the pile cutoff elevation, and the dimensions and locations of all bearing plates, the jack, the load cell, the spherical bearing plate, and the

reaction beam or platform. Working drawings for the reaction frame and loading apparatus shall be submitted in accordance with 105.02. The submittal shall include calibration certifications for the hydraulic jacks, load cell, pressure gauges, and hydraulic pumps conducted within 30 days of the load test. If required by the Engineer, the jack, load cell, and pressure gauge shall be recalibrated after the load test. The loading apparatus shall be constructed to allow the various increments of the load to be placed gradually, without causing vibration to the test pile. If the approved method requires the use of tension or reaction piles, the reaction piles, if feasible, shall be of the same type and dimensions as the production piles, and when possible shall be driven in the location of permanent piles. Reaction piles that are the same type and dimensions as the production piles and are driven in the location of permanent piles will be considered permanent piles. Timber or tapered piles installed in permanent locations shall not be used as tension piles. The primary method of determining the applied load shall be from a calibrated load cell. Incremental loads of 5% of the nominal driving resistance shall be placed on the pile at 5 minute intervals until continuous jacking is required to maintain the incremental load or the capacity of the load frame is reached. Support for the load test plates, jack, and ancillary devices shall be provided to prevent them from falling in the event of a release of load due to hydraulic failure, test pile failure, or other cause.

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 20 ft, and a weight of 5 to 20 lbs/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 provide all assistance necessary to perform the static load test. 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 nominal pile resistance of a pile from the load settlement curve does not equal or exceed the nominal driving resistance shown on the plans, the Contractor shall redrive the pile to an adequate nominal driving resistance. The increase in nominal driving resistance will be determined by 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. The pile axial resistance will be determined from the test data in accordance with the Davisson Method as specified in the AASHTO LRFD Bridge Design Specifications.

2. Hydraulic Jacks, Pressure Gauges, and Load Cell

Hydraulic jacks and pressure gauges shall be used for the superimposed load. The jacks, pressure gauges, load cell, and hydraulic pumps shall be calibrated with each other within the last 30 days by an independent laboratory. When a jack, pressure gauge, load cell, and hydraulic pump are calibrated, they shall be calibrated and used as a unit. All calibration checks shall be within 5% of the applied load if calibrated as a unit. Changing one of the four components shall require recalibration prior to use. Pressure gauges shall be a minimum of 4 1/2 in. in diameter with gradations in accordance with ASTM D 1143. Hydraulic jacks shall have a nominal

load capacity exceeding the maximum anticipated jack load by at least 20%. The jack, pump, and any hoses, pipes, fittings, gauges, or transducers used shall be rated to a safe pressure corresponding to the nominal jack capacity. The Contractor shall provide copies of the most recent calibration certification a minimum of five days prior to the static load test.

3. General Requirements

On completion of the static load test, a test pile or anchor pile which is not a part of the finished structure shall be removed or cut off at least 1 ft below either the bottom of footing or the finished ground elevation if not located within the footing area.

701.06 Blank

701.07 Piling Length

The lengths of piles shown on the plans and in the Schedule of Pay Items are estimated lengths and are for bidding purposes only. The Contractor shall provide the actual length of piles necessary to obtain the nominal driving resistance and penetration depth required as determined from results obtained from driving representative test piles or other pertinent data. There will be expected variations in final tip elevations due to differences in nominal pile driving resistance. The final tip elevation of each pile will be determined during the driving operation. If minimum tip elevations are specified, the Contractor shall drive piles to a penetration depth that satisfies this requirement in addition to the nominal driving resistance. If no penetration depth or minimum tip elevation is specified, the pile shall be driven a minimum of 10 ft below the bottom of the footing elevation. 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 pipe portion of the pile, and the limits of the reinforced concrete shall be as shown on the plans.

701.08 Nominal Driving Resistance of Production Piles

Production piles shall be driven the depth necessary to obtain the required nominal driving resistance as determined by 701.05. If a minimum pile tip elevation is shown on the plans, in addition to obtaining the required nominal driving resistance, production piles shall also be driven to the minimum pile tip elevation or to practical refusal.

When the nominal driving resistance is determined in accordance with 701.05(a), for acceptance, the Engineer will record at a minimum the number of hammer blows per inch or per foot of pile movement for the last 24 in. of driving. When the nominal driving resistance is determined in accordance with 701.05(b), for acceptance, the Engineer will record the blow count per inch or foot of pile movement and the associated hammer stroke for the last two consecutive feet of

driving, and the final pile tip elevation as per the pile driving criteria established through the dynamic pile load test.

Practical refusal will be defined as 20 blows per inch of penetration with the hammer operated at its maximum fuel or energy setting, or at a reduced fuel or energy setting recommended by the Engineer based on pile installation stress control and less than 1/4 in. rebound per blow. The Contractor shall stop driving as soon as the Engineer determines that the pile has reached practical refusal.

The nominal driving resistance of jetted piles shall be based on impact driving penetration resistance after the jet pipes have been removed. Jetted piles not attaining the nominal driving resistance at the ordered length shall be spliced and driven with an impact hammer until the nominal driving resistance is achieved in accordance with the driving criteria in 701.05.

The required nominal driving resistance of piles driven with followers will only be considered acceptable if 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.

The required nominal driving resistance of piles driven with vibratory hammers shall be based on the driving resistance recorded during impact driving after the vibratory equipment has been removed from the first pile in each group of 10 piles. Vibrated piles not attaining the nominal driving resistance at the ordered length shall be spliced and driven with an impact hammer until the nominal driving resistance is achieved in accordance with the driving criteria in 701.05. Once the nominal driving resistance is attained, the remaining nine piles in the group shall be installed to similar penetration depths with similar vibratory hammer power consumption and rate of penetration as the first pile.

701.09 Preparation and Driving

For steel and timber piling, the pile heads shall be plane and perpendicular to the longitudinal axis of the pile before the helmet is attached. The pile heads shall be protected with a hammer cushion.

Precast concrete pile heads shall be flat, smooth, and perpendicular to the longitudinal axis of the pile. Prestressing strands shall be cut off below the surface of the end of the pile. The pile head shall be chamfered on all sides. The heads of all concrete piles shall be protected with a pile cushion.

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, or improper construction methods. 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

Pilot holes are prebored, predrilled, or cored. After a pile is driven thru a pilot hole, all 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.

If the Engineer determines that preboring or predrilling has disturbed the nominal driving resistance 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 or predrilling operations in the area have been completed.

1. Preboring

When shown in the plans, the Contractor shall prebore holes at the locations shown and to the depth specified. Prebored holes shall be 2 in. smaller than the diameter or diagonal of the pile cross section that is sufficient to allow penetration of the pile to the specified penetration depth. 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.

Augering, wet-rotary drilling, spudding, or other methods of preboring shall be used only when specified or approved in writing by the Engineer. The procedures shall be carried out so as not to impair the nominal driving resistance of the piles already in place or the safety of existing adjacent structures.

Except for end bearing piles, preboring shall be stopped at least 5 ft above the pile tip elevation shown on the plans. The pile shall be driven with an impact hammer to the specified penetration resistance. 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.

2. Predrilling

The hole shall have a minimum diameter of not less than the greatest dimension of the pile cross section plus 4 in. The holes shall be drilled to the elevations shown on the plans.

Before driving piles for end bents, holes to receive piling shall be predrilled or spudded through new embankment to the original ground elevation if the new embankment is 10 ft or more in height. If the new embankment is less than 10 ft in height, predrilling is not required. If new embankment in the area of the end bents is to be constructed of sand, gravel, or other permeable material in which a predrilled hole would not remain open, the piling shall be driven before the embankment is constructed.

Pilot holes for end bent piles for structures with integral end bents shall be predrilled to the depth specified in the plans, regardless of the height of new embankment.

If pile sleeves are shown on the plans, the drilled holes shall be sleeved to maintain the opening during the driving of the piles.

If bentonite grout is shown on the plans, it shall be used to fill the annular space around the pile. The grout shall be placed at the depths shown on the plans or as directed. The entire annular space shall be filled from the bottom upwards to the top of the pile in one pumping operation using a tremie pipe.

Tremie-pipe construction shall include side discharge ports. The tremie pipe can be terminated by means of a tee connection. Tremie-pipe may be PVC, however, joints shall not be glued or cemented.

3. Cored Hole in Rock

When specified, holes shall 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 predrilled through the embankment into solid rock to the elevations shown on the plans or as otherwise directed. The piles shall be driven to practical refusal at the bottom of the cored holes. The holes in cored rock shall then be filled with concrete.

(b) Location and Alignment Tolerance

A maximum deviation of 1 1/2 in. in any direction from the plan position will be allowed in pile trestle bents and exposed pile bents. A maximum deviation of 6 in. in any direction will be allowed 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 by a welder qualified in accordance with 711.32. No pile shall be closer than 4 in. from an edge of the pile cap. Pulling or pushing laterally on installed piles to correct misalignment, or splicing a properly aligned section on a misaligned section will not be allowed. The pile head at cutoff elevation shall be within 2 in. of plan elevation for bent caps supported by piles.

Piles driven at integral end bents shall be installed so that the axial alignment of the top 10 ft of the pile is within 2% of the specified alignment.

Battered piles shall be installed so that the alignment of the top 10 ft of the pile does not vary by more than 3% from the batter rate shown in the plans.

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 by the Contractor. Proposed corrective measures will be subject to approval by the Engineer.

(c) Heaved Piles

The Contractor shall take an elevation reading on each pile in a foundation immediately after each pile in that foundation has been driven and again after all piles in that foundation have been driven. Elevation readings for checking pile heave shall continue until the Engineer determines that such checking is no longer required. All piles which have heaved more than 1/4 in. shall be redriven to the required resistance or penetration. If pile heave is detected for pipe piles, the piles shall be redriven to original position prior to filling with concrete. A hammer-pile cushion system shall be submitted and approved prior to redriving pipe piles which have been filled with concrete.

(d) Installation Sequence

The order of placing individual piles within a pile group shall begin from the center of the group and proceed outward in both directions unless an alternate installation sequence is approved in writing. For a bent with a single row of piles, pile driving shall begin at one end of the bent and proceed toward the opposite end.

(e) Inspection

The Engineer shall be given a minimum of 24 h notice before driving piling. No pile shall be driven except in the presence of the Engineer.

Prior to placing concrete in driven pipe piles, the Contractor shall supply suitable lighting for the inspection of each pipe pile by the Engineer throughout its entire length.

(f) Pouring Concrete

After all water and other foreign substances have been removed from the pipe piles and the final approval given, reinforcing bars, if specified, shall be placed, and the pipe piles shall be filled with class A concrete in the presence of the Engineer. Concrete shall be deposited into pipe piles in a stream with a cross-sectional area that is no more than approximately 50% of the area of the pipe pile to prevent air pockets from forming. At a minimum, concrete shall be vibrated in the upper 25 ft of the pipe piles. Concrete shall not be placed in pipe piles until all pile driving has progressed beyond a radius of 15 ft from the pile to be filled. All pile driving within the above limits shall be discontinued until the concrete in the last pile cast has cured for a minimum of 48 h.

701.10 Unsatisfactory Piles

The method used in driving piles shall not subject the piles to excessive or undue abuse which produces deformation of the steel, injurious splitting, splintering, and brooming of the wood, or crushing and spalling of the concrete. All piles damaged during driving due to internal defects, improper driving, being driven out of its proper location, or being 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 nominal driving resistance is proven by load tests performed by the Contractor. If such tests indicate inadequate pile resistance, corrective measures such as the use of the bent piles at reduced pile resistance, installation of additional piles, strengthening of the bent piles, or replacement of the bent piles shall be done as approved by the Engineer.

A concrete pile will be considered defective if a visible crack 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 shall be placed in the leads if practical. However, if splicing is necessary, the following methods shall be used.

(a) Steel Piles

Splicing of steel piles shall be made as shown on the plans. The top of the pile to be extended shall be restored to its original cross section shape. The mating end of the other pile shall be beveled as shown on the plans. A wire brush or grinder shall be used to remove any scale, dirt, slag, or other foreign material that is detrimental to fabricating a sound weld from all surfaces to be welded. For H piles, a mechanical splice shall not be used within 20 ft of the ground surface unless it is proven that the splice can transfer the full pile strength in compression, tension, and bending. Splices for pipe piles shall be watertight. All work shall be done with approved methods and materials and by welders qualified in accordance with 711.32. If the temperature of the piles is below 50°F, both piles to be spliced shall be preheated to a minimum temperature of 70°F in the vicinity of the splice immediately prior to welding. The temperature of the piles shall be maintained at a minimum of 50°F until the welding is complete. There shall not be more than two splices exposed to view in each length of piling after driving is completed. A mechanical splice shall not be used in integral end bents.

(b) Timber Piles

Timber piles shall not be spliced.

(c) Concrete Piles

Full length concrete piles shall be used where practical. If splicing is necessary, concrete splice details shall conform to the contract documents. Mechanical splices including drive-fit splices may also be used if the splice can transfer the full pile strength in compression, tension and bending.

701.12 Blank

701.13 Cut-Off Lengths

The tops of all steel pile shall be cut off at the elevation shown on the plans. All unused cut-off lengths shall become the property of the Contractor and shall be removed from the project site.

The length of timber pile above the elevation of cut-off shall be sufficient to enable the complete removal of all material injured by driving. Immediately after making final cut-off on treated timber foundation piles, the cut area shall be given an application of copper naphthenate until visible evidence of further copper naphthenate penetration has ceased. The copper naphthenate solution shall have minimum 2% copper metal.

Timber piling supporting timber structures where the piles are cut off, but not concrete capped, shall be treated with an application of copper naphthenate as described above. A layer of saturated building felt or fiberglass cloth which overlaps the side of the pile at least 2 in. shall be securely fastened and completely covered with 20 gage thick galvanized metal or aluminum sheeting. All cuts, injuries, and holes, which occur from removal of nails or spikes that penetrate the treating zone as well as bolt holes for connections, shall be treated by applying coal-tar roof cement in accordance with ASTM D 5643.

701.14 Method of Measurement

The driven length of treated timber piles, untreated timber piles, steel pipe piles, steel H piles, and concrete piles will be measured by the linear foot to the nearest 0.1 ft. This includes piles used as indicator test piles, dynamic test piles, or static load test piles. Measurement will be made only for the actual number of linear feet of piling complete in place. For concrete piles, this length will not include extensions or the portion of the pile cutoff to make the extension.

Dynamic pile load test, static pile load test, indicator test pile restrike, dynamic test pile restrike, pile shoes, and conical pile tips will be measured per each.

Epoxy coated piles, prebored holes, and cored holes in rock will be measured by the linear foot complete in place of the diameter specified.

Concrete encasement, class A concrete, reinforcing bars, epoxy coating, reaction piles if not used as production piles, splices, end plates, predrilling, cleaning of drilled holes, drilling fluids, sealing materials, casing, jetting, followers, spudding, or other methods used to facilitating pile driving will not be measured for payment.

701.15 Basis of Payment

All treated timber piles, untreated timber piles, steel pipe piles, steel H piles, and concrete piles driven will be paid for by the linear foot. Payment will be made only for the actual number of linear feet of piling complete in place. Extensions for concrete piles will be paid for in accordance with 109.05.

Driven piles used as indicator test piles or dynamic test piles that are left in place and subsequently used as production piles will be paid for by the linear foot as either production indicator test piles or production dynamic test piles. Reaction piles used in a static pile load test that are left in place and subsequently used as a

production pile will be paid for by the linear foot as the type of production pile they represent. Driven piles used as indicator test piles, dynamic test piles, or static load test piles that are not used as production piles will be paid for by the linear foot as non-production dynamic, indicator, or static test piles respectively.

If the quantity of driven piling is less than the plan quantity or the quantity as ordered by the Engineer, the Department will pay 50% of the cost to re-stock unused piling if the Contractor elects to re-stock piling and provides a paid invoice showing the re-stocking fee. Payment will be made for piling, restock.

Epoxy coated piles may be furnished and driven at lengths greater than those shown on the plans. These additional lengths of epoxy coated piles left in place and accepted will be paid for as either steel pipe piles or steel H piles.

Prebored holes and cored holes in rock will be paid for at the contract price in linear feet.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Conical Pile Tip, _____ (pile size)	EACH
Cored Hole in Rock, _____ in. (diameter)	LFT
Dynamic Pile Load Test	EACH
Pile, Concrete _____ x _____ (size)	LFT
Pile, Prestressed Concrete _____ x _____ (size)	LFT
Pile, Steel Pipe, _____, _____ (pipe wall thickness, diameter)	LFT
Pile, Steel Pipe, Epoxy Coated, _____, _____ (pipe wall thickness, diameter)	LFT
Pile, Steel H, Epoxy Coated, HP _____ x _____ (size)	LFT
Pile, Steel H, HP _____ x _____ (size)	LFT
Pile, Steel H, Reinforced Concrete Encased, HP _____ x _____ (size)	LFT
Pile, Timber	LFT
Pile, Timber, Treated	LFT
Pile Shoe, _____ (pile size)	EACH
Piling, Restock	LS

Prebored Hole, _____ in. ..... LFT
diameter
Static Pile Load Test, _____ ..... EACH
pile size
Test Pile, Dynamic, _____, Non-Production ..... LFT
pile size
Test Pile, Indicator, _____, Non-Production ..... LFT
pile size
Test Pile, Static Load, _____, Non-Production ..... LFT
pile size
Test Pile, Dynamic, Production ..... LFT
Test Pile, Indicator, Production ..... LFT
Test Pile, Dynamic, Restrike ..... EACH
Test Pile, Indicator, Restrike ..... EACH

All costs associated with the dynamic pile load test except the cost of the test pile and test pile restrike shall be included in the cost of the dynamic pile load test.

All costs associated with the static pile load test except the cost of the test pile shall be included in the cost of the static pile load test. The cost of reaction piles used in the static load test and not incorporated into the work as production piles shall be included in the cost of the static load test.

The cost of furnishing and placing concrete, B borrow, or bentonite grout necessary to fill pilot holes, and all necessary incidentals shall be included in the cost of the pay items of this section.

The cost of the following shall be included in the cost of the piling.

(a) predrilling pilot holes;
(b) pile sleeves;
(c) maintaining open holes during pile driving;
(d) broken, bent, damaged, or misplaced piles;
(e) concrete filling or concrete encasement;
(f) corrective location or alignment measures;
(g) epoxy coating;
(h) splicing piles and jetted sites;
(i) modifying or replacing pile driving equipment;
(j) redriving piles which have heaved more than 1/4 in.;
(k) plain and epoxy coated reinforcing bars;
(l) repairing epoxy coating;
(m) replacing epoxy coated piling;
(n) restriking production piles not shown as test piles;
(o) piles which are not acceptable or damaged during driving;
(p) piles which were not driven in accordance with these specifications;
(q) piles driven with the tops lower than the cutoff elevation;

(r) spudding or jetting of piles;
(s) end plates for pipe piles; and
(t) all labor, equipment, and necessary incidentals.

No additional payment will be made if the Contractor elects to furnish and drive thicker walled pipe piles than specified.

An increase in the size of a pile cap to satisfy edge distance clearance requirements, when approved, shall be at no additional cost to the Department.

If the method for driving the piles is specified as 701.05(b) and the contract is a local public agency contract, the Contractor shall include the cost of acquiring the PDA consultant in the cost of the Dynamic Pile Load Test.

The cost of mobilization and demobilization for pile driving operations shall be included in the cost of mobilization and demobilization in accordance with 110.04.

The cost to control sediment in water from jetting operations shall be included in the cost of the piling.

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 105.03.

702.02 Classes of Concrete

The following classes of concrete shall be used where specified.

Class of Concrete	**A**	**B**	**C**
Cement content in lbs/cu yd	564	470	658
Maximum water/cement ratio in lbs of water per lbs 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.

Concrete in superstructure, integral bents, and railings shall be class C. Concrete in bent caps, unless poured integrally with the superstructure; pier caps; abutment caps; pier stems; abutment walls; mudwalls; columns; crashwalls; collision walls; and wingwalls, unless poured with integral end bents, shall be class A. Concrete in footings shall be class B.

702.03 Materials

Materials shall be in accordance with the following:

Admixtures for Use in Concrete	912.03
Castings	910.05
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
Elastomeric Bearings	915.04
Fabric for Waterproofing	918.01
Fine Aggregate Size No. 23	904
Fly Ash	901.02
Geotextile for Use With Underdrains	918.03
Ground Granulated Blast Furnace Slag	901.03
High Density Bearing Strips	906.08
Permanent Metal Forms	910.03
Polychloroprene Joint Membrane and Adhesive	906.02(a)4
Portland Cement	901.01(b)
Utility Asphalt, UA-1	902.01(d)
Water	913.01

Drainage pipe through concrete masonry shall be in accordance with 715.

Grout material for field drilled holes shall be either a high-strength, non-shrink, non-metallic, cementitious 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 ± 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 60 lbs/cu yd. The relative yield of the concrete shall be maintained as stated above. If type IP or type IP-A cements 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.

For example: 1.06 x 564 = 598 lbs/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 allowed in conjunction with the use of blended portland cement or ground granulated blast furnace slag. Mix designs will be based on using a maximum 20% cement reduction with a minimum 1.25:1 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 allowed in conjunction with the use of blended portland cement or fly ash. Mix designs will be based on using a maximum 30% cement substitution with a 1:1 slag-to-cement ratio, by weight.

Blended portland pozzolan cements, 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 minimum 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% ± 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 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 or ground granulated blast furnace slag.

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 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 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 allowed 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 Measuring and Batching

Unless otherwise specified, the minimum batch shall be 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 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 or leak from it. Accuracy of batching shall be ± 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 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 ± 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 1,000 lbs and greater on the cement scale and applied loads of 4,000 lbs and greater on the aggregate scale, the scales shall be accurate to 0.5%. For applied loads of less than 1,000 lbs and 4,000 lbs 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 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 allowed after initial set. When concrete is delivered in transit mixers, additional water may be added occasionally to increase the slump, if allowed, 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 allowed 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 allowed only with prior written permission. Chemical admixtures type F and type G shall not be used.

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 188 lbs except for pours of 20 cu yds or less, or where otherwise specified, a 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 and no more than 20 revolutions per minute. If this procedure does not mix the concrete thoroughly, a sufficient additional number of turn 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 allowed 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 1/2 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 enable 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 one-quarter and three-quarter points of each load. If the slumps differ by more than 1 in. when the average slump is 3 in. or less, or by more than 2 in. when the average slump is greater than 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 allowed when operations with a longer mixing time or with a smaller load will enable 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 and no 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 and no 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 minutes 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 minutes 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 is 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 enable 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 minutes 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 slump differs 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 enables 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 bars. 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 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 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 35°F, or whenever it is determined that the temperature may fall below 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 are heated, the resulting concrete shall have a temperature of at least 50°F and not more than 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 150°F. When aggregates or water are heated to 100°F or above, they shall be combined first in the mixer before cement added. The maximum temperature of concrete produced with heated aggregates shall be 90°F. Materials containing frost or lumps of frozen material shall not be used.

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 may be used if approved.

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

Immediately after a pour is completed, the freshly poured concrete and forms shall be covered so as to form a complete protective enclosure around the element being poured. If the element is a bridge deck, the enclosure shall encompass the top, bottom, and all sides. The air within the entire enclosure shall be maintained at a temperature above 50°F for a minimum of 144 h for bridge decks, the top surface of reinforced concrete slab bridges, and for a minimum of 72 h for all other concrete. If

for any reason this minimum 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 all sides, top and bottom of 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 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 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 1 in. and no more than 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 150 lbs/cu ft for vertical loads and 100 lbs/cu ft for horizontal pressure. A live load allowance of 50 lbs/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 8 ft from the centerline of track and a clearance height of not less than 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 for exposed concrete edges shall be chamfered 3/4 in. Forms shall be given a bevel or draft in the case of 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 enable their removal to a depth of at least 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 allowed in copings, railings, and walls less than 2 ft thick. Devices which, when removed, leave an opening entirely through the concrete will not be allowed 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 they regard 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 this section.

The metal forms shall be designed on the basis of dead load of form, reinforcing bars, and plastic concrete plus 50 lbs/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 36,000 psi. Deflection under the weight of the forms, the plastic concrete and reinforcing bars shall not exceed 1/180 of the form span or 1/2 in. whichever is less. However, the deflection loading shall not be less than 120 lbs/sq ft total. The allowable 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 2 in. measured parallel to the form flutes. If the design span of the form sheets exceeds 9.5 ft, concrete will not be allowed 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 bars shall have a minimum clearance of 1 in. from the forms. The plan dimensions from the top surface for all primary deck reinforcing bars shall be maintained. The deck reinforcing bars shall be tied down at a maximum of 6 ft centers. Permanent metal forms shall not remain in place closer than 1 ft from any joint exposed to the underside of the slab, except when an overlay is used on the deck.

Fabricator's working drawings shall be submitted for approval. These drawings 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 drawings 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 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 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, 1/8 in. fillet welds will be allowed.

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

No. 8 gage thick, fit tight, and shall not be galvanized. Form supports shall not be welded to flanges of non-weldable grades of steel or to steel flanges subject to tensile stresses.

Form supports at prestressed concrete I-beam, prestressed concrete spread box beam, and prestressed concrete bulb-T beam bridges shall be placed in direct contact with the sides of the box or edge of the I-beam or bulb-T 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, I-beam, or bulb-T beam, straps extending across the top of the flange, hangers mechanically attached to reinforcing bars extending from the top flange, or by other approved methods. If straps are used across the top flange, they shall be No. 8 gage thick, fit tight, and shall not be galvanized. Attachments shall not be welded directly to beam reinforcement. In addition, the use of recesses cast into the beam to serve as a form supports will not be allowed.

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 MIL-P-2441, 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 702.20. 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 submitted for approval.

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 finish in accordance with 702.21. 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) Blank

(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 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 702.13(h).

In order to obtain a satisfactory surface finish, forms for railings, parapets, and exposed vertical surfaces shall be removed no less than 12 h and no 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 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 will be allowed when the modulus of rupture reaches or exceeds the following values:

Concrete Used in	Required Flexural Strength, psi, Dead Load Only
Girders, Arches, and similar units	390
Interior Bent or Pier Caps	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 working drawings for falsework and arch centering shall be submitted in accordance with 105.02. Since the quality of the lumber is not known and because of the uncertainty of computing nailed joints, no responsibility will be assumed by the Department for the strength of falsework and centering.

Working drawings for falsework shall include details for support of interior bent caps, hammerhead piers, and the portion of the bridge floor and coping beyond fascia girders or beams if the overhang is 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 minimum horizontal clearance of 13 ft from the centerline of the nearest tangent track or 14 ft from the centerline of the nearest track on a horizontal curve and a minimum vertical clearance of 22 ft from the top of the highest track rail unless different clearance values are approved by the railroad.

(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 150 lbs/cu ft shall be assumed for plastic concrete. A live load allowance of 50 lbs/sq ft 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 allowed.

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 ..... 1,800 psi
Columns..... 1,800 (1-L/60D) psi
For spruce, cypress, short-leaf pine, white pine, western hemlock:
Bending ..... 1,500 psi
Columns..... 1,500 (1-L/60D) psi
In the above:
L = length of column in inches
D = least diameter or least dimension in 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 enable 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 specified, the nominal thickness shall be no less than 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 specified, 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 specified, 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 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 702.13(h) 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 it enables 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 specified 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.

When 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 on 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 cannot 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 allowed in footings. If there is a probability that the entire amount of concrete cannot 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 6 in. or, if there is a coping, no less than the depth of the coping. Horizontal construction joints will not be allowed in the stems of concrete T-beams or 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 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.

(e) Polychloroprene Joint Membrane

Polychloroprene joint membrane used for semi-integral end bents shall be secured to the concrete with an adhesive. The polychloroprene joint membrane shall be centered vertically on the joint and shall have no gaps. Any field joint in the polychloroprene membrane shall be lapped a minimum of 12 in.

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 enable 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 or 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 bars 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 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 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 18 in. of the top of a face. However, if provisions have been made for a coping of less than 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 reinforcement 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 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 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 or 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 10 in. and constructed in sections having flanged couplings fitted with gaskets. Support of the tremie shall be such that it enables free movement of the discharge end over the entire top surface of the area on which the concrete is to be deposited and also enables 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 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 enable 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 or 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 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 702.13(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 702.13(b).

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

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 six parts of pre-mix mortar mix for masonry and one 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.

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 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.

702.22 Curing Concrete

Concrete in bridge decks or the top surface of reinforced concrete slab bridges shall be cured continuously for a minimum of 168 h commencing immediately after the surface is able to support the protective covering without deformation. Curing time for bridge decks and the top surface of reinforced concrete slab bridges are not controlled by beam tests and the cure time shall not be reduced. Curing of patches or small full depth deck replacement areas on existing bridge decks that are to be overlaid, may be controlled by test beams in accordance with 702.24(a).

Unless otherwise specified, 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. Curing shall continue until the flexural strength stated in 702.13(h) has been attained.

Membrane forming curing compound may be used in lieu of protective covering curing methods. Where it has been determined that a surface treatment 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 further precautions are necessary to ensure strength, they shall be taken as directed.

(a) Protective Covering Curing Methods

1. Water Curing Method

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.

2. 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 curing method.

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 1 gal. of liquid coating for 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.

(b) 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)1 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)1 may be required. The concrete shall then be surface 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 enable 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 35°F, waterproofing shall not be done, unless otherwise specified.

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 300°F and 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 allowed on structures until test beams representing all concrete required to carry live loads have attained a flexural strength of 550 psi for third-point loading.

(b) Unbalanced backfill will not be allowed until test beams representing the concrete required to resist it have attained a flexural strength of 440 psi for third-point loading. The unbalanced height shall not exceed 10 ft until test beams representing the concrete have attained a flexural strength of 480 psi for third-point loading.

(c) The dead weight of steel or precast concrete superstructure shall not be placed on concrete until test beams representing the concrete have attained a flexural strength of 400 psi for third-point loading. A dead load shall not be placed on hammer-head piers until test beams representing have attained a flexural strength of at least 480 psi for third-point loading. The concrete floor, if to be placed thereon, shall not be poured until test beams representing the concrete supporting the superstructure have attained a flexural strength of at least 440 psi for third-point loading.

(d) Test beams representing concrete anchoring inserts to support falsework shall attain a flexural strength of a minimum of 480 psi for third-point loading, before a dead load of concrete is applied.

No time extension will be considered for delays due to time necessary to attain specified strengths.

Beams will be prepared and tested in accordance with 702.13(h). Before traffic is allowed over a concrete structure built to be under fill, it shall be covered with 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 a 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 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, concrete bulb-T 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 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 1 sq ft.

Cast iron grates, basins, and fittings will be measured by the pound based on the theoretical weight shown on the plans. The volume will be computed based on finished dimensions. Drainage pipe through concrete masonry will be measured in accordance with 715. Field drilled holes will be measured by the number of holes drilled.

Concrete in railings will be measured in accordance with 706.07. Reinforcing bars 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 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 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 706.08. Reinforcing bars will be paid for in accordance with 703.08. Drainage pipe through concrete masonry will be paid for in accordance with 715.

If a foundation seal is constructed as shown on the plans, it will be paid for at the contract price per cubic yard for concrete, foundation seal. If ordered to be done, or allowed to be done, payment will be made at a unit price per cubic yard equal to 75% of the contract unit price per 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 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 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 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	**Pay Unit Symbol**
Concrete, A, Substructure	CYS
Concrete, A, Superstructure	CYS
Concrete, B, Above Footings	CYS
Concrete, B, Footings	CYS
Concrete, C, ____ use	CYS
Concrete, Foundation Seal	CYS
Field Drilled Hole in Concrete	EACH
Grates, Basins, and Fittings, Cast Iron	LBS

The cost of forms, PVC for bridge floor drains, falsework, falsework piling, centering, expansion joints, waterproofing, curing, finishing, and necessary incidentals shall be included in the cost 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 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, 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.

Elastomeric bearings will not be paid for directly, unless otherwise specified. The cost thereof shall be included in the cost 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 cost of grout for grouting reinforcing bars 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 bars required shall be included in the cost of field drilled hole in concrete.

The cost of furnishing and installing polychloroprene sheeting shall be included in the cost of concrete, A, substructure.

The cost of high density plastic bearing strips shall be included in the cost of concrete, A, substructure.

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

The sizes and lengths of reinforcing bars shall be marked plainly to facilitate inspection and checking.

703.03 Bar List

The Contractor shall verify the quantity and size of reinforcing bars against the structure drawings prior to 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

Plain and epoxy coated reinforcing bars shall be protected from damage during storage, handling, installation and concrete placement. Plain and epoxy coated reinforcing bars shall not be stored in direct contact with the ground. Epoxy coated reinforcing bars shall be protected from exposure to ultraviolet light and moisture during storage. Once placed into the work, epoxy coated reinforcing bars shall not be exposed to ultraviolet light for a total of more than 21 days prior to placement of concrete. At the time of concrete placement, reinforcing bars shall be free of dirt, loose rust or scale, grease, oil, or other foreign substance. If the Engineer suspects the epoxy coating has been damaged by exposure to ultraviolet light, a sample will be obtained and will be tested in accordance with 910.01(b)9.

Damage to the epoxy coating of epoxy coated reinforcing bars shall be repaired or the bars shall be replaced. Repairs to the epoxy coating shall be performed on all damaged areas larger than 1/4 by 1/4 in. A bar will be rejected if the accumulated area of damaged coating exceeds 2% of the nominal surface area of the bar or if the total area of repaired coating exceeds 5% of the nominal surface area of the bar. All damaged areas shall be cleaned and the repair shall be performed before visible oxidation appears. Coating 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

Reinforcing bars shall not be ordered for piers or bents to be founded on soil or rock until the foundation conditions have been investigated. The bottom elevations of such footings will then be determined. Written permission will then be given to order such reinforcing bars. Sufficient excavation and all necessary soundings shall be made as directed so that exact bottom elevations of footings may be determined.

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. 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 non-corrosive 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 allowed.

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 allowed at points where the section does not provide a distance of at least 2 in. between the splice and the nearest adjacent bar or surface of the concrete.

When splicing is indicated or allowed, an appropriate splice system on the list of approved Reinforcing Bar Splicing Systems may be used in lieu of lapped bars. The splicing system shall be installed in accordance with the manufacturer's recommendations. If an offset splicing system is selected, it shall only be used on spiral, hoop, or ring-type reinforcement.

WWR, 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 strength in accordance with 910.01(b)2. The Contractor shall coat any exposed part of threaded bar assemblies in accordance with 910.01(b)2.

703.07 Method of Measurement

Reinforcing bars will be measured by the pound based on the theoretical number of 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 weights of the reinforcing bars actually placed in accordance with these specifications. The weights calculated shall be based upon the following 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.

WWR will not be measured.

703.08 Basis of Payment

The accepted quantities of reinforcing bars will be paid for at the contract price per pound, complete in place.

If the substitution of reinforcing bars larger than those specified is allowed, payment will be made for only that 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 allowed for convenience in transporting or placing the bars, payment will be based on the 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	**Pay Unit Symbol**
Reinforcing Bars	LBS
Reinforcing Bars, Epoxy Coated	LBS
Threaded Tie Bar Assembly	EACH
Threaded Tie Bar Assembly, Epoxy Coated	EACH

The cost 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 cost of coating materials and repair of damaged or removed 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 WWR 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 bars as a bridge floor in accordance with 105.03.

704.02 Materials

Materials shall be in accordance with the following:

Castings	910.05
Concrete, Class C	702
Joint Materials	906
Profile Wall PVC Pipe	907.22
Reinforcing Bars	910.01
Smooth Wall PVC Pipe	907.23

CONSTRUCTION REQUIREMENTS

704.03 Forms

Forms shall be in accordance with 702.13.

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 allowed. The areas where welding will be allowed will be established in writing.

704.04 Placing Reinforcement and Concrete

Applicable provisions of 703 shall apply to placing reinforcing bars. 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 702.20(a). Placing of reinforcement during placing of concrete will not be allowed without prior written approval. Splices, when allowed, shall be at locations of least tension in the steel.

The concrete deck pour sequence and procedure shall be submitted for approval a minimum of 14 days prior to the planned deck pour. The submittal shall include the following information:

(a) the contract number;
(b) the Contractor's name;
(c) the bridge file number;
(d) the Contractor's proposed pour sequence;
(e) the Contractor' proposed pour rate;
(f) the approved concrete mix design; and
(g) the delivery time from the concrete batching location to the jobsite.

If, during the pour, the approved pour rate is not achieved, placement of transverse construction joints may be directed as shown on the plans. Placement of concrete shall be continuous between joints. Horizontal joints will not be allowed.

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 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.

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 702.20(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 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 screed. 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 support securely fastened in place at spacing sufficiently close to prevent any appreciable deflection of the screed. Welding of supports to structural bridge members will not

be allowed. 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 screed 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 may be used 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 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 508.04 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 10 ft straightedge of light construction laid parallel to the centerline at intervals of no more than 2 ft transversely and 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 5 ft long and 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 lightweight 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 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 702.22. If membrane curing is used, no exposed reinforcement 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 exposed reinforcement shall be cured in accordance with 702.22. 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 yard in accordance with 702.27. 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 bars will be measured in accordance with 703.07. Castings will be measured in accordance with 702.27.

704.08 Basis of Payment

The accepted quantities of concrete floor slab will be paid for at the contract unit price per cubic yard for concrete, C, superstructure. Reinforcing bars will be paid for in accordance with 703.08. Castings will be paid for in accordance with 702.28.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Concrete, C, Superstructure	CYS

The cost of forms, curing, finishing, preformed expansion joints within structure limits, slab bridge floor drains, and necessary incidentals shall be included in the cost 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 and reinforced concrete bridge approaches in accordance with 105.03.

705.02 Materials

Materials shall be in accordance with the following:

Concrete, Class C	702
Joint Filler	906.01
Reinforcing Bars	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 bars shall be in accordance with 703.

After floating, the surface shall be marked into uniform rectangles by transverse markings formed with a jointer having 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 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 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 1/8 in. from the straightedge, except at grade changes, and shall be free from blemishes.

705.04 Method of Measurement

Sidewalks on structures and reinforced concrete bridge approaches will be measured by the cubic yard in accordance with the dimensions shown on the plans or as ordered. Reinforcing bars will be measured by the pound in accordance with 703.07.

705.05 Basis of Payment

The accepted quantities of sidewalks on structures and reinforced concrete bridge approaches will be paid for at the contract unit price per cubic yard for concrete, C, superstructure. Reinforcing bars will be paid for at the contract unit price per pound in accordance with 703.08.

Payment will be made under:

Pay Item	Pay Unit Symbol
Concrete, C, Superstructure	CYS

SECTION 706 – BRIDGE RAILINGS

706.01 Description

This work shall consist of the furnishing and placing of concrete or steel railings on bridges, atop or aside of wingwalls and retaining walls, furnishing and placing bridge railing pedestrian fences on new existing bridge railings, and furnishing and placing reinforced concrete moment slabs in accordance with 105.03.

706.02 Materials

Materials shall be in accordance with the following:

Barrier Delineators	926.02(c)
Bridge Railing Pedestrian Fence	910.18(b)5
Coarse Aggregate, Class B or Higher, Size No. 8 or 9	904
Concrete, Class C	702
Dowel Bars	910.01(b)10
Joint Materials	906
Organic Zinc Primer	909.02(a)2
Polyurethane Finish Coat	909.02(c)
Reinforcing Bars, Epoxy Coated	910.01
Steel Bridge Railing Components	910.20

Concrete for reinforced concrete moment slabs shall be QC/QA PCCP in accordance with 501 or PCCP in accordance with 502.

Thrie-beam railing and guardrail elements for retrofit bridge railing shall be steel and shall be in accordance with the applicable requirements of 910.09, 910.11, and 910.12 for steel beam guardrail.

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 2 in. thick shall be used for coping forms.

Concrete bridge railing shall be built monolithically and continuous from support to support. A joint shall be provided at the end of the bridge between the bridge railing and the railing transition as shown on the plans.

Unless otherwise specified the slip form method may be used 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 bars 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 1/2 in. ± 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 2 1/2 in. ± 1/2 in. at the joint locations may be made as soon as the concrete has hardened sufficiently to enable 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 1/4 in. in 10 ft from the specified cross section, as measured longitudinally.

706.04 Concrete Railing With Reinforced Concrete Moment Slab

The railing portion shall be constructed in accordance with 602.03 except it shall be cast-in-place. Type D-1 contraction joints in the moment slab shall match the locations of the joints in the abutting PCC pavement. If the abutting pavement is

HMA, the D-1 contraction joints shall be spaced at 18 ft. The locations of the transverse joints in the moment slab and the railing shall be the same.

Moment slabs shall be formed with either steel or wood forms in accordance with 508.04(c)1 or 508.04(c)2. Vibration of the concrete shall be in accordance with 702.20(c). The thickness of the moment slab shall match that of the adjoining PCCP, but it shall not be less than 12 in.

The underdrains for MSE walls layer shall be compacted in accordance with 302.06(b). The MSE-wall coping may be precast or cast-in-place.

Type D-1 contraction joints and dowel bar assemblies shall be in accordance with 503.

Finishing and curing the moment slab shall be in accordance with 504. Finishing and curing the railing shall be in accordance with 702.

Job control testing for acceptance shall be in accordance with 502.05.

706.05 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.

706.06 Bridge Railing Pedestrian Fence

Posts shall be installed plumb. They may be shimmed with an approved metallic shim. Base plate anchor bolts shall be galvanized, positioned as shown on the plans, and shall be anchored by means of epoxy adhesive.

The fabric shall be connected to the tension bar with brace bands and tension bands as shown on the plans.

The top and bottom fabric selvedges shall be knuckled. If the coating is damaged during handling or placement, such portion of the fabric shall be replaced.

706.07 Method of Measurement

Concrete railing, including all concrete work above the top of curb, will be measured by the linear foot or by the 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.

Bridge railing pedestrian fence will be measured by the linear foot along the bottom of the fence, from center to center of end posts.

Reinforced concrete moment slabs will be measured by the square yard for the thickness specified. Underdrains for MSE walls placed under moment slabs will be measured in accordance with 718.09. Type D-1 contraction joints will be measured in accordance with 503.07.

Reinforcing bars in the railing 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 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.

706.08 Basis of Payment

The accepted quantities of concrete railing will be paid for at the contract price per linear foot or cubic yard, for railing, concrete, of the type specified. Steel railing will be paid for at the contract unit price per 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. Bridge railing pedestrian fence will be paid for at the contract unit price per linear foot. Reinforced concrete moment slabs will be paid for at the contract unit price per square yard for the thickness specified, complete in place. Underdrains for MSE walls placed under moment slabs will be paid for in accordance with 718.10. Type D-1 contraction joints will be paid for in accordance with 503.08. 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	**Pay Unit Symbol**
Bridge Railing Pedestrian Fence	LFT
Concrete Bridge Railing Transition, ____ (type)	EACH
Railing, Concrete ____ (type)	LFT CYS
Railing, Steel ____ (type)	LFT
Reinforced Concrete Moment Slab, ____ (thickness)	SYS

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

The cost of all miscellaneous hardware including anchor bolts, base plates, fence post caps, horizontal rail end cups, fence post loop caps, tension bars, tension bands, brace bands, and fabric ties, and replacement fence due to damaging coating during handling or placement shall be included in the cost of bridge railing pedestrian fence.

The cost of the epoxy coated reinforcing bars and tie bars in the moment slab shall be included in the cost of the reinforced concrete moment slab.

The cost of all labor and materials required to provide for the monolithic concrete coping with moment slabs shall be included in the cost of the moment slab.

The cost of furnishing and placing all materials not specified as pay items shall be included in the cost of the pay items in this section.

SECTION 707 – PRECAST AND PRECAST PRESTRESSED CONCRETE STRUCTURAL MEMBERS

707.01 Description

This work shall consist of fabricating, furnishing, and installing reinforced precast concrete structural members cast outside the structure, transported to, and incorporated into the structure, or precast prestressed concrete structural members having a design 28-day concrete compressive strength, f'c, of up to and including 8,000 psi, all in accordance with 105.03.

707.02 Materials

Materials shall be in accordance with the following:

Admixtures for Concrete	912.03
Backer Rod	906.02(b)
Coarse Aggregates, Class A or Higher, Size No. 91	904
Concrete Curing Materials	912
Concrete Sealers	909.09, 909.10
Elastomeric Bearings	915.04
Fine Aggregates, Size No. 23	904
Fly Ash	901.02
Ground Granulated Blast Furnace Slag	901.03
PCC Sealer/Healer	901.06
Portland Cement	901.01(b)
Reinforcing Bars	910.01
Silica Fume	901.04
Uncoated Seven-Wire Strand	910.01(b)7

Structural steel for steel intermediate diaphragms shall be in accordance with 910.02(a) and shall be galvanized in accordance with ASTM A 123 after cutting, bending, and welding. Bolts for steel intermediate diaphragms shall be 7/8 in. and in accordance with 910.02(g), except they shall be type 1. All bolts, nuts, washers, and similar threaded fasteners shall be galvanized in accordance with ASTM A 123 or may be mechanically zinc coated in accordance with ASTM B 695, class 50.

All precast non-prestressed structural members shall be manufactured by a Department Certified Precast Concrete Producer in accordance with ITM 813. All precast prestressed structural members including, but not limited to concrete box-beams, I-beams, U-beams, and bulb-T beams shall be manufactured in a Department approved plant in accordance with ITM 814.

CONSTRUCTION REQUIREMENTS

707.03 General Requirements

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. A beam which is to include a field attached curb shall have curb reinforcement located longitudinally within 3/4 in. of the locations shown on the plans. If detailed drawings are not included in the plans, working drawings shall be submitted for approval in accordance with 105.02. Certified mill test reports shall be furnished for all uncoated seven-wire strands.

Where temperature requirements are specified herein, the Contractor shall provide the Department with written verification that the temperature requirements have been met.

Prior to the beginning of fabrication, a prefabrication meeting shall be held at the fabrication facility or another agreed upon location. The meeting shall be conducted by the Contractor and attended by the fabricator's production supervisor and quality control inspector, and the Engineer. The Contractor shall take notes of the meeting and distribute copies to all attending parties within five days of the date of the meeting. Items to be discussed at the meeting shall include a minimum of: fabrication and shipping schedule including hours of operation; line of communication between Contractor and Engineer; material test reports; working drawings; special fabrication methods; fabrication hold points for inspection; final inspection and acceptance of materials; method of shipment. The requirement to hold prefabrication meetings may be waived by the Department.

A type A field office in accordance with 628 shall be provided at any facility that fabricates precast prestressed structural members for the Department's exclusive use. In lieu of a field office, a work area and the following items in accordance with 628 for the exclusive use by the Department shall be provided on the property where the structural members are being fabricated.

(a) office desktop

(b) office chair
(c) broadband internet service
(d) telephone
(e) fax machine
(f) copier
(g) filling cabinet.

707.04 Steel and Concrete Requirements

(a) Reinforcing Bars

A tight coat of concrete grout extending 1/2 in. maximum from the top of precast and precast prestressed concrete structural members will be allowed to remain on reinforcing bars extending from precast and precast prestressed structural members. All loose and flaky material on these reinforcing bars shall be removed. Lap splices shall be in accordance with 703.06.

(b) Prestressing Strands

Uncoated seven-wire strands shall be used as prestressing strands. The splicing of straight prestressing strands is acceptable provided that the location of the splice does not occur within a concrete structural member. Splicing of draped strands is not allowed. Spliced prestressing strands shall have the same twist or lap. For single strand tensioning, slippage of the splices should be considered in computing the elongation. For multiple strand tensioning, either all of the strands shall be spliced or not more than 10% of the strands. If all of the strands are spliced the average splice slippage shall be considered in computing the elongation. If 10% or less of the strands are spliced, no slippage allowance will be required.

Wire breaks will be allowed to remain on the prestressed concrete casting bed as follows:

Number of Strands in Bed	Wire Breaks
19 or fewer	0
20 through 39	1
40 through 59	2
60 or more	3

The ends of each allowable wire break shall be tied to the strand. If more than the allowable number of wire breaks appears in a particular strand pattern, or if more than one broken wire appears in an individual strand, such strands shall be removed and replaced.

The tolerance for the center of gravity for a prestressing strand group shall be ± 1/4 in. The tolerance for the longitudinal position of handling devices shall be ± 6 in.

(c) Concrete

Concrete shall be air entrained and in accordance with the applicable requirements of 702.05. The concrete shall have a minimum temperature of 50°F and a maximum temperature of 90°F at the time of placement. When a chemical admixture type A, D, F, or G is used, it shall be used in combination with an air entraining admixture. A high range water reducing, HRWR, or high range water reducing retarding, HRWRR, admixture system may be used. Chemical admixture types B, C, and E will only be allowed with prior written permission. Air-entraining cement will not be allowed. The cement content of the mixed concrete shall be sufficient to obtain the specified minimum 28 day compressive strength. The total of portland cement and other cementitious materials shall be a minimum of 564 lbs/cu yd and shall not exceed 800 lbs/cu yd. Silica fume may be added in an amount not to exceed 5% of the total cementitious material.

When a type A, D, or E admixture is not used, or if a type B or C chemical admixture is used, slump shall be no less than 1 in. or more than 3 in. When concrete admixtures type A, D, or E is used, slump shall be no less than 2 in. or more than 5 in. When concrete containing admixture type F, G, or admixture systems is used, the concrete shall have a slump no less than 3 in. or more than 8 in. The amount of time from mixing to placement and consolidation shall be a maximum of 30 minutes. The concrete shall not be retempered with additional amounts of chemical admixture types F or G after the initial mixing has been completed.

1. Cold Weather Concrete

Cold weather concrete shall be in accordance with 702.11.

2. Hot Weather Concrete

When it is necessary to fabricate concrete structural members during times of hot weather the mix water may be chilled or an appropriate amount of ice may be added to the concrete mix in order to produce concrete of the temperature specified herein.

3. Acceptance Testing

Acceptance of precast and precast prestressed structural members will be based on tests for slump, air content, and compressive strength. All slump, air content, and compressive strength tests shall be performed in the presence of the Engineer. Slump and air content measurements shall be obtained each time cylinders are made. Compressive strengths of the structural members shall be determined from cylinder sets described herein. The 28-day compressive strength shall be equal to or greater than the specified concrete compressive strength. The compressive strength of the concrete for each structural member will be determined from the average strength of the cylinder set representing that member. No individual strength within a cylinder set representing a structural member shall be less than 90% of the specified concrete compressive strength.

All molds, facilities, labor, and materials necessary to prepare, cure, and test the cylinder sets shall be furnished.

a. Cylinder Set

A cylinder set shall consist of at least three cylinders obtained from three separate batches or loads of concrete used in casting a structural member. The batches or loads to be sampled may be as directed by the Engineer. All cylinders for acceptance shall be 6 in. diameter by 12 in., molded and field cured in accordance with ASTM C 31. The Contractor may make additional cylinder sets for use in acceptance testing.

All cylinders shall be identified by use of Department-marked cylinder identification tags which are inserted a maximum of 3/8 in. into the top of each freshly molded cylinder. The cylinder number, a unique structural member identification number, temperature, air content, and slump of the concrete represented by each cylinder shall be referenced to the numbers on these cylinder identification tags and provided to the Engineer by the end of each day in which cylinders are cast.

Cylinders shall be stored as near as possible to the point of deposit of the concrete represented. All surfaces of the cylinders shall be protected from the elements in the same manner as the formed structural members. Cylinders shall be cured at the same temperature and moisture environment as the structural members.

Cylinders shall be in the moisture condition resulting from the selected curing treatment prior to testing. To meet these conditions, the cylinders shall be removed from the molds at the time the structural member is removed from the form work. Cylinders shall be tested in accordance with ASTM C 39. The Contractor shall have on file a certificate of calibration for the testing machine. All cylinders in a cylinder set, for a given age, shall be broken within the time tolerances shown in ASTM C 39. The Department will remove cylinder identification tags prior to the Contractor testing the cylinders.

b. Precast, Non-Prestressed Structural Members

When fabricating precast non-prestressed structural members, a minimum of one cylinder set shall be made per member cast. The 28-day compressive strength of the concrete for each structural member will be determined by the average strength of the cylinder set representing that member. The fabricator may elect to make additional cylinder sets for use in acceptance testing prior to 28 days.

c. Precast, Prestressed Structural Members

A minimum of two cylinder sets shall be made for each structural member cast. One cylinder set shall be tested and used to determine when the precast prestressed structural member has met or exceeded the required strength for detensioning the prestressing bed. If an additional cylinder set as described above has been made, the Contractor may test this set to determine if the required strength for detensioning of

the prestressing bed has been met or exceeded, or if the required 28-day compressive strength has been met or exceeded prior to an age of 28 days. The Engineer will accept the results from the compression testing on the additional cylinder set, in place of either the detensioning strength test results, or the 28-day compressive strength test results, if the results equal or exceed the respective compressive strength requirements. If an additional cylinder set was not made, or if the additional cylinder set does not meet or exceed the 28-day compressive strength requirement, the remaining cylinder set shall be tested at 28 days of age to determine the acceptability of the structural members.

Coring of precast prestressed structural members shall not be performed. Precast prestressed structural members that have been cored will not be accepted. Compressive strength results for cylinders that exceed 28 days in age or results from cylinders that do not have the Department-marked cylinder identification tag intact will result in the structural members not being accepted.

(d) Other Requirements

Precast concrete structural members which are not prestressed shall have a minimum compressive strength of 4,500 psi in 28 days. Precast prestressed structural members shall be in accordance with the following unless otherwise shown on the plans:

1. Maximum water/cementitious ratio in pounds of water per pound of cementitious material shall be 0.420.

2. Minimum 28-day compressive strength of concrete shall be 5,000 psi.

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

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

Inspection of the precast prestressed structural member during manufacture and checking and testing aggregates, cement, concrete, and steel specimens shall be performed. All specimens shall be furnished without cost to the Department. Inspection, checking, and testing performed by the Department will not relieve the Contractor or the fabricator from performing their own quality control inspection, testing, and checking as necessary to maintain quality control over the manufacturing, handling, and curing procedure. A permanent record of the force applied to and measured elongation obtained for each prestressing strand and the identification of the strand and structural member to which the record applies shall be provided. This record shall be certified that it accurately represents the force applied and measured elongation by the fabricator's production supervisor and provided to the Engineer prior to shipment.

707.05 Forms

Structural members shall be manufactured in steel forms which are unyielding, smooth, 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 chamfered in accordance with 702.13(a). 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 either reinforcing bars or prestressing strands.

707.06 Placing and Finishing Concrete

The temperature of the prestressing strands and forms shall be monitored between the time of the application of prestressing force and the placement of the concrete. During hot weather, approved means shall be undertaken to cool the forms immediately prior to placement of the concrete.

When abutment anchorage set-ups where prestressing strands are anchored to abutments that are independent from the form, thermal adjustments shall be made if the temperature of the prestressing strands at the time of tensioning differs by more than 25°F from the temperature of the concrete mixture during placement. This requirement will not apply to self-stressing beds.

Void boxes, inserts, and attachments shall be securely fastened in order to maintain the proper position during concrete placement and consolidation. All voids shall have weep holes or otherwise be vented during beam production until after the initial concrete set, then sealed before the beams are shipped.

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 structural member shall be placed in one continuous operation. The outside vertical faces of fascia structural members and the exposed face and top of the curb section, if applicable, shall be finished in accordance with 702.21.

The tops of all beams and the outside faces and bottom flanges of the fascia beams shall be sealed in accordance with 709.

707.07 Removal of Forms and Curing

Curing shall be in an enclosure designed to minimize heat and moisture loss. Insulated blankets may be used. The concrete in the form shall be maintained at a minimum temperature of 50°F during the entire curing cycle. Curing for precast or precast prestressed structural members shall be done by wet curing without supplemental heat or by accelerated curing. During the period of initial set of the structural member and during the accelerated curing by radiant heat, the concrete shall be kept wet by the method outlined below for wet curing without supplemental heat.

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

Side forms may be removed when no distortion, slump, or misalignment of the concrete will result. Precast structural 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 2,000 psi as evidenced by cylinders sets made and cured in the same manner as the slab.

(a) Wet Curing without Supplemental Heat

When wet curing without supplemental heat is used, the exposed surfaces of the structural members shall be covered by two layers of wet burlap and the burlap shall be kept wet to ensure that free water is present at all times. In lieu of using wet burlap, the Contractor may propose an alternate method which provides a moist environment with free water being present at all times. Written approval from the Engineer will be required prior to use of the proposed alternate method. Additional curing of precast or precast prestressed structural members will not be required provided the minimum specified ultimate strength can be obtained.

In precast prestressed concrete structural members, wet curing without supplemental heat shall continue until such time as the compressive strength of the concrete reaches or exceeds the strength specified for transfer of prestress or detensioning. At this point wet curing is considered to have concluded. Detensioning shall be performed within 6 h after wet curing has concluded. In precast non-prestressed structural members, wet curing without supplemental heat shall continue until such time as the compressive strength of the concrete reaches the strength specified for stripping of forms.

(b) Accelerated Curing

When accelerated curing of the concrete is used, it shall be done by low pressure steam or radiant heat curing. 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 cylinders. The steam shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement.

Except to maintain a minimum concrete temperature of 50°F, heat shall not be applied until the concrete has attained initial set. The time of initial set may be determined by ASTM C 403. Once the penetration resistance, as performed in accordance with ASTM C 403, equals or exceeds 500 psi accelerated curing may begin. When the initial set is not determined by ASTM C 403, the initial application of heat shall be a minimum of 4 h after final concrete placement. When retarders are used and the initial set is not determined by ASTM C 403, this time shall be increased to a minimum of 6 h after final concrete placement. 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 entire curing cycle.

During the initial application of radiant heat or live steam, the temperature measured in the concrete shall increase at an average rate not exceeding 36°F/h. The maximum concrete temperature shall not exceed 158°F. A minimum of three time and temperature recording devices capable of recording temperatures in degrees Fahrenheit at intervals not exceeding 15 minutes shall be provided throughout a contiguous form group and common heat source. The time and temperature recording devices shall be located at the portions of the contiguous form group likely to experience the maximum temperatures during curing.

The curing temperature shall be sustained until the concrete has reached the minimum required compressive strength for detensioning the structural members. Once the concrete has achieved the required compressive strength, detensioning shall be performed while the concrete is still warm and moist. Detensioning operations shall not interfere with the curing of the structural member.

As the application of heat is discontinued, the concrete temperature shall decrease at a rate not to exceed 50°F/h. When the concrete temperature has reached 40°F or less above the ambient temperature outside the curing enclosure, accelerated curing is considered to have concluded. A thermometer shall be provided to monitor ambient air temperatures. This thermometer does not have to have recording capabilities.

The time and temperature recording devices shall be used to verify compliance with the heating and cooling rates contained herein.

When multiple structural members are cast in the same bed, all members shall meet or exceed the specified release strength prior to detensioning. Additional curing of precast or precast prestressed structural members will not be required provided the minimum specified ultimate strength can be obtained.

A grinder or other methods that induce minimal amounts of heat into the prestressing strand shall be used to cut off prestressing strands. The ends of the concrete structural member where prestressing strands have been cut to be flush with the end of the member shall be coated with bituminous mastic sealant in accordance with 907.11. All prestressing strands that are exposed and protrude from the end of the beam shall be protected from rusting by use of a spray, brush, or roller-applied rust-inhibiting paint or other material that is not considered detrimental to bonding with concrete.

707.08 Handling and Shipping

Precast and precast prestressed structural members shall not be subjected to excessive abuse which produces crushing or undue marring of the concrete. All structural members damaged during handling, storing, transporting, or erecting shall be replaced. Unless otherwise approved, precast and precast prestressed structural 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 structural member due to lifting and shall be equipped with leads and hooks at each end. The structural members shall be lifted by the devices shown on the plans. Proposed alternate lifting devices and procedures shall be approved prior to use and shown on the working drawings. If any other method of handling is used, it shall be shown on the working drawings and approved prior to use. If the method produces horizontal forces in the precast or precast prestressed structural member, sufficient reinforcement shall be added to compensate for them.

The structural 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, all structural members shall be fully supported across their width on battens not less than 4 in. wide with one being placed at each end at the centerline of the bearing. The supports of the structural members while in storage shall be maintained in a level position so no twisting occurs.

Precast structural members shall not be shipped or used until the concrete compressive strength reaches a minimum of 4,500 psi for members which are not prestressed and 5,000 psi for members which are prestressed.

During transportation, the structural members shall be supported with truck bolsters or battens no less than 4 in. wide which are padded with no less than 1/2 in. of rubber. The ends of I-beams, U-beams, and bulb-T beams shall extend no more than the depth of the beam and not more than 3 ft 6 in. beyond the supports. The ends of box-beams shall extend no more than 1 1/2 times their depth and not more than 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 allowed, provided the beams are fully seated on the outer bolsters and the inner bolsters are no more than 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 precast prestressed structural members shall commence at the centerline and proceed out to the curb, one member at a time. As each structural member is placed, the transverse tie bars, if shown on the plans, shall be inserted and secured. Any shifting of the structural 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 allowed. Structural 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, structural 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 1 part portland cement, 2 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 structural members together shall be furnished.

Dowel holes shall not be grouted nor concrete or the forming thereof, be placed in floor slabs, diaphragms, or shear keys prior to receipt of complete documentation of the acceptability of the structural members and bearing pads, including the satisfactory laboratory reports and certifications in accordance with 915.04(f). Neither the structural 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 precast 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 precast prestressed structural 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 structural members is satisfactory to handle these loads. However, such approval shall not relieve the Contractor of any damage from this operation.

707.10 Blank

707.11 Method of Measurement

Precast or precast prestressed concrete structural members will be measured by the linear foot. Railing will be measured in accordance with 706.07 if specified as a pay item. Structural steel for intermediate diaphragms will not be measured.

707.12 Basis of Payment

The accepted quantities of precast or precast prestressed concrete structural members will be paid for at the contract unit price per linear foot for structural member, concrete, of the type and size specified.

Railing will be paid for in accordance with 706.08 when specified as a pay item.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Structural Member, Concrete, ____, ____ (type, size)	LFT

Reinforcing bars, prestressing strands, elastomeric bearing pads, modifications to bearing pads, bearing beams required for box beams, bearing assemblies required for I-beams, bulb-T beams, U-beams, and box beams, bearing plates, expanded polystyrene, threaded reinforcing bars, threaded inserts in fascia beams, hex bolts, sealer on the outside face and bottom flange of fascia beams and on the tops of all beams, and necessary incidentals shall be included in the cost of the pay items of this section. The cost of tensioning rods and steel plates shall be included in the cost of the pay items of this section. The cost for providing all molds, cylinder identification tags, facilities, labor, and materials necessary to prepare and cure the test specimens required for work in this section shall be included in the cost of the pay items in this section.

No payment will be made for removing and replacing prestressing strands due to excessive wire breakage, or replacing precast or precast prestressed structural members damaged during handling, storing, transporting or erecting.

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

The cost of all materials, including galvanizing, labor, and equipment for furnishing and installing steel intermediate diaphragms shall be included in the cost of structural member, concrete of the type and size specified.

The cost of time and temperature recording devices and their monitoring shall be included in the cost of the structural members.

The cost of a field office or of providing the field office items listed herein shall be included in the cost of the pay items of this section.

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:

Deformed and Smooth Steel WWR	910.01(b)5
Fine Aggregate	904.02(d)
Fly Ash	901.02
Portland Cement	901.01(b)
Water	913.01

WWR shall consist of wire, size W 1.5 or approximately No. 10 gage, spaced and welded at 3 in. intervals, or wire, size W 1 or approximately No. 12 gage, spaced and welded at 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 WWR 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 2 ft.

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

WWR shall be used in all areas where the thickness of the mortar exceeds 3 in. and also if the present steel reinforcement is exposed after the disintegrated concrete has been removed. WWR shall be fastened to the concrete masonry with 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 8 in. centers in each direction and shall be of sufficient length to space the WWR approximately 2 in. from the surface being repaired. Where WWR can be fastened to the reinforcing bars, the bolts, pins, or nails may be omitted.

708.05 Proportioning and Mixing

The dry mixture shall consist of 1 part portland cement to 3 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 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 they have satisfactorily completed similar work on other structures of like type.

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 2 in. thick in one operation. Where a finished thickness of more than 2 in. is required, it shall be obtained in successive operations and enough time allowed to enable 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 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 1/8 in. or larger shall be removed by screening. No less than one bag of the white cement to each 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 50°F or 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 foot, complete in place. The area measured will be the actual finished surface. WWR, where used, will be measured by the square foot, complete in place.

708.09 Basis of Payment

The accepted quantities of pneumatically placed mortar and WWR will be paid for at the contract unit price per square foot, complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Pneumatically Placed Mortar	SFT
Welded Steel Wire Reinforcement	SFT

The areas where loose or defective portions of masonry exceed an average of 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 4 in. but less than 6 in. 1.25

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

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

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

(e) for all portions thereof whose average depth is greater than or equal to 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 105.03. 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 materials.

709.02 Materials

Materials shall be in accordance with the following:

Epoxy Penetrating Sealers 909.09
Non-Epoxy PCC 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 40°F or above and when the air temperature is 50°F or above, unless otherwise approved in writing. Concrete sealer shall not be applied when the ambient temperature is expected to fall below 35°F within 12 h after application.

(b) Epoxy Penetrating Sealers

Cast-in-place concrete shall have a minimum of 72 h dry cure prior to the application of epoxy penetrating sealer.

(c) Non-Epoxy PCC Sealers

The concrete to be sealed shall be cured as stated on the list of approved Non-Epoxy 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 35°F or above. Low temperature concrete sealer shall not be applied when the ambient temperature is expected to fall below 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 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 1 to 2 lbs/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
No. 16 (1.18 mm)	100
No. 100 (150 µm)	0-5

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

(c) Non-Epoxy PCC Sealers

The sealer chosen for use shall be applied at the application rate specified on the list of approved Non-Epoxy 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 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 shall be selected from the Department's list of approved Non-Epoxy Portland Cement Concrete Sealers and shall be spread to achieve uniform coverage. 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 including, but not limited to concrete bridge railing, barrier wall and exterior concrete bridge beams when sealing is specified for these items. Clear sealers will be those identified on the list of approved Non-Epoxy Portland Cement Concrete Sealers. Epoxy penetrating sealers are not clear 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 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 dermatitic. 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 Symbol
Surface Seal	LS

The cost 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(b) is used in lieu of sealing concrete surfaces or portions thereof, it will be paid for as surface seal.

SECTION 710 – PATCHING CONCRETE STRUCTURES AND REPOINTING MASONRY IN STRUCTURES

710.01 Description

This work consists of patching concrete piers, end bents, abutments, wingwalls, retaining walls, concrete structure surfaces other than bridge decks, and patching concrete drainage structures, and repointing rubble, dressed stone, or brick masonry structures in accordance with 105.03.

Bridge deck patching shall be in accordance with 722.

710.02 Materials

Materials shall be in accordance with the following:

Coarse Aggregate, Class A or Higher, Size No. 11	904
Concrete, Class A	702.02
Curing Compound	912.01
Epoxy-Resin-Base System	909.11
Fine Aggregate	904.02
Hydrated Lime	913.04
Masonry Cement	901.01(c)
Portland Cement, Type I	901.01(b)

Reinforcing Bars..... 910.01

Mortar shall consist of 1 part cement to 2 parts No. 23 fine aggregate, by volume.

CONSTRUCTION REQUIREMENTS

710.03 Patching Concrete Structures

(a) Concrete Removal

Areas of unsound concrete to be removed will be marked by the Engineer.

A saw cut shall be made perpendicular to the existing concrete surface a minimum of 1 in. outside marked areas. The cut shall be a minimum 1 in. deep or to the top of the reinforcement, whichever is less.

Removal of unsound concrete shall not exceed 6 in. in depth and shall be performed by means of handchipping. Handchipping tools may be hand or mechanically driven. Jackhammers shall not be heavier than nominal 45 lb class and chipping hammers shall not be heavier than nominal 15 lb class. Only chipping hammers shall be used when removing concrete within 1 in. of the reinforcement. Mechanically driven tools shall be operated at a maximum angle of 45° to concrete surfaces.

Where the bond between the existing concrete and the reinforcement has been destroyed, concrete adjacent to the reinforcement shall be removed to a minimum clearance of 1 in. around the entire periphery of the exposed reinforcement. Exposed reinforcement shall not be damaged due to the removal operations. Reinforcement damaged by the Contractor shall be replaced.

Regardless of the method of removal, removal operations shall cease if sound concrete is being removed beyond the limits approved by the Engineer. Removal methods shall be adjusted to prevent unnecessary removal of sound concrete prior to resuming removal operations.

(b) Replacement of Reinforcement

Existing reinforcement that has lost 50% or more of its original cross sectional area shall be removed and replaced with new reinforcement of the diameter of the original reinforcement. Replacement reinforcement shall be lapped a minimum of 3 in. along the existing reinforcement.

(c) Patching

After concrete removal operations are completed and just prior to placing patches, all patch areas shall be sandblasted to expose aggregates in concrete surfaces and to remove rust, residual concrete and laitance layers from the surface of the reinforcement. All surfaces shall be free of dust, chips, water, and foreign

material to produce a firm, solid surface for adherence of patching concrete. Air lines for sandblasting and air cleaning shall be equipped with oil and water traps.

Surfaces of prepared cavities and all exposed reinforcement within the cavities shall be coated with epoxy resin adhesive in accordance with 722.06(a)1. Cavities of 1/2 in. depth or greater shall be filled with concrete. Cavities of less than 1/2 in. depth shall be filled with mortar.

For patched areas that require forms, forms may be removed after 24 hr and surfaces cured in accordance with 702.22 or the forms may be left in place for 72 hr and no additional curing will be required. Patched areas that do not require forms shall be cured in accordance with 702.22.

Concrete patches shall be finished to match the texture and finish of abutting existing concrete.

710.04 Repointing Rubble Masonry

Joints in rubble masonry shall be cleaned of all loose mortar and foreign material. All spaces around the rubble aggregate, after being cleaned, shall be filled with mortar and trowel finished. All loose rubble shall be settled into place before the mortar has set.

710.05 Repointing Dressed Stone and Brick Masonry

Joints in masonry shall be cleaned of all loose mortar and foreign material for a depth of at least twice the width of the joint. Joints shall be filled with mortar and trowel finished.

710.06 Method of Measurement

Patching concrete structures and repointing rubble, dressed stone and brick masonry in structures will be measured by the square foot of actual surface area of patching or repointing. Individual areas of less than 1 sq ft in area will be considered as 1 sq ft. Areas greater than 1 sq ft will be recorded as the actual measurement of the repaired area to the nearest 0.1 sq ft.

710.07 Basis of Payment

The accepted quantities of patching concrete structures will be paid for at the contract unit price per square foot complete in place. Repointing rubble, dressed stone, and brick masonry in structures will be paid for at the contract unit price per square foot of repointing masonry complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Patching Concrete Structures	SFT
Repointing Masonry in Structures	SFT

Areas where patching concrete structures or repointing rubble, dressed stone, or brick masonry in structures exceeds an average of 4 in. in depth will be paid for at a price calculated by means of multiplying the contract unit price for the respective item by the following factors:

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

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

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

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

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

The cost of removing the existing concrete or masonry cement, furnishing, hauling, and placing all materials, preparing the surface, and all necessary incidentals shall be included in the pay items in this section.

The cost of replacing damaged reinforcement shall be included in the cost of patching concrete structures.

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 105.03.

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

Where grade HPS 70W or grade HPS 50W steel is shown on the plans, the high performance steel shall be in accordance with 910.02(d).

Where grade 50W steel is shown on the plans, the weathering steel shall be in accordance with 910.02(b).

Material specifications shall be shown on the working 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 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.

Fabrication of high performance steel shall be in accordance with the Guide Specification for Highway Bridge Fabrication with HPS 70W Steel except as modified herein.

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

(a) General Information

If the fabrication of secondary structural steel members and other miscellaneous structural steel components, such as but not limited to diaphragms, bearing assemblies, and miscellaneous plates does not involve any welding or heating of the steel, the fabrication facility that is fabricating these components will not be required to be American Institute of Steel Construction, AISC, certified as described in this section.

Prior to approval for fabrication, the results of the latest AISC certification review shall be made available to the Engineer to determine if items critical to successful fabrication meet the needs of the specific work.

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.

(b) Certification Categories

The fabricator of structural steel furnished under this section shall be certified in accordance with the AISC Certification Program for Steel Bridge Fabricators – Standard for Steel Bridges, to the certification category commensurate with the work to be fabricated. Fabricators producing fracture-critical members, intermediate bridges, or advanced bridges, shall also meet the applicable supplemental requirements of the certification program. For shop painting the Department will only accept an AISC-420-10/SSPC-QP 3 certification. It shall be the fabricator's responsibility to maintain a valid certification and annual endorsements thereto.

1. Simple Bridges

Fabricators of main load-carrying components for simple span bridges or bridges that do not have welded or bolted splices shall, as a minimum, be certified under the simple bridges category.

2. Intermediate Bridges

Fabricators of main load-carrying components for the following types of structures shall, as a minimum, be certified under the intermediate bridges category.

a. rolled beam bridge with field or shop splices, either straight or with a radius greater than 500 ft,
b. a built-up I-shaped plate girder bridge with constant web depth, with or without splices, either straight or with a radius greater than 500 ft,
c. a built-up I-shaped plate girder with variable web depth, either straight or with a radius greater than 1000 ft,
d. a truss with a length of 200 ft or less that is entirely or substantially pre-assembled at the certified facility and shipped in no more than three subassemblies.

3. Advanced Bridges

Fabricators of main load-carrying components for the following types of structures shall be certified under the advanced bridges category.

a. tub or trapezoidal box girders,
b. closed box girders,
c. large or non-preassembled trusses,
d. arches,
e. bascule bridges,
f. cable-supported bridges,
g. moveable bridges, and
h. bridges with a curve radius equal or tighter than that specified for the intermediate bridges category above.

711.05 Working Drawings

Working drawings shall be submitted in accordance with 105.02.

Working drawings shall include a detailed bill of materials showing weights of materials completed in accordance with 711.73(b) if payment is on a unit weight basis. The working drawings shall indicate whether reaming is to be done in the shop or in the field. The working drawings shall indicate which splices are to be eliminated.

If the contract plans include detailed structural steel drawings, they may be used. Such drawings shall be checked. The Contractor shall provide notification in writing that it 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

A copy of all mill test reports for all steel on hand that is to be used to fabricate structural steel members shall be furnished prior to the start of fabrication. For steel not on hand when fabrication is started that arrives during fabrication, a copy of the mill test reports for that steel shall be provided within 24 h of receipt of the steel. If copies of mill test reports are not provided within the specified timeframe, the Engineer may suspend the fabrication of all structural steel members until such time that copies of the missing mill test reports are provided. Delays due to suspension of fabrication will be considered non-excusable. 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 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 working drawings. Approval of working drawings 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 allowed, 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 709 grade 100 steel members will not be allowed. The temperatures of the heated area shall not exceed 1,200°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 allowed. Following the straightening of a bend or buckle, the surface of the metal shall be inspected for evidence of fracture.

Short term application of heat to high performance steel for purposes of heat curving, heat straightening, camber and sweep adjustment, or for other reasons is

limited and shall not exceed 1,100°F. Heat applications shall be in accordance with Department approved procedures.

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 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 in accordance with 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 1/16 in. radius by grinding after flame cutting.

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

Surface roughness exceeding the above values and occasional gouges not more than 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 3/16 in. deep but not more than 7/16 in. deep may be repaired by welding with low hydrogen electrodes not exceeding 5/32 in. in diameter and with a preheat of 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 1/2 in. in thickness and carrying calculated stress shall be planed to a depth of 1/4 in. Re-entrant cuts shall be filleted before cutting.

Visually observed defects in sheared or flame cut edges of plates 4 in. or less in thickness, except 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 1/8 in. max. depth.	None-depth shall be explored as directed.
Any discontinuity over 1 in. in length with depth over 1/8 in. but not greater than 1/4 in.	Remove and weld.
Any discontinuity over 1 in. in length with depth over 1/4 in. but not greater than 7/16 in.	Remove completely and weld. Aggregate length of welding not over 20% of plate edge length being repaired.
Any discontinuity over 1 in. in length with depth greater than 7/16 in.	Plate rejected. Defective portion may be removed and remainder may be used in 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 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 an allowable tolerance of +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 working 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 inches	Up to 1/2 in.	Over 1/2 in. to 1 in.	Over 1 in. to 1 1/2 in.	Over 1 1/2 in. to 2 1/2 in.	Over 2 1/2 in. to 4 in.
All grades of structural steel in this specification	2 t	2 1/2 t	3 t	3 1/2 t	4 t

If a shorter radius is essential, the plates shall be bent hot at a temperature no greater than 1,200°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 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 six 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 and not 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 1/16 in. larger than the nominal diameter of the bolts whenever the thickness of the metal is no greater than 3/4 in. for structural steel or 5/8 in. for high-strength steel. If there

are more than five thicknesses or when the main material is thicker than 3/4 in. for structural steel, or 5/8 in. for high strength steel, or if required in accordance with 711.24, all holes shall be subpunched or subdrilled 3/16 in. smaller and, after assembling, reamed 1/16 in. larger or drilled from the solid to 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 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 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 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 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 1 in. Open holes for high strength bolts shall be 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.

If beams or girders are shop reamed or drilled, progressive beam or girder assembly will be allowed 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 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 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 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 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 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 1/4 in. The cuts shall be straight enough that a 1/8 in. plate passes between the parts on any designated straightline cut.

711.30 Blank

711.31 Peening Welds by Means of Ultrasonic Impact Treatment, UIT

This work shall consist of removing existing paint, repairing existing cracked welds, peening existing and repaired welds, and painting in accordance with 105.03.

Equipment operators shall be American Society for Nondestructive Testing, ASNT, Level II technicians, trained in the use of the equipment for peening by ultrasonic impact methods. Proof of certification shall be furnished two weeks prior to commencing work.

All welding shall be in accordance with the applicable section of the Bridge Welding Code. All welding shall be performed by AWS certified welders. Weld repair shall be in accordance with Bridge Welding Code section 3.7.

Paint removal shall be in accordance with 619.08(b) and 619.08(h). However, pressure washing will not be required. Painting shall be in accordance with 619.09 and 619.10.

Prior to beginning the peening process, all welds shall be inspected with a 10x magnifying glass and with either ultrasonic or magnetic particle non-destructive testing equipment. Welds needing repair shall be ground and repaired in accordance with the Bridge Welding Code. Peening using ultrasonic impact treatment methods shall be applied to all repaired welds in addition to the welds shown on the plans.

UIT shall be performed along the toe of the weld to cause the center of the treatment groove to be at the weld toe. UIT shall be performed to result in a uniform groove with a bright, metallic surface. All non-uniform areas shall be retreated.

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 bridges and bridge components shall be performed in accordance with AASHTO/AWS D1.5 Bridge Welding Code, hereinafter referred to as the Bridge Welding Code. Welders, welding operators, and tack welders shall be qualified in accordance with Bridge Welding Code, Chapter 5 Part B.

When welding steel structural or steel non-structural tubing or steel structural supports for highway signs, luminaires, or traffic signals, it shall be performed in accordance with AWS D1.1 Structural Welding Code – Steel, hereinafter referred to as AWS D1.1. Welders, welding operators, and tack welders shall be qualified in accordance with AWS D1.1, Chapter 4 Part C.

(b) Welding of High Performance Steel

All welding on high performance steel shall be in accordance with the Bridge Welding Code, except as modified herein and by the Guide Specification for Highway Bridge Fabrication with HPS 70W Steel, hereinafter referred to as the Guide.

Only submerged arc welding, SAW, and shielded metal arc welding, SMAW, processes will be allowed. Consumable handling requirements shall be in accordance with the Bridge Welding Code, Sections 12.6.5 and 12.6.6, when using reduced preheat as described in Table 3 of the Guide, except that SAW consumables for matching weld metal shall meet the hydrogen control level of H4 in accordance with Section 12, Article 12.6.2. Consumable handling requirements shall meet the provisions of the Bridge Welding Code, Section 4, when using the preheat requirements contained in Section 4, except that the diffusible hydrogen level must never exceed H8. SMAW consumables may meet diffusible hydrogen levels of either H4 or H8 except the higher preheat and interpass temperatures as noted in Table 3 of the Guide shall apply to H8 conditions.

Filler metals used to make single pass fillet welds for web to flange applications which join HPS 70W steel plates, HPS 70W to grade 50W plates and for attaching stiffeners and connection plates to grade HPS 70W webs and flanges, shall be in accordance with the Bridge Welding Code, Table 4.1 for ASTM A 709, grade 50W base metal. Filler metals for single pass 5/16 in. fillet welds need not meet the requirements for exposed bare applications.

Filler metals used for all complete penetration groove welds joining grade HPS 70W plate to ASTM A 709, grade HPS 50W or grade 50W plate shall conform to the requirements for welding grade 50W base metal.

Filler metals used for all complete penetration groove welds joining grade HPS 70W plates to grade HPS 70W plates shall conform to the requirements for HPS 70W base metal as follows:

1. Submerged Arc Welding process:

   Wire - LA85 by Lincoln Electric Company
   Flux - MIL800HPNi by Lincoln Electric Company

2. Shielded Metal Arc Welding process:

   Matching - E9018MR*
   Undermatching - E7018MR*

* The designator 'MR', for moisture resistant coating, is required for all SMAW electrodes used for welding HPS 70W steels.

The Contractor may request approval of alternate consumables for matching weld strengths in lieu of the above filler metals for SAW. The request for approval shall include documentation of successful welding and shall also include diffusible hydrogen tests, both in accordance with the Bridge Welding Code.

All welding procedures shall be qualified in accordance with the Bridge Welding Code Section 5, Qualification. In general, the provisions of Article 5.12 shall apply. Qualification tests shall measure strength, toughness and ductility, with results evaluated in accordance with Article 5.19. If specified on the plans, additional tests shall measure the Charpy V-notch toughness of the coarse grained area of the heat affected zone, HAZ. The notch in the specimens shall be carefully located in the coarse grained area of the HAZ, as determined by macro-etching the specimens prior to machining and testing. The toughness requirement for the HAZ shall be the same as the weld metal.

All procedure qualification tests shall be ultrasonically tested in accordance with the requirements of the Bridge Welding Code, Section 6, Part C. Evaluation shall be in accordance with Table 6.3, UT Acceptance – Rejection Criteria – Tensile Stress. Indications found at the interface of the backing bar may be disregarded regardless of the defect rating.

A representative of the Department must witness all welding procedure qualification tests.

Results of the welding procedure qualification tests and final welding procedure specifications shall be submitted to the Engineer for review and approval.

In general, post weld heat treatment will not be required. The use of such post weld heat treatment will require additional qualification testing.

Wherever magnetic particle testing is done, only the yoke technique will be allowed, as described in Section 6.7.6.2 of the Bridge Welding Code, modified to use alternating current only.

(c) Field Welding

Field welding shall be by the shielded metal arc welding, SMAW, process and shall be in accordance with the requirements herein. Magnetic particle testing will not be required on welded connections that do not carry calculated stresses. All field welding shall be preheated in accordance with Section 4 of the Bridge Welding Code. The Contractor shall provide a copy of the minimum preheat and interpass temperature table to the Engineer prior to beginning welding. Electrodes with a low hydrogen classification shall be used.

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 A 941. 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 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 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 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 B 46.1:

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 working drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than 9 in. in diameter shall be forged. Pins and rollers 9 in. or less in diameter may be forged or cold finished, carbon steel shafting. In pins larger than 9 in. in diameter, a hole no less than 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

1/32 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 1/50 in. for pins 5 in. or less in diameter, or 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 1 3/8 in. or more shall be threaded six threads per 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 1/32 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 1/16 in. in 5 ft, with a maximum variation not to exceed 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 the working drawings.

1. This method shall consist of the assembly of at least three contiguous members, and no less than 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 will be allowed to complete the structure. This laydown shall be the last span unless otherwise approved on the working drawings. 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.

711.48 Shop Cleaning and Storage of Weathering 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 on bare steel sections. Storage shall be such to enable free drainage to avoid moisture pockets.

A sound uniform surface for the 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 entire length and perimeter of each fascia beam or girder shall be cleaned in accordance with 619.08(c). The entire length and perimeter of each interior beam or girder shall be cleaned in accordance with 619.08(d). 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 Area

All exposed welds on fascia 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.

711.49 Furnishing Bolts

Sufficient field bolts shall be furnished to complete the entire structure.

711.50 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.

711.51 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.

711.52 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.

711.53 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

711.54 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 reasonable 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.

711.55 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.

711.56 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.

711.57 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.

711.58 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 enable the free movement of the span.

711.59 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.

711.60 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 enable 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. 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.

711.61 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 the 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.

711.62 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.

711.63 Blank

711.64 Diaphragm Connections

Diaphragm connections other than those shown on the plans may be allowed. If other connections are proposed, 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 allowed which require welding to the web, except at supports.

711.65 Bolted Connections Using High Strength Bolts

(a) General

This subsection covers the assembly of structural joints using 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 7/8 in. in diameter unless noted.

(b) Bolts, Nuts, and Washers

Bolts, nuts, and washers shall be in accordance with 910.02(g). 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 slip-critical joints shall be free of oil, grease, and any other material that reduces friction between the contact surfaces.

(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 325 BOLTS

Bolt Size, in.	Minimum Bolt Tension,* lbs
1/2	12,050
5/8	19,200
3/4	28,400
7/8	39,250
1	51,500
1 1/8	56,450
1 1/4	71,700
1 3/8	85,450
1 1/2	104,000

* Equal to the proof load (length measurement method) given in 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 LRFD Bridge Construction Specifications. The snug tight condition as defined in AASHTO LRFD Bridge Construction Specifications 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 711.65(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 711.65(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 1 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 8 in.	Bolt length[4] exceeding 8 diameters or 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 711.65(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 711.65(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 711.65(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 711.65(e) shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in 711.65(d)1. The inspecting wrench shall then be applied to the tightened bolt. The torque necessary to turn the nut or head 5°, or approximately 1 in. at a 12 in. radius, in the tightening direction

shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspecting torque to be used in the manner specified in requirement 3e of 711.65(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 711.65(e) to a tension at least 5% but no more than 10% greater than the minimum tension specified for its size in 711.65(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 711.65(e).

e. Bolts represented by the sample prescribed in requirement 3b of 711.65(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.

711.66 Bolted Connections Using Other Than High Strength Bolts

Bolts for these connections shall be in accordance with 910.02(h).

711.67 Final Clean-Up

Final clean-up shall be conducted in accordance with 104.07.

711.68 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.

711.69 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.

711.70 Field Cleaning and Storage of Weathering Steel

Cleaning of structural steel specified to be left unpainted shall be in accordance with 619.08(b) or 619.08(f) or as determined by the Engineer, 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 allowed.

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

711.71 Painting

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

711.72 Method of Measurement

Structural steel shapes, fabricated steel, steel castings, iron castings, bolts, pins, rollers, rockers, anchor bolts, and threaded rods will be measured by the 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 pound. Pay weight will be based on a theoretical density of 536 lbs/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 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.

Peening will be measured by the linear inch of peened weld. The length of weld peened will be measured once per weld regardless of the number of passes necessary to complete the work as specified.

Repair welds will be measured by the linear inch of repaired weld.

711.73 Basis of Payment

The accepted quantities of 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 711.73(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 pound for structural steel. Such pay item will include all work listed above, complete in place. Payment will be in accordance with 711.73(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 pound. The accepted quantities of field structural steel cutting will be paid for at the contract unit price per 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.

The accepted quantities of peened weld will be paid for at the contract unit price per inch. The accepted quantities of repaired weld will paid for at the contract unit price per inch.

Bolts, including anchor bolts and threaded rods, will be paid for as the full weight computed on the basis of 490 lbs/cu ft, including nuts and washers, for the actual number of bolts in the structure.

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

The weight of castings will be computed on the basis of 490 lbs/cu ft for cast steel, and 450 lbs/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 weight of structural steel will be shown on the plans. Such weight will be computed by the same method as that used when computing the estimated weight when paid for on a unit price per pound basis from semi-detailed plans. This weight will include all structural steel and miscellaneous metals unless otherwise included in specific pay items.

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

If there is a discrepancy between the plan weight and the actual 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 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 pound obtained by dividing the lump sum amount for structural steel by the total estimated weight of structural steel shown on the plans. Such unit price may be adjusted in consideration of the fabricating and connection cost. 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 weight of materials will be shown in the bill of materials on the plans when this information is included in such plans, or as computed from the fabricator's approved working drawings when this information is not included in the plans. In either case, such weight shall include all changes ordered.

For rolled sections, the gross weight of the steel will be considered. The weight will be figured on the basis of 490 lbs/cu ft. The weight of each piece will be the 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 working drawings, the weight of groups of two or more pieces shall be the 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	**Pay Unit Symbol**
Bolt, Remove	EACH
Bronze Plates	LBS
Drilled Hole	EACH
Jacking and Supporting _____ structural member type	LS
Peening Weld, UIT	INCH
Repair Weld	INCH
Rivet, Remove	EACH
Structural Steel	LS LBS
Structural Steel, Field Cut	SIN

Stud Shear Connectors .....EACH

The cost of paint removal, painting, non-destructive testing, equipment, labor, materials, access, permits, and necessary incidentals shall be included in the cost of peening weld, UIT.

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

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

No increase in pay weight will be considered 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 weight of shims required does not exceed that planned. No shim shall be less than 1/8 in. in thickness.

No allowance in 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 105.03.

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(h)
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 O. G. 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.

CONSTRUCTION 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 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 allowed 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 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 1/16 in. larger than the rod; and

(e) lag screws shall be the screw diameter to the base of thread, and 1/2 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 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 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 3/4 in. in diameter extending at least 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 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 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 3/4 in. in diameter and shall project at least 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 3/4 in. in diameter and extend into the mudsills or piles at least 6 in. When feasible, all earth shall be removed from contact with sills to enable free circulation of air around them.

Posts shall be fastened to pedestals with dowels of no less than 3/4 in. in diameter extending at least 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 3/4 in. in diameter driven diagonally through the base of the post, and extending at least 9 in. into the sill, or by means of dowels of no less than 3/4 in. in diameter extending at least 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 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 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. Joints shall be staggered at least 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 1,000 board foot measure. Planks for floors will be measured by the 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 pound computed in accordance with 711.73(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 1,000 board foot measure for lumber and timber, either treated or untreated as specified. Plank floors will be paid for at the contract unit price per square foot for plank floors of the ply specified. Metal parts will be paid for at the contract unit price per pound.

Payment will be made under:

Pay Item	Pay Unit Symbol
Metal Parts	LBS
Plank Floors, ____ Ply	SFT
Lumber and Timber, Treated	MFBM
Lumber and Timber, Untreated	MFBM

The cost of preservative treatment, hardware, painting, and necessary incidentals shall be included in the cost 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 105.03.

713.02 Materials

Materials shall be in accordance with the following:

Delineators	926.02
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 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 Pipe

The minimum thickness required for the temporary pipe or pipe-arch shall be as follows:

(a) Corrugated Steel Circular Pipe

Thickness, in.	Pipe Diameter, in.
0.064	48 or less
0.079	54 or less
0.109	72 or less
0.138	78 or less
0.168	84 or less

(b) Corrugated Steel Pipe-Arch, 3 in. by 1 in. Corrugations

Thickness, in.	Pipe-Arch Area, sq ft
0.109	40 or less
0.138	58 or less

(c) Structural Plate Pipe-Arch 6 in. by 2 in. Corrugations

Thickness, in.	Pipe-Arch Area, sq ft
0.111	38 or less
0.140	71 or less
0.170	122 or less
0.188	131 or less

For thicknesses, diameters, or areas not listed above, the Engineer shall be contacted for approval.

713.06 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.

713.07 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.

713.08 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 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.

713.09 Method of Measurement

Temporary bridges, temporary pipes, and approaches will not be measured for payment unless otherwise specified. HMA mixtures for temporary pavement will be measured by the ton. Guardrail of the type specified will be measured by the 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 621.13. The removal and disposal of temporary HMA pavement will not be measured for payment.

713.10 Basis of Payment

The accepted quantities of temporary bridge and approaches, or temporary pipe 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 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 621.14.

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	**Pay Unit Symbol**
Guardrail End Treatment, ____, Temporary Bridge Approaches (type)	EACH
Guardrail, W-Beam, ____ ft.-____ in. Spacing, Temporary Bridge Approaches	LFT
Temporary Bridge	LS
Temporary Bridge and Approaches	LS
Temporary Pipe and Approaches	LS
Temporary Pipe	LS

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

The cost of furnishing, installation, and removal of guardrail and guardrail end treatment shall be included in the cost 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 – REINFORCED CONCRETE BOX STRUCTURES

714.01 Description

This work shall consist of the construction of a cast-in-place or precast reinforced concrete box structure and such parts of similar structures composed of concrete in accordance with these specifications and 105.03.

The Contractor will be allowed to substitute a three-sided structure in accordance with 723. The three-sided structure shall be of equivalent hydraulic capacity to that of the box structure shown on the plans. The structure shall be sumped as shown on the plans.

714.02 Materials

Materials shall be in accordance with the following:

Chemical Anchor System	901.05
Coarse Aggregates, Class A or Higher, Size No. 91	904

Concrete	702
Epoxy Coated Reinforcing Bars	910.01
Flowable Backfill	213
Geotextile	918.01 or 918.02
Hydrated Lime	913.04(a)
Joint Membrane System for Precast Reinforced Concrete Box Structure Sections	907.07
Masonry Cement	901.01(c)
Mortar Sand	904.02(e)
Natural Sand	904.02(a)
Pipe Joint Sealant	907.11
Portland Cement	901.01(b)
Precast Reinforced Concrete Headwalls, Wingwalls, Footings, and Spandrel Walls	907.06
Precast Reinforced Concrete Structure Sections	907.05
Reinforcing Bars	910.01
Riprap	904
Sealer	909.09 or 909.10
WWR, Smooth and Deformed	910.01
Structure Backfill	904.05

Cast-in-place concrete for a reinforced concrete box structure, or splices between an existing culvert structure and a precast reinforced concrete box structure section extension shall be class A or higher in accordance with 707.04(c). It shall have a 28-day minimum concrete compressive strength of 5,000 psi. Cast-in-place concrete for headwalls or wingwalls shall be class A or higher in accordance with 707.04(c). It shall have a 28-day minimum concrete compressive strength of 4,000 psi.

When the Contractor elects to provide a cast-in-place structure, acceptance of the structure will be based on tests for relative yield, air content, slump, water/cementitious ratio, and compressive strength. Relative yield and air content shall be in accordance with 702.05. The slump and concrete temperature shall be in accordance with 707.04(c). The amount of time from the introduction of mixing water to the cement and aggregates to the completion of the discharge of the concrete shall not exceed 90 minutes. The water/cementitious ratio shall be in accordance with 707.04(d). The 28-day compressive strength shall be equal to or greater than the specified concrete compressive strength and otherwise shall be in accordance with 707.04(c)3. The Contractor shall provide the necessary 6 in. diameter by 12 in. cylinder molds for the Department's use.

For plastic concrete sampling, acceptance testing procedures and casting cylinders will be in accordance with 505.01. Except for footings, concrete flexural strength or results from beam breaks will not be accepted in lieu of concrete compression cylinder test results.

Cast-in-place concrete used to seal existing culverts shall be class A. Cast-in-place concrete for footings shall be class B.

Unless otherwise specified herein, reinforcement may consist of either reinforcing bars or WWR. If specified to be coated, WWR shall be coated with either galvanized coating or epoxy coating, and reinforcing bars shall be coated with epoxy coating. For WWR, material with minimum yield strength of 65 ksi shall be used.

CONSTRUCTION REQUIREMENTS

714.03 General Requirements

Unless otherwise specified, the applicable requirements of 702 and 703 shall apply to the construction of box structures, structure extensions, and concrete parts of similar structures. Excavation and disposal shall be in accordance with the applicable requirements of 206. 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. Handling of box structures shall be in accordance with 907.05. Handling of wingwalls shall be in accordance with 907.06.

When riprap is specified, geotextile shall first be placed on the in-situ soil in accordance with 616.11. Riprap shall then be placed in accordance with 616.

714.04 Design Requirements

Where reinforcing bars are used, reinforcing bar splicing and spacing shall be in accordance with the AASHTO LRFD Bridge Design Specifications, except as modified herein.

(a) Box Structure

A box structure may be designed in accordance with ASTM C 1577 if the box section is listed therein. A box structure section not listed therein shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications with the following exceptions.

The box structure shall be designed in accordance with the soil parameters shown in the contract documents.

Minimum structural reinforcement area shall be at least 0.002 of the gross concrete area A_g or 0.125 sq in./ft, whichever is greater. The allowable variation in diameter of reinforcement shall be in accordance with the tolerances prescribed in the AASHTO specification for that type of reinforcement.

If coated reinforcement is specified, reinforcement, including support devices, in that structure shall be coated. In lieu of coating, the support device may be manufactured of a non-corrosive material.

(b) Concrete Headwalls, Wingwalls, and Footings

Headwalls, wingwalls, and footings may be precast or cast-in-place. Headwalls and wingwalls shall be designed based on a minimum equivalent fluid pressure of 40 lbs/cu ft. If flowable backfill is to be used, the Contractor shall consider the effects of hydrostatic pressure on the wingwalls. Weep holes shall be provided in all wingwalls. Horizontal pressures shall be increased for sloping backfill surfaces and live-load surcharge. Headwall connections and wingwall footings shall be checked for sliding and for overturning.

Wingwalls and wingwall footings shall be designed in accordance with the soil parameters shown in the contract documents.

A headwall with guardrail mounted on top, the anchorage of the headwall to the box structure section, or a moment slab with bridge railing shall be designed for the bridge railing test level shown on the plans.

Reinforcement in headwalls shall consist of reinforcing bars and shall be epoxy coated. Tension splices in circumferential reinforcement shall be made by means of lapping. Where reinforcing bars are used in wingwalls, the maximum spacing for wingwall reinforcing bars shall be 18 in. for horizontal bars and 12 in. for vertical bars.

Concrete cover for headwall and wingwall reinforcement shall be a minimum of 2 in. Concrete cover for footing reinforcement shall be 3 in. for the top and sides, and 4 in. for the bottom.

(c) Working Drawings

Working drawings shall be submitted in accordance with 105.02 for fabrication of a precast reinforced concrete box structure greater than 12 ft span, a box structure of a size not described in ASTM C 1577, headwalls, wingwalls, and footings. Design calculations shall be submitted with the working drawings. Detailed plans for falsework and centering will not be required. Working drawings shall include all details, dimensions, and quantities necessary to construct the structure, headwalls, wingwalls, or footings and shall include, but not be limited to, the following information.

1. Structure span and rise.

2. Structure section details showing all concrete dimensions and reinforcement requirements.

3. Headwall details, showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, spacings, and anchorage details. Headwall elevation and section views shall be provided.

4. Wingwall design calculations and details showing all concrete dimensions, elevations, reinforcement sizes, bending diagrams, lengths, spacings, and anchorage details. Wingwall plan, elevation, and section views shall be provided.

5. Wingwall backfill type and limits.

6. Footing details showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, and spacings indicated. Footing plan and section views shall be provided. The actual soil bearing pressure shall be shown on the footing detail sheets.

7. Structure backfill type and limits for the structure and wingwalls.

8. Minimum concrete strength for all concrete portions of the structure.

714.05 Erection Requirements

The soils in the bottom of the excavation shall be compacted in accordance with 203.23.

Where a precast footing is utilized, a 4 in. layer of coarse aggregate No. 53 in accordance with 301 shall be placed under the full width of the footing. All cast-in-place footings shall be given a smooth float finish. The footing concrete shall reach a compressive strength of 2,000 psi or flexural strength in accordance with 702.24(c) before placement of the wingwalls. The surface shall not vary more than 1/4 in. in 10 ft if tested with a 10 ft straightedge.

Structure backfill shall be placed and compacted in accordance with 211. Structure backfill shall be placed and compacted on each side of the structure to the fill line shown on the plans. During the backfill operation, the difference in elevations of the fill on each side of the structure shall not exceed 24 in.

Unless otherwise specified by the manufacturer on the working drawings, once the level of structure backfill reaches the top of the structure, two lifts shall be spread and hand compacted over the structure without traversing the structure with heavy equipment. Compaction with heavy equipment will not be allowed until a minimum of two lifts have been placed, hand compacted, and accepted.

The operation of equipment over a structure shall be in accordance with the structure manufacturer's recommendations.

714.06 Precast Concrete Headwalls, Wingwalls, and Footings

(a) Headwall Reinforcement Placement Relative to Top of Structure

The headwall shall be a single precast piece which spans from sidewall to sidewall of a span. The vertical headwall reinforcement shall be attached to the top of the structure by either drilling holes or precasting holes. A chemical anchoring material, if used, shall be from the Department's List of Approved Chemical Anchoring Materials.

(b) Wingwall Placement

Each wingwall that is not precast as one unit with the footing shall be set on masonite or steel shims. A minimum gap of 1/2 in. shall be provided between the footing and the bottom of each wingwall. Once the wingwalls are placed, the space underneath the wingwall section to the top of the keyway sides shall be filled with prepackaged grout in accordance with ASTM C 1107, or conventional or self-consolidating fine grout in accordance with ASTM C 476, except as modified herein. If conventional fine grout is used, it shall be troweled into the keyway and mounded on one side of the wingwall. The mound of conventional fine grout shall be vibrated until it passes through to the other side of the wingwall. After completing this process on one side, if the conventional fine grout has not passed through to the other side, the process shall be repeated on the other side. Conventional or self-consolidating fine grout shall be from a prepackaged source or composed of one of the following mixtures.

1. 930 lbs/cu yd Type I portland cement with No. 23 natural sand or mortar sand.

2. 930 lbs/cu yd Type M masonry cement with No. 23 natural sand or mortar sand.

3. 828 lbs/cu yd Type I portland cement and 75 lbs/cu yd hydrated lime with No. 23 natural sand or mortar sand.

The maximum water/cement ratio shall be 0.446 for both conventional and self-consolidating fine grout. An air entraining agent from the Department's list of approved PCC admixtures may be used. A type F or G chemical admixture from the Department's list of approved PCC admixtures shall be used in self-consolidating fine grout in order to achieve the slump flow and visual stability index requirements. Filling procedure B of ASTM C 1611 will be used for measuring slump flow. Appendix X1 of ASTM C 1611 will be used for determining the visual stability index value.

Acceptance of conventional fine grout will be based on an air content of 12% ± 4%. Acceptance of self-consolidating fine grout will be based on tests for air content, slump flow, and visual stability index. Air content shall be 12% ± 4%. Slump flow shall be 27 in. ± 3 in. Visual stability index value shall not exceed 1.

Where prepackaged grout is used, a type C certification in accordance with 916 shall be provided.

Wingwalls shall be connected to the outside box structure sections with bolted steel plates.

714.07 Rejection

Structure sections, headwalls, wingwalls, or footings will be rejected due to the following conditions:

(a) fractures or cracks passing through the section or wall, except for a single end crack which does not exceed one-half the thickness of the section or wall;

(b) defects which indicate proportioning, mixing, or molding which are not in accordance with this specification;

(c) honeycombed or open texture; or

(d) damaged section ends, where such damage prevents making a satisfactory joint.

714.08 Repairs

Structure sections, headwalls, wingwalls, and footings shall be repaired, if necessary, due to imperfections in manufacture, or damage caused by handling or construction. Repairs will be acceptable if it is determined that the repairs are sound, properly finished and cured, and if the repaired structure section, headwall, wingwall, or footing is in accordance with the requirements herein.

714.09 Extension of Existing Structure

All applicable requirements of this specification shall apply to the extension of an existing box structure, slab-top structure, or arch structure. Such portions of the existing structure 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.

Before removing concrete from an existing structure with wingwalls, the Contractor shall saw around the perimeter of the removal area on the interior and exterior of the existing structure a depth of 1 in. All existing reinforcement in the top slab, bottom slab, and sidewalls exposed after concrete removal shall be cleaned and straightened in preparation for lapping with reinforcement from adjacent new work. Where existing reinforcement 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 bars. The holes shall be of the diameter and depth required by the manufacturer of the approved chemical anchor system. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

No concrete shall be removed from an existing structure that has a headwall but no wingwalls. Reinforcing bars to tie the existing structure to the new structure section shall be installed by drilling holes into the face of the existing structure to provide embedment for reinforcing bars. The diameter and depth of the holes shall be according to the recommendations of the manufacturer of the approved chemical anchor system. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

An existing structure shall be extended by one of the following methods.

(a) Precast Reinforced Concrete Box Structure Extension

A cast-in-place concrete splice shall be constructed as a transition between the existing structure and the precast structure extension. The splice reinforcement in the precast structure extension section that will abut the existing structure shall be exposed 18 in. on the tongue end of the precast structure extension section. It shall be lapped 18 in. with either exposed existing structure reinforcement, in the case of an existing structure with wingwalls, or newly installed reinforcing bars in the existing structure, in the case of an existing structure with a headwall only as shown on the plans. Existing exposed structure reinforcement from an existing structure with wingwalls shall be cut off 1 in. from the face of the new precast extension.

If the existing tongue or groove joint end is acceptable and matches the mating joint on the new precast reinforced concrete box structure extension, the new extension may be installed using the mating joint of the existing box structure. No cutting of the box structure or splicing of reinforcement is then required. The joint between the new precast box structure extension and the existing structure shall be sealed as directed below.

(b) Cast-In-Place Concrete Structure Extension

The reinforcement for the structure extension shall be lapped with the exposed reinforcement of the existing structure as shown on the plans.

714.10 Precast Reinforced-Concrete Box Structure Section Joints

Precast reinforced concrete box structure section joints shall be sealed as shown on the plans. Pipe joint sealant shall be applied once the concrete surface temperature is above 40°F or above the minimum application temperature recommended by the pipe joint sealant manufacturer. The concrete surfaces shall be clean and dry prior to application of the pipe joint sealant. Heat may be applied to the concrete surfaces until they are in accordance with the temperature and dryness requirements. The pipe joint sealant 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 2 1/2 in. will be required to start the next roll of material. The manufacturer's application instructions shall apply in addition to the above requirements.

714.11 Method of Measurement

Precast reinforced concrete box structures or structure extensions, precast coated reinforced concrete box structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete box structures or structure extensions, cast-in-place coated reinforced concrete box structures or structure extensions, cast-in-place headwalls, and cast-in-place wingwalls will not be measured. The accepted quantities for payment will be the quantities shown on the plans.

Geotextile and riprap will be measured in accordance with 616.12. Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08. Field drilled holes will be measured in accordance with 702.27.

Plain or coated reinforcement or WWR used in precast reinforced concrete box structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete box structures or structure extensions, cast-in-place headwalls, or cast-in-place wingwalls will not be measured for payment.

If the Contractor elects to provide a three-sided structure in lieu of the box structure shown on the plans, it will be measured in accordance with 723.17.

714.12 Basis of Payment

The accepted quantities of precast reinforced concrete box structures or structure extensions, precast coated reinforced concrete box structures or structure extensions, cast-in-place reinforced concrete box structures or structure extensions, and cast-in-place coated reinforced concrete box structures or structure extensions of the size specified will be paid for at the contract unit price per linear foot.

Geotextile or riprap will be paid for in accordance with 616.13. Structure backfill will be paid for in accordance with 211.10. Flowable backfill will be paid for in accordance with 213.09. Field drilled holes will be paid for in accordance with 702.28.

If the Contractor elects to provide a three-sided structure in lieu of the box structure shown on the plans, it will be paid for in accordance with 723.18. The Department will not incur additional cost for allowing the Contractor to substitute a three-sided structure for the box structure shown on the plans.

Payment will be made under:

Pay Item **Pay Unit Symbol**

Structure Extension, Coated Reinforced Concrete, Box Sections,
____ ft x ____ ft .....LFT
span rise
Structure Extension, Reinforced Concrete, Box Sections,
____ ft x ____ ft .....LFT
span rise
Structure, Coated Reinforced Concrete, Box Sections,
____ ft x ____ ft .....LFT
span rise
Structure, Reinforced Concrete, Box Sections,
____ ft x ____ ft .....LFT
span rise

The cost of excavation except as provided in 206.11(a), expansion joint material, perpetuation of existing drains shown on the plans, removal of portions of existing structures, cleaning out old channels or structures, approved chemical anchor system, precast reinforced concrete structure joints, and necessary incidentals shall be included in the cost of the structure or structure extension.

The cost of precast concrete headwalls, precast concrete wingwalls, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of plain or coated reinforcement or WWR used in precast reinforced concrete box structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete box structures or structure extensions, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of concrete used in a cast-in-place splice shall be included in the cost of the structure extension.

The cost of designing a box structure, box structure extension, headwalls, and wingwalls shall be included in the cost of the structure or structure extension.

The costs of coring, testing, excavation, repairs, plugging core and handling holes, mortar, grout, sealer, cylinder molds, and necessary incidentals shall be included in the cost of the structure. The cost of wingwall footing and the aggregate base under such footing shall be included in the cost of the structure or structure extension.

No additional payment will be made for carrying an underground drain through a structure or structure extension. However, no deduction will be made for the

volume of concrete occupied by the drain pipe in a cast-in-place structure or structure 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. When metal pipe is selected, the same base metal and coating shall be used for the structure or a pipe extension.

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
Concrete	702
Flowable Backfill	213
Geotextiles	918.02
Pipe Joint Sealant	907.11
Reinforcing Bars	910.01
Rubber Type Gaskets	907.13
Straps, Hook Bolts, and Nuts	908.12
Structure Backfill	904

The maximum particle size of backfill material for corrugated pipe shall be less than 1/2 the corrugation depth.

(a) Type 1 Pipe

Type 1 pipe shall be used for culverts under mainline pavement and public road approaches and shall be in accordance with the following:

Clay Pipe, Extra Strength	907.08
Corrugated Aluminum Alloy Pipe and Pipe-Arches	908.04
Corrugated Polyethylene Pipe, Type S	*
Corrugated Steel Pipe and Pipe-Arches	908.02
Non-Reinforced Concrete Pipe, Class 3	907.01
Polymer Precoated Galvanized Corrugated Steel Pipe and Pipe-Arches	908.08
Profile Wall PVC Pipe	*
Reinforced Concrete Horizontal Elliptical Pipe	907.03
Reinforced Concrete Pipe	907.02
Ribbed Polyethylene Pipe	*
Smooth Wall Polyethylene Pipe	*
Smooth Wall PVC Pipe	*
Structural Plate Pipe and Pipe-Arches	908.09

* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

(b) Type 2 Pipe

Type 2 pipe shall be used for storm sewers and shall be in accordance with the following:

Clay Pipe, Extra Strength	907.08
Corrugated Polyethylene Pipe, Type S	*
Fully Bituminous Coated and Lined 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 PVC Pipe	*
Reinforced Concrete Horizontal Elliptical Pipe	907.03
Reinforced Concrete Pipe	907.02
Ribbed Polyethylene Pipe	*
Smooth Wall Polyethylene Pipe	*
Smooth Wall PVC Pipe	*

* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

(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 and shall be in accordance with the following:

Clay Pipe**	907.08
Corrugated Polyethylene Drainage Tubing	*
Corrugated Polyethylene Pipe, Type S**	*
Corrugated Polyethylene Pipe, Type SP	*
Drain Tile**	907.10
Non-Reinforced Concrete Pipe	907.01
Perforated Clay Pipe**	907.09
Perforated PVC Semicircular Pipe	*
Profile Wall PVC Pipe	*

* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

** 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 and shall be in accordance with the following:

Corrugated Aluminum Alloy Pipe and Pipe-Arches	908.04
Corrugated Polyethylene Pipe, Type S	*
Corrugated Steel Pipe and Pipe-Arches	908.02
Fully Bituminous Coated and Lined Corrugated Steel Pipe and Pipe-Arches	908.07
Polymer Precoated Galvanized Corrugated Steel Pipe and Pipe-Arches	908.08
Profile Wall PVC Pipe	*
Ribbed Polyethylene Pipe	*
Smooth Wall Polyethylene Pipe	*
Smooth Wall PVC Pipe	*

* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

(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 in accordance with 908.14.

(h) End Bent Drain Pipe

End bent drain pipe shall be perforated profile wall PVC pipe, perforated smooth wall PVC pipe, or corrugated polyethylene drainage tubing Type SP from the Department's list of approved thermoplastic liner pipe in accordance with 907.16.

(i) Underdrain Outlet Pipe

Pipe shall be smooth wall pipe for outlets in accordance with 907.24.

(j) Grated Box End Sections

Grating for box end sections shall be in accordance with 910.22. Threaded inserts for type II grated box end sections shall have a minimum pull-out capacity of 6,000 lbs. The 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 1/4 in. mesh or galvanized steel wire No. 4 mesh with a minimum wire diameter of 1/32 in. It shall be firmly anchored to the outside of the structure and shall be centered on the holes.

Unless otherwise specified, materials furnished as described herein shall be covered by a type C certification in accordance with 916.

(k) Pipe End Sections

Metal pipe end sections shall be in accordance with 908.06. Precast concrete pipe end sections shall be in accordance with 905.06.

(l) Roadway Drain Casting Extensions

Pipe used for extending roadway drain castings located in a bridge deck shall be in accordance with 907.23, 907.28, or 908.10. Pipe support brackets and all hardware shall be galvanized in accordance with ASTM A 153, class D or ASTM B 695, class 40, type I. A type C certification in accordance with 916 shall be provided for the pipe brackets.

(m) Drainage Pipe through Concrete Masonry

Pipe used as drainage pipe through concrete masonry as described in 702.16 shall be either profile wall or smooth wall PVC from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16, or steel in accordance with 908.11.

(n) Bridge Deck Drain System

Pipe and fittings used in an enclosed bridge deck drainage system shall be cast iron soil pipe in accordance with 908.10 or reinforced thermosetting resin pipe in accordance with 907.28. All mounting hardware shall be installed in accordance with the pipe manufacturer's recommendations. All mounting hardware shall be galvanized in accordance with ASTM B 695, class 40, type I. A type C certification in accordance with 916 shall be provided for the pipe brackets.

CONSTRUCTION REQUIREMENTS

715.03 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.

When riprap is specified, geotextile shall first be placed on the in-situ soil in accordance with 616.11. Riprap shall then be placed in accordance with 616.

715.04 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 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.

715.05 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. Fully bituminous coated and lined corrugated steel pipe and pipe-arches shall only be placed when the ambient temperature is 35°F or above.

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, pipe joint sealant, 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.

715.06 Joining Pipe

Band couplers for AASHTO M 36 type I and type II corrugated steel pipe and pipe-arches shall have corrugations that mesh with the corrugations of the pipe sections being joined or the annular rerolled ends of those pipe sections. Band couplers with projections or dimples may be used with pipe having either annular or

helical corrugations only when corrugated band couplers will not provide a matching connection to both pipes. Band couplers for AASHTO M 36 type IA and IIA corrugated steel pipe and pipe-arches shall have corrugations that mesh with the corrugations of the pipe or shall be gasketed flat bands.

At the connection of a pipe extension to an existing structure where the joint system of the pipe extension differs from that in place, or if a satisfactory joint cannot be obtained between the two structures, 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 18 in. and a thickness of at least 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 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 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 6 in. inside the upgrade end of the pipe.

715.07 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-P-641, 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 6 in. and no more than 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.

715.08 Blank

715.09 Backfilling

All pipes shall be backfilled with structure backfill or flowable backfill. Structure backfill shall be placed in accordance with 211. Flowable backfill shall be placed in accordance with 213.07 as shown on the plans or as directed.

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 2 ft above the groundwater. The remainder of the trench shall be backfilled as shown on the plans.

All pipes, except underdrains, will be visually inspected for acceptance a minimum of 30 days after the completion of backfill operations. Pipes that cannot be visually inspected shall be video inspected for acceptance using equipment in accordance with 718.07. The Engineer will determine the sections of pipe to be video inspected.

For pipes that were video inspected, a copy of the video inspection shall be provided in a format acceptable to the Engineer. The video inspection shall be provided prior to performing the mandrel testing or if mandrel testing is not required, prior to acceptance of the pipe.

For pipe not requiring mandrel testing that is determined to be unacceptable by the Engineer, the unacceptable pipe shall be replaced between the nearest pipe joints or to the nearest structure, or a remediation plan shall be prepared by a professional engineer and submitted to the Engineer for final determination.

After the visual or video inspection, the Contractor shall check pipe deflection by performing a mandrel test for all pipes manufactured from materials listed in the following table or as otherwise directed.

PIPES REQUIRED TO BE MANDREL TESTED			
Pipe Material	Standard Specifications	AASHTO	ASTM
Corrugated Polyethylene Pipe	907.17(b)	M 294	
Ribbed Polyethylene Pipe	907.20		F 894
Smooth Wall Polyethylene Pipe	907.21		F 714
Profile Wall PVC Pipe*	907.22	M 304	
Smooth Wall PVC Pipe	907.23	M 278	F 679

* Mandrel testing will not be required for profile wall PVC pipe in accordance with 907.22 that also is in accordance with ASTM F 949.

The mandrel shall have a minimum of nine arms or prongs and a diameter that is 95% of the nominal pipe diameter. The Contractor shall provide a proving ring that is 95% of the nominal pipe diameter for each mandrel.

The Contractor shall pull the mandrel through the pipe by hand. If the mandrel does not pass through the pipe, the Contractor shall measure and report the minimum diameter of the deficient pipe to the Engineer.

If the minimum diameter of the deficient pipe is between 92.5% and 95.0% of the nominal pipe diameter, the Contractor shall provide an evaluation of the deficient pipe prepared by a professional engineer. The evaluation shall consider the severity of the deflection and its effects on structural integrity, environmental conditions, and the design service life of the pipe. A report summarizing the evaluation and including the professional engineer's recommendation for acceptance, remediation, or replacement of the pipe shall be submitted to the Engineer for final determination.

If the minimum diameter of the deficient pipe is equal to or less than 92.5% of the nominal pipe diameter, the deficient pipe shall either be replaced or a remediation plan shall be prepared by a professional engineer and submitted to the Engineer for final determination.

The deficient pipe shall be replaced if the professional engineer's remediation plan recommends replacement of the pipe or if the pipe has been damaged.

Deficient pipe shall at a minimum be replaced between the nearest pipe joints or to the nearest structure. Replaced or remediated pipe sections shall be mandrel tested a minimum of 30 days after the completion of backfill operations.

Commercial and private drive pipes are excluded from the mandrel testing and video inspection requirements.

Where material other than structure backfill or flowable backfill is allowed and used for backfilling, it shall be of such nature that compacts readily. That portion around and for 6 in. above the top of the pipe shall be free from large stones. This material shall be placed in layers not to exceed 6 in., loose measurement, and each layer compacted thoroughly by means of mechanical tamps. Where coarse aggregate is used for structure backfill, geotextile shall be installed.

An adequate earth cover, as shown on the plans, shall be placed over the structure before heavy equipment is operated 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.

715.10 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. Anchor straps shall be placed at both the upstream and downstream end of each corrugated aluminum alloy, corrugated steel, or structural plate pipe or pipe-arch with a diameter or span of 42 in. or greater. Hook bolts and anchor straps shall be placed at both the upstream and downstream end of each corrugated aluminum alloy, corrugated steel, or structural plate pipe or pipe-arch with a diameter or span of 84 in. or greater.

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 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 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 reinforcement shall have a minimum cover of 1 1/2 in. and shall have a minimum lap of 21 in. The type A construction joint between the floor and the wall is optional for cast in place units.

715.11 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.

715.12 Pavement Replacement

Where a structure is to be placed under an existing pavement, the pavement removal and replacement shall be as shown on the plans.

The pavement replacement areas in asphalt pavements shall be filled with HMA for Structure Installation of the mixture type specified in the pay item in accordance with 402 except OG mixtures shall be in accordance with 401.05. A MAF in accordance with 402.05 will not apply. Mixtures will be accepted in accordance with

402.09. Each course shall be compacted by approved mechanical equipment in accordance with 409.03(d).

The pavement replacement areas in Portland Cement Concrete pavements shall be filled with PCCP in accordance with 502 except utilization of the Department provided spreadsheet is not required for the CMDS.

Partial loads of HMA or PCCP left over from structure installation processes shall not be incorporated into other work.

715.13 Method of Measurement

The accepted quantities of circular pipe, deformed pipe, slotted drain pipe, slotted vane drain pipe, end bent drain pipe, sanitary sewer pipe, and pipe extensions will be measured by the 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.

Where used other than as a roadway drain extension pipe or as a bridge deck drain system, cast iron soil pipe will be measured by the pound based on the theoretical weight shown on the plans.

Roadway drain extension pipe will be measured per each drain extended.

Pipe used as drainage pipe through concrete masonry or pipe used for bridge deck drainage system will not be measured for payment.

Reinforcing bars, 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 5 lft of the smaller diameter pipe will be included for making such connection.

Elbow connections will be measured along the centerline of such connection. An additional 2 lft of pipe of the same diameter as that of the elbow will be included 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.

Pavement replacement and subbase necessary due to structure placement under an existing pavement will be measured to the neat lines shown on the plans.

For structures for which the plans show pipes of differing sizes for either smooth or corrugated interiors, and the corrugated interior alternate is installed, measurement of structure backfill or flowable backfill 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.

Video inspection for pipe will be measured by the linear foot as determined by the electronic equipment.

Geotextile used to wrap backfill material will not be measured for payment.

715.14 Basis of Payment

The accepted quantities of pipe and pipe extensions will be paid for at the contract unit price per linear foot for pipe of the type, shape, and size specified, complete in place. Where used other than as a roadway drain casting extension pipe or as a bridge deck drain system, cast iron soil pipe will be paid for at the contract unit price per pound for the diameter specified.

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. Roadway drain casting extension pipe will be paid for at the contract unit price per each.

Pavement replacement necessary due to structure installation under an existing pavement will be paid for at the contract unit price per ton of HMA for structure installation of the type specified and per square yard for PCCP for structure installation. Subbase will be paid for in accordance with 302.09.

Structure backfill will be paid for in accordance with 211.10. Where used as a substitute for structure backfill, flowable backfill will be paid for as structure backfill. When specified for pipe backfill, 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 10 cu yd or less.

For structures for which the plans show pipes of differing sizes for entire 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.

Video inspections for pipe will be paid for at the contract unit price per linear foot completed.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Concrete Anchor, _____ in. (diameter)	EACH
Concrete Anchor, Min. Area ____ sq ft	EACH
Grated Box End Section, ____, ____, _____ in. (type, slope, diameter)	EACH
Grated Box End Section, ____, ____, Min. Area ____ sq ft (type, slope)	EACH
HMA for Structure Installation, Type _____ (mixture type)	TON

PCCP for Structure Installation ..... SYS
Pipe End Section, _____ in. ..... EACH
diameter
Pipe End Section, Min. Area ____ sq ft ..... EACH
Pipe Extension, Circular, _____ in., _____ ..... LFT
diameter material
Pipe Extension, Deformed, Min. Area ____ sq ft, _____ ..... LFT
material
Pipe, Bridge Deck Drain System ..... LS
Pipe, Drainage through Concrete Masonry ..... LS
Pipe, End Bent Drain, _____ in. ..... LFT
diameter
Pipe, Relaid, ____ in. x ____ in. ..... LFT
span rise
Pipe, Relaid, _____ in. ..... LFT
diameter
Pipe, Roadway Drain Casting Extension ..... EACH
Pipe, Sanitary Sewer, _____ in. ..... LFT
diameter
Pipe, Slotted Drain, _____ in., _____ in. ..... LFT
diameter thickness
Pipe, Slotted Vane Drain, _____ in. ..... LFT
diameter
Pipe, Type ____, Circular, _____ in. ..... LFT
diameter
Pipe, Type ____, Deformed, Min. Area ____ sq ft ..... LFT
Pipe, Underdrain Outlet, _____ in. ..... LFT
diameter
Safety Metal End Section, ____, _____ in. ..... EACH
slope diameter
Safety Metal End Section, ____, Min. Area ____ sq ft ..... EACH
slope
Soil Pipe, Cast Iron, _____ in. ..... LBS
diameter
Video Inspection for Pipe ..... LFT

The cost of reinforcing bars, straps, and hook bolts used in anchors shall be included in the cost of the concrete anchor. The cost of the toe plate anchor and galvanized bolts required for pipe end sections and safety metal end sections shall be included in the cost of the pay items. The cost of pipe support brackets and all hardware used to attach the roadway drain casting extension pipe to the drain casting and the pipe support bracket to the structural member and to the drain extension pipe shall be included in the cost of the pay items. The cost of the pipe, all necessary fittings, all mounting hardware, design costs, and all other costs to provide the bridge deck drain system shown on the plans shall be included in the lump sum cost of the

bridge deck drain system. The cost of concrete backfill for slotted drain pipe and slotted vane drain pipe shall be included in the cost 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 cost 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, 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 in this section. 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 cost of concrete, grating, pipe tubing, reinforcing bars, 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.

Geotextile required for coarse aggregate structure backfill material will not be paid for separately. The cost of the geotextile shall be included in the cost of structure backfill.

The cost of providing video inspection equipment, technician, and a copy of the video inspection shall be included in the cost of video inspection for pipe.

No additional payment will be made for repair, remediation, or replacement of pipes, backfill, video inspection of the repaired, remediated, or replaced pipe, and all other work associated with the repair, remediation, or replacement of unacceptable pipes.

The cost of mandrel testing shall be included in the cost of the pipe.

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 in accordance with 105.03. This specification addresses auger boring, guided boring, horizontal directional drilling using a reamer diameter up to and including 24 in., pipe jacking, and pipe ramming, as defined below.

Installations by means of directional drilling which require a reamer larger than 24 in., microtunneling, or other tunneling methods, may be utilized if approved by the Engineer. The Contractor shall submit a detailed proposal prepared by a professional engineer for installations other than auger boring, guided boring, horizontal directional drilling using a reamer diameter less than 24 in., pipe jacking, and pipe ramming.

The following definitions apply to trenchless pipe installation.

(a) Auger Boring

Technique for forming a bore from a drive shaft to a reception shaft, by means of a rotating cutting head. Spoil is removed back to the drive shaft by helically wound auger flights rotating in a steel casing.

(b) Carrier Pipe

The tube which carries the product being transported and which may pass through casings at highway or railroad crossings. It may be made of steel, concrete, clay, plastic, ductile iron, or other materials.

(c) Casing Pipe

A pipe installed as external protection to a carrier pipe.

(d) Drive Shaft

Excavation from which trenchless technology equipment is launched. It may incorporate a thrust wall to spread reaction loads to the soil.

(e) Guided Boring

A trenchless tunneling method that utilizes small diameter pilot tubes that are installed and steered through the ground utilizing a slanted face at the cutting head containing a target with light emitting diodes, LEDs, and a camera mounted theodolite located in the shaft to achieve high accuracy in line and grade. The hole is enlarged to the same outside diameter of the final product pipe after the installation of the pilot tubes, which is then jacked into place.

(f) Horizontal Directional Drilling

A steerable system for the installation of pipes, conduits, or cables in a shallow arc using a surface launched drilling rig.

(g) Microtunneling

A remote controlled trenchless construction method that simultaneously installs pipes as the soil is excavated. This method provides continuous support of the excavation face with slurry pressure to balance groundwater and earth pressures.

(h) Pipe Jacking

A system of directly installing pipes behind a shield machine by means of hydraulic jacking from a drive shaft such that the pipes form a continuous string in the ground.

(i) Pipe Ramming

A non-steerable system of forming a bore by driving an open ended steel casing using a percussive hammer from a drive shaft. The soil may be removed from the casing by augering, jetting, or compressed air.

(j) Reception Shaft

Excavation into which trenchless technology equipment is driven and recovered following the installation of the pipe.

(k) Response Levels

Pre-established levels of instrument readings of settlement or of other monitored behavior such as lateral movement or vibrations, which trigger the implementation of mitigative measures. Response levels consist of the initial review level, at which mitigative measures must be implemented, and the alert level, at which construction must be halted and actions taken to ensure the alert level will not be exceeded in subsequent construction.

(l) Spoils

Earth, rock, or other materials displaced by a tunnel or casing, and removed as the tunnel or casing is installed.

MATERIALS

716.02 Materials

Materials shall be in accordance with the following:

Cellular Grout	725
Clay Pipe, Extra Strength	907.08
PVC Pipe	*
Reinforced Concrete Pipe	907.02
Smooth Wall Polyethylene Pipe	*
Steel Pipe	908.11
Water	913.01

* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

Concrete pipe shall be from the Department's Approved List for Certified Precast Concrete Producers.

Concrete pipe installed by means of pipe jacking shall be designed with sufficient concrete strength and steel reinforcement to resist jacking forces and shall have tongue and groove joints. All reinforced concrete pipes shall have steel reinforcement concentric with the pipe wall.

Steel pipe used as a carrier pipe shall have the following minimum wall thickness. Steel pipe used as a casing pipe, but not used as a carrier pipe, shall be selected by the Contractor to have minimum wall thickness sufficient to resist jacking forces. For installations where the casing is not used as a carrier but only as a casing for a carrier pipe, the thickness of the casing shall be determined by the Contractor.

Outside Diameter, in.	Wall Thickness, in.
18 or less	1/4
19 – 20	5/16
21 – 26	3/8
27 – 30	1/2
31 – 42	1/2
43 – 48	9/16

CONSTRUCTION REQUIREMENTS

716.03 General Requirements

The Contractor shall submit a Quality Control Plan, QCP, in accordance with ITM 803. The QCP shall be submitted to the Engineer for review and acceptance, at least 15 days prior to the start of trenchless pipe installation operations.

Where ground water is known or anticipated, and where the technique selected for trenchless pipe installation does not provide positive support at the trenchless excavation face, such as by slurry support in microtunneling, then trenchless pipe installation shall not proceed without dewatering in advance of trenchless pipe installation. 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.

Where 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 watertight. Where welded joints are utilized, they shall be welded in accordance with 711.32. Joints in concrete pipe or other jacking pipe materials including clay pipe shall be designed to withstand the additional forces that are created in the joints during the installation process. The joints in concrete pipe or other pipe jacking materials 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.

Pavement or ground surface heave or settlement resulting in damage to pavement, existing utilities, or structures above the installation will not be allowed. To confirm if heave or settlement is occurring, the Contractor shall undertake surface monitoring.

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 1 in., grouting shall be used to fill such voids.

When the installation is 4 in. or larger and the casing is used as the carrier pipe, a visual or a video inspection shall be performed using a high resolution, high sensitivity color video camera and recording equipment. The pipe shall be cleaned of debris prior to the inspection. Cleaning shall be accomplished by means of water jetting or other approved methods.

The camera and recording equipment shall be specifically designed for continuous viewing and 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. 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 or replaced as approved by the Engineer.

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, the Engineer shall be notified. For installations utilizing tunnel shields or tunnel-boring machines or other methods that allow access to the face, the obstruction shall be removed in accordance with the QCP. For installations utilizing methods that do not allow access to the face, at the direction of the Engineer, the pipe shall be abandoned in place and filled with grout or other approved materials.

Where 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 with cellular grout.

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.

716.04 Method of Measurement

Pipe installed by means of trenchless installation methods will be measured by the linear foot along the center line of the pipe installed.

716.05 Basis of Payment

Pipe installed by means of trenchless installation methods will be paid for by the linear foot for pipe installation, trenchless, of the size specified, complete and in place including all incidentals.

Removal of boulders, concrete, or other obstructions will be paid in accordance with 104.03.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Pipe Installation, Trenchless, _____ size	LFT

The cost of the QCP, excavating and backfilling of the drive shaft and reception shaft, video inspection, camera and recording equipment, bentonite or other lubricant, grout, and the casing if 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.

No payment will be made to repair or replace sections of pipe that have been damaged or show evidence of joint failure.

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 105.03.

717.02 Materials

Materials shall be in accordance with the following:

Concrete, Class A	702
Flowable Backfill	213
Pipe Joint Sealant	907.11
Reinforcing Bars	910.01
Structural Plate Arches	908.09
Structural Plate Pipe and Pipe-Arches	908.09
Structure Backfill	904.05

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. When metal pipe is selected, the same base metal and coating shall be used for the structure or a pipe extension.

CONSTRUCTION REQUIREMENTS

717.03 General Requirements

Forming, punching, and assembling shall be in accordance with AASHTO LRFD Bridge Construction Specifications. 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 bars 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 structure. Where the span of the arch is greater than 14 ft, or the skew angle is more than 20°, 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 3/16 in. in thickness with the horizontal leg securely anchored to the substructure on 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 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 12 in. and no more than 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

All structural plate pipe and pipe arches shall be backfilled with structure backfill or flowable backfill. Arch 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. Structure backfill shall be placed in accordance with 211. Flowable backfill shall be placed in accordance with 213.

An adequate earth cover shall be provided over the structure, as shown on the plans, before heavy construction equipment is operated over it. This earth cover shall be free of stones.

Where 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 allowed, except below the free water table, then the provisions of 203.23 do not apply.

717.05 Relaid 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 WWR and sealed with pipe joint sealant 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, new, extended, and re-laid, will be measured in accordance with 715.13. Structural plate arches will be measured by the 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 bars used in substructures will be measured in accordance with 703.07. Concrete anchors will be measured in accordance with 715.13. Reinforcing bars, straps, and hook bolts used in anchors will not be measured for payment.

Structural 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 re-laid structural plate pipe, or pipe-arch will be paid for in accordance with 715.14. 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 702.28. Reinforcing bars

in substructures will be paid for in accordance with 703.08. Concrete anchors will be paid for in accordance with 715.14.

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 715.14. Structure backfill will be paid for in accordance with 211.10. Where used as a substitute for structure backfill, flowable backfill will be paid for as structure backfill. Where specified for backfill, 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 715.14.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Arch, Structural Plate, Min. Area ____ sq ft	LFT

The cost of excavation, concrete field paved inverts, disposal of surplus materials, reinforcing bars, straps, and hook bolts used in anchors, and necessary incidentals shall be included in the cost of the pay item.

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	918.03
Reinforcing Bars	910.01
Sod, including Nursery Sod	621
Structure Backfill	904.05
Underdrain Outlet Pipe	*
Underdrain Pipe	715.02(d)

* All thermoplastic pipes shall be from the Department's list of approved thermoplastic pipe and liner pipe in accordance with 907.16

Transition pipes, 45° elbows, elbow connector pipes, and increasers shall be of the same material as the underdrain outlet pipe.

Rodent screens shall be woven stainless steel wire mesh or galvanized hardware cloth. Coarse aggregate No. 8 or 9 shall be used for 6 in. underdrain installations and for underdrains for MSE walls. Coarse aggregate No. 9 shall be used for 4 in. underdrain installations.

The mixture for HMA for underdrains shall be Intermediate OG19.0 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

(a) Locations Outside MSE Wall Ground Reinforcement Limits

Trenches shall be excavated to the dimensions and grade shown on the plans. Each longitudinal underdrain trench shall be cut continuously across all twin outlet areas and all single outlet areas. Such pipeless portions of the trench shall be backfilled with aggregate for underdrains. Pipes shall be secured to ensure that the pipe's required grade and horizontal alignment 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. The pipe shall be installed in the underdrain trench such that a minimum clearance of 2 in. exists between the pipe and the trench walls. Aggregate for underdrains shall be placed in a manner which minimizes contamination. HMA for underdrains shall be placed and compacted separately from mainline mixtures. HMA for underdrains may be placed in one lift and shall be compacted with equipment in accordance with 409.03(d).

If plain end concrete pipe is being laid, no joint width shall not exceed 1/4 in.

(b) Underdrains Within MSE Wall Ground Reinforcement Limits

Underdrains for MSE walls shall be as shown on the plans. Coarse aggregate used as underdrains for MSE walls shall be compacted in accordance with 706.04.

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 1 ft. The upstream geotextile shall overlap the downstream geotextile. Placement of aggregate shall proceed following placement of the geotextile. HMA for underdrains shall be placed and compacted

separately from mainline mixtures. HMA for underdrains may be placed in one lift and shall be compacted with equipment in accordance with 409.03(d).

718.05 Underdrain Outlets

If the underdrain pipe and the outlet pipe are of different sizes, an increaser of the same material as the outlet pipe shall be installed between the transition pipe and the 45° elbow. If a single outlet pipe is to be skewed at 45°, a second 45° elbow and an elbow-connector pipe are not required.

The outlet pipe or pipes shall be located as close as possible to the center of the outlet protector.

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 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 record video of a quality and in a format acceptable to the Engineer. 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 pipe that impedes the progress of the camera, blockages, vertical pipe sags filled with water to a depth of d/2 or greater, 90° 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 Patching Underdrains

Underdrains that are disturbed shall be repaired such that the underdrain is perpetuated. This repair shall include the construction of new outlets where the existing configuration prior to the damage cannot be reinstalled. The repairs shall be as approved by the Department. Once the repairs are completed, a video inspection may be required by the Department to verify that the repairs have been successfully completed.

Geocomposite edge drains that are disturbed shall be outletted as approved and not perpetuated.

718.09 Method of Measurement

Underdrain and outlet pipe will be measured by the linear foot, complete in place. If the pipe connects to structures such as manholes, inlets, or catch basins, the pipe will be field measured to the outside face of the structures. Outlet protectors will be measured by the number and type of units installed.

Measurement of outlet pipe will be made along the centerline of the pipe from the point of connection with the underdrain pipe to the downstream end of the outlet pipe and will include all transitions, elbows, and increaser or decreaser connections.

Structure backfill will be measured in accordance with 211.09. HMA for underdrains will be measured by the ton.

Aggregate for underdrains and underdrains for MSE walls will be measured by the 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 yard based on the neat line limits shown on the plans.

Video inspections for underdrains will be measured by the linear foot as determined by the electronic equipment.

Patching of underdrains will not be measured.

Rodent screens and other incidentals will not be measured for payment.

Concrete, reinforcing bars, or sod for underdrain outlet protectors will not be measured for payment.

718.10 Basis of Payment

The accepted quantities of underdrains and underdrain outlet pipe will be paid for in accordance with 715.14. Aggregate for underdrains will be paid for at the contract unit price per cubic yard. Underdrains for MSE walls will be paid for as aggregate for underdrains. Geotextile for underdrains will be paid for at the contract unit price per 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 ton.

Underdrain patching for structure installation will be paid for at the contract unit price per linear foot of underdrain, patching and shall be equal to the length of the theoretical pavement replacement as shown on the plans.

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 linear foot.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Aggregate for Underdrains	CYS
Geotextile for Underdrains	SYS
HMA for Underdrains	TON
Outlet Protector, ____ type	EACH
Underdrain, Patching	LFT
Video Inspection for Underdrain	LFT

Geotextile for underdrains which has been rejected due to contamination or other reasons shall be replaced with no additional payment.

The cost of excavation, forming, reinforcing bars, concrete, curing materials, and sod shall be included in the cost of outlet protector.

The cost of providing the video inspection equipment, technician, and a copy of the video inspection shall be included in the cost of the underdrain video inspection. The cost of repair of underdrain pipes, aggregates, backfill, outlet protectors, geotextile fabric, providing video re-inspection of the repairs, and other incidentals shall be included in the cost of the other pay items in this section.

Where underdrain repair for structure installation is required, the cost of underdrain pipe, aggregate for underdrains, geotextile for underdrains, HMA for underdrains, outlet protectors if required, video inspection for underdrains, and all other incidentals for underdrains shall be included in the cost of underdrain,

patching. The cost of repairing underdrains damaged by activities other than for structure installation, or as defined above, shall be at the Contractor's expense.

The cost of disposal of unsuitable excavated materials, installation of pipe end caps, rodent screens, and other incidentals shall be included in the cost of the pay items in this section.

SECTION 719 – TILE DRAINS

719.01 Description

This work shall consist of the installation of drain tile in accordance with 105.03.

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 Bars	910.01
Riprap	616.02
Structure Backfill	904
Rodent Screen	718.02

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 pans, the trench shall be of sufficient width to provide ample working space on each side of the drain tile to enable 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 1 in. thick, 10 in. wide, and 10 ft long.

If rock is encountered at or above the required trench bottom grade, the trench shall be excavated at least 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 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 10-foot 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 715.09.

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 715.13. Terminating pipe sections of the type and size specified will be measured per 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 616.12.

Tee or wye branch connections will be measured per each along the centerline of the barrel. An additional allowance of 5 lft 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 2 lft 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 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 715.14. Terminating pipe sections will be paid for at the contract unit price per 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 616.13.

Tee and wye connections will be paid for by means of the allowance of an additional 5 lft of the smaller pipe at the connection. Elbow connections will be paid for by means of the allowance of an additional 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:

Pay Item	**Pay Unit Symbol**
Pipe, Drain Tile Terminal Section, _____ in. diameter	LFT

The cost 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 105.03.

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 Brick	905.02
Concrete Masonry Blocks	905.03
Concrete	702
Hydrated Lime	913.04
Joint Filler	906.01
Joint Mortar	901.08, 907.12
Non-Reinforced Concrete Pipe	907.01
Precast Concrete Manholes, Inlets, and Catch Basins	907.04
Reinforced Concrete Pipe	907.02
Reinforcing Bars	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 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 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 1 part cement to 2 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 6 in. seal is formed. Joints between hoods and walls shall be made gas tight.

Mortar for laying brick and masonry units shall be composed of 1 part masonry cement and 2 parts mortar sand. Mortar for plastering may be the same or it may be composed of 1 part of a combination of portland cement and hydrated lime and 2 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 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 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.

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 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 120 ft lbs.

Steel grating type 12 shall be an approved, galvanized grating which shall be of sufficient strength to support a 12,000 lb wheel load with a maximum fiber stress of 20,000 lbs/sq in. 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 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 7 in. and a bearing plate for such casing 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 3/8 in. in width. All units shall be wetted thoroughly immediately prior to being laid. Broken or chipped units will not be allowed 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 1/2 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 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 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 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 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 12 in. average height of the upper portion of the masonry.

When manholes, 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 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 directed, be adjusted to grade after the last binder course has been laid and before placing the surface course.

720.05 Capping Existing Structures

All structures directed to be capped shall be as shown on the plans or by filling the structure with class A concrete after the existing drainage has been maintained. The flow of water through pipes or underdrains in structures shall be perpetuated. Alternate methods for capping shall be submitted for approval before they may be used.

720.06 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 12 in. If corrections to the structure involve portions exceeding an average adjustment height of 12 in., the additional work will be measured by the linear foot for the type of structure involved.

The capping of existing structures will be measured by the number of structures capped.

720.07 Basis of Payment

The accepted quantities of manholes, inlets, spring boxes, catch basins, castings adjusted to grade not exceeding 12 in., and castings furnished and adjusted to grade not exceeding 12 in. will be paid for at the contract unit price per each, complete in place.

That portion of a reconstructed structure which exceeds 12 in. in average height will be paid for at the contract unit price per linear foot, for structure, of the type specified, reconstruct, complete in place.

The capping of inlets and other structures will be paid for at the contract unit price per each for cap inlet.

Payment will be made under:

Pay Item	**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, ____ ..... EACH
type

Pipe Catch Basin, ____ in. ..... EACH
size

Spring Box ..... EACH

Structure, ____, Reconstructed ..... LFT
type

The cost of both inlets, the 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 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 cost of excavation, backfill, reinforcing bars, structure backfill, concrete collar required for pipe connection to structures, removal, disposal and replacement of pavement, or surface material, casting removal, installation of concrete cap, HMA wedge, damage repair to pavement and shoulders, and necessary incidentals shall be included in the cost 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 105.03.

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 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 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:

Pay Item	**Pay Unit Symbol**
Automatic Drainage Gate, _____ in. (diameter)	EACH
Automatic Drainage Gate, _____ in. (width) x _____ in. (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 accordance with 105.03.

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
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 No. 4 (4.75 mm) sieve. The coarse aggregate shall be No. 11, class A crushed stone. The cement content shall be a minimum of 658 lbs/cu yd of concrete. The same brand of cement shall be used throughout a bridge structure. The amount of latex modifier shall be 3.5 gal. per 94 lbs of cement. The net water added shall produce a slump of 5 in. ± 1 in. at 4 to 5 minutes 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 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 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 minutes 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 564 lbs/cu yd of portland cement type III or type IIIA, or 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 4 in.

722.05 Preparation of the Bridge Floor

(a) Concrete Removal

1. Deck Surface

The top 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 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. Jackhammers shall not be heavier than nominal 45 lb class and chipping hammers shall not be heavier than nominal 15 lb class. Only chipping hammers shall be used when removing concrete within 1 in. of reinforcing bars. Mechanically driven tools shall be operated at a maximum angle of 45° 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 allowed. 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 reinforcing bars have been exposed or the bond between the existing concrete and reinforcing bars has been destroyed, the concrete adjacent to the bars shall be removed to a minimum clearance of 1 in. around the entire periphery of the exposed bars. If the concrete is unsound down to the top layer of bottom reinforcing bars, 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 bars shall not be damaged by the removal operation. Any damaged reinforcing bars 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 1 in. vertical surface shall remain, or be cut, 1 in. 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 patches or 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 bars and the concrete under and around the exposed bars shall be thoroughly cleaned by sandblasting. The surface shall be then cleaned free of all dust, chips, water, and foreign material to the extent necessary to produce a firm, solid surface for adherence of the new concrete. 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 requested and approved. 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 550 psi. Curing of the patch shall be as directed.

1. Patching with Bridge Deck Patching Concrete

Epoxy resin adhesive shall be used to coat the surfaces of the prepared cavities and all the exposed reinforcement 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 722.09. 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 722.09. The cavities shall then be filled with the latex modified concrete at the time that the overlay is placed.

722.07 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 722.04.

The existing concrete shall be removed as required in accordance with 722.05(a). Exposed reinforcement shall not be cut or otherwise damaged.

Power driven hand tools for removal by handchipping will be allowed. Pneumatic hammers with a maximum weight of 69 lbs 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 bars, and the concrete under and around the bars 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.

722.08 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 722.12. Sufficient mixing capacity or mixers shall be provided to enable the intended pour to be placed without interruption. The mixer shall carry sufficient quantities of unmixed ingredients to produce at least 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 94 lbs 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.

722.09 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 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 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 three-quarters 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 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 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 45 in. in length, or a vibrating oscillating metal faced screed of 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.

722.10 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 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.

722.11 Curing

When fly ash is used, the requirement for additional wet 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, 702.22 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 4,000 psi or greater. The strength requirements, and the making and curing of the cylinders, shall be in accordance with 702.24. 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 50°F during either the wet or dry curing periods, the time that the temperature is below 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 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 3/8 in. in depth shall not be sealed at this time. Corrective procedures for repairing cracks exceeding 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.

722.12 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 1/4 lb intervals with a minimum capacity of 500 lbs. 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 94 lbs of cement. At least 3,760 lbs 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 90 lbs 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 94 lbs of cement and the time required to discharge 94 lbs of cement.

$$94 \div \frac{A}{B} = \text{Counts per 94 lbs of cement}$$

$$94 \div \frac{A}{C} = \text{Time in seconds per 94 lbs of cement}$$

A = Total weight of cement in 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 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 weight in pounds of the discharged water shall be divided by 8.33 to determine the number of gallons. This procedure shall be repeated with the flow meter adjusted to 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 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 No. 4 (4.75 mm) sieve. The fine aggregate will be considered as the amount passing the No. 4 (4.75 mm) 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 94 lbs of cement. With the unit operating at the required revolutions per minute for the calculated time in seconds per 94 lbs 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 1/2 lb of the amount required for each 94 lbs 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.

722.13 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 722.08.

(g) Placing and Finishing

Placing and finishing shall be in accordance with the applicable provisions of 722.09. Machine finishing shall be required when directed.

(h) Texturing

Texturing shall be in accordance with 722.10. In addition, the surface texturing shall match the pattern of the adjacent overlay.

(i) Curing

Curing shall be in accordance with 722.11.

(j) Calibration of Continuous Mixers

Calibration shall be in accordance with 722.12.

722.14 Method of Measurement

Surface milling will be measured by the square yard for the initial 1/4 in. depth. Additional surface removal required below the initial 1/4 in. depth will be measured by the square yard for each required 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 foot. The patching material used in full depth patching will not be measured for payment.

Partial depth patching will be measured by the square foot. 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 2 in. and converting the resulting volume into cubic yards. Overlay material used in partial depth patching will be measured by the 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 yard. Such quantity will be included in the measurement of additional bridge deck overlay.

Bridge deck overlay will be measured by the square yard for the specified thickness. If there is no specified thickness shown on the plans, the specified thickness shall be 1 3/4 in.

Overlay dams and patching an existing overlay will be measured by the 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.

722.15 Basis of Payment

Milling of the initial 1/4 in. depth of surface will be paid for at the contract unit price per square yard for surface milling. Additional surface removal below the initial 1/4 in. depth will be paid for at the contract unit price per square yard for surface milling for each required 1/4 in. depth.

Full depth patching will be paid for at the contract unit price per square foot for bridge deck patching, full depth.

Partial depth patching will be paid for at the contract unit price per square foot for bridge deck patching, partial depth.

Prepared partial depth cavities exceeding 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 foot for bridge deck patching, partial depth. Additional payment will be made at 80% of the contract unit price per square foot for bridge deck patching, full depth.

Prepared partial depth cavities of 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 foot for bridge deck patching, full depth.

Patching material used for partial depth patching will be paid for at the contract unit price of $550 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 $550 per cubic yard for bridge deck overlay, additional.

Bridge deck overlay will be paid for at the contract unit price per square yard.

Patching an existing bridge deck overlay will be paid for at the contract unit price per square foot for bridge deck overlay patching.

Overlay dam will be paid for at the contract unit price per square foot, complete in place.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Bridge Deck Overlay	SYS
Bridge Deck Overlay, Additional	CYS
Bridge Deck Overlay, Patching	SFT
Bridge Deck Patching, Full Depth	SFT

Bridge Deck Patching, Partial Depth.....SFT
Overlay Dam .....SFT
Surface Milling..... 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 722.11 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 – REINFORCED CONCRETE THREE-SIDED STRUCTURES

723.01 Description

This work shall consist of constructing a reinforced concrete three-sided arch-topped structure or structure extension with headwalls and wingwalls, a reinforced concrete three-sided flat-topped structure or structure extension with headwalls and wingwalls, or a reinforced concrete true arch shape structure or structure extension with spandrel walls and wingwalls in accordance with 105.03. The reinforced concrete three-sided structure, structure extension, headwalls, wingwalls, footings, and spandrel walls may be precast or cast-in-place.

The Contractor will be allowed to substitute a box structure in accordance with 714. The box structure shall be of equivalent hydraulic capacity to that of the three-sided structure shown on the plans. The structure shall be sumped as shown on the plans.

MATERIALS

723.02 Materials

Materials shall be in accordance with the following:

Chemical Anchor System	901.05
Coarse Aggregates, Class A or Higher, Size No. 91	904
Concrete	702
Epoxy Coated Reinforcing Bars	910.01(b)9
Flowable Backfill	213
Geotextile	918.01, 918.02, or 918.03
Hydrated Lime	913.04(a)
Masonry Cement	901.01(c)
Mortar Sand	904.02(e)
Natural Sand	904.02(a)
Pipe Joint Sealant	907.11
Portland Cement	901.01(b)
Precast Reinforced Concrete Headwalls, Wingwalls, Footings, and Spandrel Walls	907.06
Precast Reinforced Concrete Structure Sections	907.05
Reinforcing Bars	910.01
Riprap	904
Sealer	909.09 or 909.10
WWR, Smooth and Deformed	910.01
Structure Backfill	904

Cast-in-place concrete for a reinforced concrete three-sided structure, or splices between an existing culvert structure and a precast reinforced concrete three-sided structure extension shall be class A or higher in accordance with 707.04(c). It shall have a 28-day minimum concrete compressive strength of 5,000 psi. Cast-in-place concrete for headwalls, wingwalls, or spandrel walls shall be class A or higher in accordance with 707.04(c). It shall have a 28-day minimum concrete compressive strength of 4,000 psi.

When the Contractor elects to provide a cast-in-place structure, acceptance of the structure will be based on tests for relative yield, air content, slump, water cementitious ratio, and compressive strength. Relative yield and air content shall be in accordance with 702.05. The slump and concrete temperature shall be in accordance with 707.04(c). The amount of time from the introduction of mixing water to the cement and aggregates to the completion of the discharge of the concrete shall not exceed 90 minutes. The water cementitious ratio shall be in accordance with 707.04(d). The 28-day compressive strength shall be equal to or greater than the specified concrete compressive strength and otherwise shall be in accordance with 707.04(c)3. The Contractor shall provide the necessary 6 in. diameter by 12 in. cylinder molds for the Department's use.

For plastic concrete sampling, acceptance testing procedures and casting cylinders will be in accordance with 505.01. Except for footings, concrete flexural strength or results from beam breaks will not be accepted in lieu of concrete compression cylinder test results.

Cast-in-place concrete used to seal existing culverts shall be class A. Cast-in-place concrete for footings and base slabs shall be class B.

Unless otherwise specified herein, reinforcement may consist of either reinforcing bars or welded wire reinforcement, WWR. If specified to be coated, WWR shall be coated with either galvanized coating or epoxy coating, and reinforcing bars shall be coated with epoxy coating. For WWR, material with minimum yield strength of 65 ksi shall be used.

Reinforcement in headwalls and pedestals shall consist of reinforcing bars and shall be epoxy coated. Reinforcement in spandrel walls shall be coated. If the structure is specified as requiring coated reinforcement, reinforcement, including support devices, in that structure shall be coated. In lieu of coating, the support device may be manufactured of a non-corrosive material.

Headwalls, wingwalls and spandrel walls shall be connected to the outside structure sections. Wingwalls shall be connected to the spandrel walls if the structure is a true arch shape structure. Precast headwalls, precast wingwalls, and precast spandrel walls shall be connected with bolted steel plates.

CONSTRUCTION REQUIREMENTS

723.03 General Requirements

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. Handling of three-sided structures shall be in accordance with 907.05. Handling of wingwalls and spandrel walls shall be in accordance with 907.06.

For precast three-sided structures, the manufacturer's representative shall provide technical instruction and on-site technical assistance to the Contractor during the erection of the members.

723.04 Design Requirements

A three-sided structure shall be designed for HL-93 loading in accordance with AASHTO LRFD Bridge Design Specifications.

The three-sided structure, headwalls, wingwalls, footings, and spandrel walls shall be designed in accordance with the soil parameters shown in the contract documents.

Headwalls, wingwalls, and spandrel walls shall be designed based on a minimum equivalent fluid pressure of 40 lbs/cu ft. If flowable backfill is to be used, the Contractor shall consider the effects of hydrostatic pressure on the structure. Weep holes shall be provided in all wingwalls. Horizontal pressures shall be increased for sloping backfill surfaces and live load surcharge. Headwall connections, wingwall footings, and spandrel walls shall be checked for sliding and for overturning.

A headwall with guardrail mounted on top, the anchorage of the headwall or spandrel wall to the structure section, or a moment slab with bridge railing, shall be designed for the bridge railing test level shown on the plans.

Continuity shall be established between the structure footing and the wingwall footing.

(a) Placement of Reinforcement

For three-sided arch-topped or true arch shape structure sections, the concrete cover over the outside circumferential reinforcement shall be a minimum of 2 in. The cover over the inside circumferential reinforcement shall be a minimum of 1 1/2 in. The clear distance of the end circumferential reinforcement shall not be less than 1 in. and no more than 2 in. from the ends of the structure section. The ends of the longitudinal distribution reinforcement shall be no more than 3 in. from the ends of the structure section.

For flat-topped structure sections, the cover dimension over the top mat of reinforcement shall be a minimum of 2 in. The cover over the lower mat of reinforcement in the structure top shall be a minimum of 1 1/2 in. The cover in the legs shall be a minimum of 2 in. The clear distance of the end circumferential reinforcement shall not be less than 1 in. and no more than 2 in. from the ends of the structure section. The ends of the longitudinal distribution reinforcement shall be no more than 2 in. from the ends of the structure section.

Cover for headwall, wingwall, spandrel wall, and pedestal reinforcement shall be a minimum of 2 in. Cover for footing and base slab reinforcement shall be 3 in. for the top and sides and 4 in. for the bottom.

(b) Splicing and Spacing of Reinforcement

Reinforcement splicing and spacing shall be in accordance with the AASHTO LRFD Bridge Design Specifications except as indicated herein. Tension splices in circumferential reinforcement shall be made by means of lapping. Where reinforcing bars are used for longitudinal distribution reinforcement, the reinforcing bars shall

have a center to center spacing not to exceed 12 in. in flat-topped structure sections or 16 in. in arch-topped or true arch shape structure sections.

Where reinforcing bars are used in wingwalls, the maximum spacing for wingwall reinforcing bars shall be 18 in. for horizontal bars and 12 in. for vertical bars.

Exterior corner reinforcement for flat-topped structure sections shall be fully developed beyond the point where it is no longer required to resist flexure.

(c) Working Drawings

Working drawings shall be submitted in accordance with 105.02 for fabrication of a precast or cast-in-place reinforced concrete three-sided structure, precast or cast-in-place reinforced concrete three-sided structure extension, precast or cast-in-place headwalls, precast or cast-in-place wingwalls, and precast or cast-in-place spandrel walls. The working drawings shall include all details, dimensions, and quantities necessary to construct the structure, headwalls, wingwalls, or spandrel walls and shall include, but not be limited to, the following information.

1. Structure span and rise.

2. Structure section details showing all concrete dimensions and reinforcement requirements. An analysis of the precast segment modeled as a simple span and designed in accordance with AASHTO LRFD Bridge Design Specifications Section 5.7.3. This analysis shall demonstrate that the precast segment is designed to withstand the forces of erection.

3. Headwall details showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, spacings, and anchorage details. Headwall elevation and section views shall be provided.

4. Wingwall design calculations and details showing all concrete dimensions, elevations, reinforcement sizes, bending diagrams, lengths, spacings, and anchorage details. Wingwall plan, elevation, and section views shall be provided.

5. Spandrel wall details showing all concrete dimensions, elevations, reinforcement sizes, bending diagrams, lengths, spacings, and anchorage details. Spandrel wall elevation and section views shall be provided.

6. Footing design calculations and details showing all concrete dimensions, elevations, reinforcing bar sizes, reinforcing bar bending diagrams, lengths, and spacings indicated. Footing plan

and section views shall be provided. If a pile footing is required, the pile layout shall be shown. The actual soil bearing pressure shall be shown on the footing detail sheets.

7. Design calculations and details for pedestals or closure pours, if required.

8. Structure backfill type and limits for the structure and wingwalls.

9. Minimum concrete strength for all concrete portions of the structure.

723.05 Manufacture

The structure sections, headwalls, wingwalls, footings and spandrel walls shall be free of fractures. Headwalls, wingwalls, and spandrel walls shall be given a finish in accordance with 702.21.

The structure units shall not be stored in an upright position until the designated handling and storage compressive strength, as shown on the working drawings, has been achieved.

723.06 Rejection

Structure sections, wingwalls, footings, or spandrel walls will be rejected due to the following conditions.

(a) fractures or cracks passing through the section or wall, except for a single end crack which does not exceed one-half the thickness of the section or wall;

(b) defects which indicate proportioning, mixing, or molding which are not in accordance with this specification;

(c) honeycombed or open texture; or

(d) damaged section ends, where such damage prevents making a satisfactory joint.

723.07 Repairs

Structure sections, headwalls, wingwalls, footings or spandrel walls shall be repaired, if necessary, due to imperfections in manufacture, handling damage, or construction. Repairs will be acceptable if it is determined that the repairs are sound, properly finished and cured, and if the repaired structure section headwall, wingwall, footing, or spandrel wall is in accordance with the requirements herein.

723.08 Trench Compaction

The soils in the bottom of the excavation shall be compacted to 95% of the maximum dry density in accordance with 203.23. If 95% of the maximum dry density cannot be obtained in the bottom of the excavation or in other areas, the Office of Geotechnical Services shall be contacted for additional recommendations. If during construction, soft soils are encountered at depths that make removal impractical, the Office of Geotechnical Services shall be contacted for additional recommendations.

723.09 Footings

All footings shall be given a smooth float finish. Footing concrete shall reach a compressive strength of 2,000 psi or flexural strength in accordance with 702.24(c) prior to placement of the structure sections or wingwalls. The surface shall not vary more than 1/4 in. in 10 ft when tested with 10 ft straightedge.

Where a precast footing is utilized, a 4 in. layer of coarse aggregate No. 53 in accordance with 301 shall be placed under the full width of the footing. Precast footings shall be made into a continuous strip footing by the use of closure pours between the precast units. Closure pours shall be as detailed in the working drawings and shall be designed to accommodate the design loads.

723.10 Pedestals

Where a reinforced concrete pedestal is required between the base of the structure leg and the top of the footing, the Contractor shall have the option of providing a structure with extended legs or constructing the pedestals.

723.11 Placement of Structure Sections and Wingwalls

For three-sided arch-topped structures and three-sided flat-topped structures, the structure sections shall be set on masonite or steel shims. Each wingwall that is not precast as one unit with the footing shall be set on masonite or steel shims. A minimum gap of 1/2 in. shall be provided between the footing and the bottom of each section or wingwall. Once the wingwalls or structure sections are placed, the space underneath the wingwall or structure leg section to the top of the keyway sides shall be filled with prepackaged grout in accordance with ASTM C 1107, or conventional or self-consolidating fine grout in accordance with ASTM C 476, except as modified herein. If conventional fine grout is used, it shall be troweled into the keyway and mounded on one side of the leg or wingwall. The mound of conventional fine grout shall be vibrated until it passes through to the other side of the leg or wingwall. After completing this process on one side, if the conventional fine grout has not passed through to the other side, the process shall be repeated on the other side. Conventional or self-consolidating fine grout shall be from a prepackaged source or composed of one of the following mixtures:

(a) 930 lbs/cu yd Type I portland cement with No. 23 natural sand or mortar sand.

(b) 930 lbs/cu yd Type M masonry cement with No. 23 natural sand or mortar sand.

(c) 828 lbs/cu yd Type I portland cement and 75 lbs/cu yd hydrated lime with No. 23 natural sand or mortar sand.

The maximum water/cement ratio shall be 0.446 for both conventional and self-consolidating fine grout. An air entraining agent from the Department's list of approved PCC admixtures may be used. A type F or G chemical admixture from the Department's list of approved PCC admixtures shall be used in self-consolidating fine grout in order to achieve the slump flow and visual stability index requirements. Filling procedure B of ASTM C 1611 will be used for measuring slump flow. Appendix X1 of ASTM C 1611 will be used for determining the visual stability index value.

Acceptance of conventional fine grout will be based on an air content of 12% ± 4%. Acceptance of self-consolidating fine grout will be based on tests for air content, slump flow, and visual stability index. Air content shall be 12% ± 4%. Slump flow shall be 27 in. ± 3 in. Visual stability index value shall not exceed 1.

Where prepackaged grout is used, a type C certification in accordance with 916 shall be provided.

True arch shape structures may have grout leveling pads poured in the footing keyways to ensure the correct seating of the true arch sections. Leveling pads shall be approximately 2 in. thick and 16 in. long to ensure that each true arch section is resting on approximately 8 in. of pad at each joint. The leveling pads shall be poured within 1/8 in. of the required elevation. No loads shall be placed on the grout leveling pads within 72 h of their placement. Masonite shims may also be used as leveling pads. Concrete blocks of 1 1/2 in. thickness, hardwood wedges, and steel or plastic shims shall be placed to retain the true arch sections in their proper positions until grout can be placed in the keyway. Grout shall be consolidated in the keyway to ensure that the entire area around the true arch section is completely filled. The grout used to construct the leveling pads and to fill the keyways shall be in accordance with this section. Grout shall not be placed if the air temperature is expected to be below 35°F for a period of 72 h following grout placement.

723.12 Extension of Existing Structure

All applicable requirements of this specification shall apply to the extension of an existing three-sided arch-topped structure with headwalls and wingwalls, a three-sided flat-topped structure with headwalls and wingwalls, or a true arch shape structure with spandrel walls and wingwalls. Such portions of the existing structure 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.

Before removing concrete from an existing structure with wingwalls, the Contractor shall saw around the perimeter of the removal area on the interior and exterior of the existing structure a depth of 1 in. All existing reinforcement in the top slab and sidewalls exposed after concrete removal shall be cleaned and straightened in preparation for lapping with reinforcement from adjacent new work. Where existing reinforcement 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 bars. The holes shall be of the diameter and depth required by the approved chemical anchor system manufacturer. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

No concrete shall be removed from an existing structure that has a headwall but no wingwalls. Reinforcing bars to tie the existing structure to the new structure section shall be installed by drilling holes into the face of the existing structure to provide embedment for reinforcing bars. The diameter and depth of the holes shall be in accordance with the recommendations of the manufacturer of the approved chemical anchoring system. The holes shall be cleaned prior to placing the approved chemical anchor system and the reinforcing bars.

An existing structure shall be extended by means of one of the following methods.

(a) Precast Reinforced Concrete Three-Sided Structure Extension

A cast-in-place concrete splice shall be constructed as a transition between the existing structure and the precast structure extension. The splice reinforcement in the precast structure extension section that will abut the existing structure shall be exposed 18 in. on the tongue end of the precast structure extension section. It shall be lapped 18 in. with either exposed existing structure reinforcement, in the case of an existing structure with wingwalls, or newly installed reinforcing bars in the existing structure, in the case of an existing structure with a headwall only as shown on the plans. Existing exposed structure reinforcement from an existing structure with wingwalls shall be cut off 1 in. from the face of the new precast extension.

If the existing tongue or groove joint end is acceptable and matches the mating joint on the new precast reinforced concrete structure extension section, the new extension may be installed using the mating joint of the existing structure. No cutting of the structure or splicing of reinforcement is then required. The joint between the new precast structure extension and the existing structure shall be sealed as directed below.

(b) Cast-In-Place Concrete Three-Sided Structure Extension

The reinforcement for the structure extension shall be lapped with the exposed reinforcement of the existing structure as shown on the plans.

723.13 Blank

723.14 Joints

Joints between structure sections for three-sided arch-topped structures and true arch shape structures, and for flat-topped structures with cover of 3 ft or more, may be either butt joints or keyway joints.

The sections of flat-topped structures with less than 3 ft of cover shall be produced with a minimum 4 in. depth by 1 1/2 in. width keyway joint. Non-shrink grout in accordance with 707.09 shall be placed in the keyway joint.

All butt joints between structure sections shall be covered with a joint wrap in accordance with ASTM C 877. The surface shall be free of dirt before the joint material is applied. The entire joint shall be continuously covered. Joints between structure sections and wingwalls, between wingwalls and spandrel walls, and between structure sections and headwalls or spandrel walls shall be covered with either the same wrap used between structure sections or with geotextile in accordance with 918.03.

The joint wrap shall be kept in its proper location over the joint. It shall not be damaged during the backfilling operation.

Joints in true arch shape structures shall be sealed with 1 1/2 in. diameter preformed pipe joint sealant before placement of the joint wrap.

723.15 Backfilling

Structure backfill shall be placed and compacted in accordance with 211. Structure backfill shall be placed and compacted on each side of the structure to the fill line shown on the plans. During the backfill operation, the difference in elevations of the fill on each side of the structure shall not exceed 24 in.

Unless otherwise specified by the manufacturer on the working drawings, once the level of structure backfill reaches the top of the structure, two lifts shall be spread and hand compacted over the structure without traversing the structure with heavy equipment. Compaction with heavy equipment will not be allowed until a minimum of two lifts have been placed, hand compacted, and accepted.

The operation of equipment over the structure shall be in accordance with the structure manufacturer's recommendations.

723.16 Scour Protection

When riprap is specified, geotextile shall first be placed on the in-situ soil in accordance with 616.11. Riprap shall then be placed in accordance with 616.

For concrete base slabs, concrete shall be placed in accordance with 702.

723.17 Method of Measurement

Precast reinforced concrete three-sided flat-topped structures or structure extensions, precast reinforced concrete three-sided arch-topped structures or structure extensions, precast reinforced concrete true arch structures or structure extensions, cast-in-place reinforced concrete three-sided flat-topped structures or structure extensions, cast-in-place reinforced concrete three-sided arch-topped structures or structure extensions, and cast-in-place reinforced concrete true arch structures or structure extensions will not be measured. The accepted quantities for payment will be the quantities shown on the plans.

Structure backfill will be measured in accordance with 211.09. Flowable backfill will be measured in accordance with 213.08. Geotextile and riprap will be measured in accordance with 616.12. Field drilled holes will be measured in accordance with 702.27.

Plain or coated reinforcement or WWR used in precast reinforced concrete three-sided flat-topped structures or structure extensions, precast reinforced concrete three-sided arch-topped structures or structure extensions, precast reinforced concrete true arch structures or structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete three-sided flat-topped structures or structure extensions, cast-in-place reinforced concrete three-sided arch-topped structures or structure extensions, cast-in-place reinforced concrete true arch structures or structure extensions, cast-in-place headwalls, or cast-in-place wingwalls will not be measured for payment.

If the Contractor elects to provide a box structure in lieu of the three-sided structure shown on the plans, it will be measured in accordance with 714.11.

723.18 Basis of Payment

The accepted quantities of precast reinforced concrete three-sided flat-topped structures or structure extensions, precast reinforced concrete three-sided arch-topped structures or structure extensions, precast reinforced concrete true arch structures or structure extensions, cast-in-place reinforced concrete three-sided flat-topped structures or structure extensions, cast-in-place reinforced concrete three-sided arch-topped structures or structure extensions, and cast-in-place reinforced concrete true arch structures or structure extensions, of the size specified will be paid for at the contract unit price per linear foot.

Structure backfill will be paid for in accordance with 211.10. Flowable backfill will be paid for in accordance with 213.09. Geotextile and riprap will be paid for in

accordance with 616.13. Field drilled holes will be paid for in accordance with 702.28.

If the Contractor elects to provide a box structure in lieu of the three-sided structure shown on the plans, it will be paid for in accordance with 714.12. The Department will not incur additional cost for allowing the Contractor to substitute a box structure for the three-sided structure shown on the plans.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Structure Extension, Coated Reinforced Concrete, Three-Sided Sections, ____ in. x ____ in. (span, rise)	LFT
Structure Extension, Reinforced Concrete, Three-Sided Sections, ____ in. x ____ in. (span, rise)	LFT
Structure, Coated Reinforced Concrete, Three-Sided Sections, ____ in. x ____ in. (span, rise)	LFT
Structure, Reinforced Concrete, Three-Sided Sections, ____ in. x ____ in. (span, rise)	LFT

The cost of all design, coring, testing, pedestals or extended legs, excavation, repairs, plugging core and handling holes, mortar, grout, sealer, cylinder molds, and necessary incidentals shall be included in the cost of the structure or structure extension. The cost of spandrel walls, concrete base slab, footings, and aggregate base under precast footings shall be included in the cost of the structure or structure extension.

The cost of precast concrete headwalls, precast concrete wingwalls, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of plain or coated reinforcement or WWR used in precast reinforced concrete three-sided structures, precast reinforced concrete three-sided structure extensions, precast headwalls, precast wingwalls, cast-in-place reinforced concrete three-sided structures, cast-in-place reinforced concrete three-sided structure extensions, cast-in-place headwalls, or cast-in-place wingwalls shall be included in the cost of the structure or structure extension.

The cost of concrete used in a cast-in-place splice shall be included in the cost of the structure extension.

The cost of footings for wingwalls and aggregate base under the wingwall footings shall be included in the cost of the structure or structure extension.

The quantities for payment shall remain as shown on the plans whether the Contractor installs the three-sided arch-topped structure or structure extension, the three-sided flat-topped structure or structure extension, or the true arch shape structure or structure extension.

No additional payment will be made for carrying an underground drain through a structure or structure extension. However, no deduction will be made for the volume of concrete occupied by the drain pipe in a cast-in-place structure or structure extension.

No additional payment will be made for the repair or replacement of existing concrete damaged by Contractor operations.

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 105.03.

(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 specified, in accordance with 105.03.

(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 specified.

MATERIALS

724.02 Materials

Materials shall be in accordance with the following:

Concrete, Class C	702
Expansion Joint M	906.07(b)
Expansion Joint SS	906.07(a)
Inorganic Zinc Primer	909.02(a)1
Structural Steel	910.02

The joint manufacturer shall prepare and submit working drawings in accordance with 105.02. The working drawings shall include details of the assembly, installation details for where changes in the joint direction are required, manufacturer's specifications, and joint setting data.

(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. The strip seal shall be sized to accommodate a minimum of 4 in. 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 allowed.

(b) Expansion Joint M

The joint assembly shall be manufactured in accordance with the details shown on the working drawings as prepared by the manufacturer of the joint assembly. The strip seals shall be furnished in one continuous length for the entire limits of the installed joint. Field splicing of the strip seals will not be allowed.

CONSTRUCTION REQUIREMENTS

724.03 General Requirements

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. 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.

Final adjustment of the assembly shall be made as directed at the time of installation. All movements due to such factors as shrinkage, creep, and midslab deflection shall be accounted for prior to this final adjustment.

(a) 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. Concrete shall be class C in accordance with 702.

(b) 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 linear foot along and parallel to the plane of the finished joint surface. Replacement of existing structural expansion joints will be measured by the linear foot along and parallel to the plane of the finished joint surface. Concrete removal and class C 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 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 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 linear foot for structural expansion joint, of the type specified, replace, complete in place. Replacement of existing structural expansion joint seals will be paid for at the contract unit price per linear foot for structural expansion joint seal, of the joint type specified, replace.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Structural Expansion Joint, ____ type	LFT
Structural Expansion Joint, ____ type, Replace	LFT
Structural Expansion Joint Seal, ____ type, Replace	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 reinforcing bars, concrete removal and class C 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 pipe into an existing pipe and filling the space between the liner pipe 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:

Admixture	*
Cellular Concrete Grout	ASTM C 796
Cement, Type I or Type III	901.01(b)
Concrete, A	702
Fine Aggregate**	904
Flowable Backfill	213
Foaming Agent	912.05

Profile Wall HDPE Liner Pipe ..... 907.25(b)
Profile Wall PVC Liner Pipe ..... 907.25(c)
Solid Wall HDPE Liner Pipe ..... 907.25(a)
Water 913.01

* An admixture may be used as recommended by and in accordance with the foaming agent manufacturer's specifications.

** The supplier may elect to use gradations in accordance with 904.02(h) or may propose the use of alternate gradations.

Where circular liner pipe is shown on the plans, the pipe structure shall be lined with solid wall HDPE liner pipe; profile wall HDPE liner pipe; or profile wall PVC liner pipe. Where deformed liner pipe is shown on the plans, the pipe structure shall be lined with solid wall HDPE liner pipe or profile wall HDPE liner pipe.

The maximum number of joints and corresponding maximum length of each section of liner pipe used in each pipe structure to be lined shall be as shown on the plans. If the Contractor has obtained the necessary right-of-entry from all affected property owners and all necessary new permits or amendments to existing permits to enable work in areas accessible via Contractor-obtained right-of-entry, the Department will consider a written request by the Contractor to use liner pipe sections which exceed the maximum length shown on the plans. A corresponding reduction in the maximum allowable number of joints shall be included with the written proposal. The Contractor shall not install longer sections of liner pipe until written approval has been received from the Engineer.

The liner pipe shall either be chosen from those shown on the Department's list of approved Plastic Pipe and Pipe Liner Sources or shall be accompanied by a certification in accordance with 907.25. If the liner pipe is not on the Department's list of approved Plastic Pipe and Pipe Liner Sources, then the certification shall be furnished. Liner pipe shall be submitted to the Engineer for review and approval prior to installation.

Proper care shall be taken to ensure that no damage is done to the liner pipe during the unloading process. All liner pipes shall be unloaded with straps and lifting equipment.

Liner pipe joints shall be bell and spigot, screw type, grooved press-on, butt fused, extrusion welded, or other joint as recommended by the liner pipe manufacturer and shall be installed according to the manufacturer's recommended methods.

CONSTRUCTION REQUIREMENTS

Where a deformed HDPE liner pipe is specified, the liner pipe shall be made deformed by using equipment specifically designed to take a circular liner pipe and deform it without causing damage to the liner pipe. The equipment and method used to deform the liner pipe shall be described in the QCP. Once the liner pipe has been

deformed, it shall be structurally reinforced in the horizontal and vertical planes. Structural reinforcement shall be spaced at a maximum distance of 3 ft on centers. Structural reinforcement shall not be removed until the installation of the liner pipe and cellular concrete grout at that structure has been completed.

725.03 Right-of-Entry Areas

If the Contractor desires more working room than the right-of-way provides, the Contractor may elect to pursue rights-of-entry from all necessary adjacent property owners 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.

725.04 Quality Control

A QCP shall be submitted in accordance with ITM 803. No work on the pipe lining operation shall begin until written notice has been received that the QCP has been accepted by the Engineer. Acceptance of the QCP in no way relieves the Contractor of the responsibility for installation procedures and testing requirements.

A QC representative shall be present at the jobsite for the initial testing of the first welding or fusing at each liner pipe installation location and for the joining, welding, or fusing of the liner pipe at each location.

725.05 Filling of Cavities Outside of the Existing Pipe

All obvious cavities outside the existing pipe shall be filled with non-removable flowable backfill in accordance with 213 prior to the liner pipe installation or with cellular concrete grout placed in conjunction with the grouting operation after the liner pipe is installed.

725.06 Joining Liner Pipe

Each liner pipe joint shall be welded, fused, or joined according to the manufacturer's recommended methods. Welded liner pipe joints shall be welded with a continuous weld for the circumference of the liner pipe both inside and outside. Welded liner pipe joints shall have weld beads that are smooth and shall not project further than 3/8 in. into the inside of the liner pipe and shall not reduce the hydraulic capacity of the liner pipe. The ends of liner pipe that are to be welded or butt fused shall be at the same temperature ±5º F.

A visual inspection will be conducted for acceptance of all liner pipe joined by methods other than by welding or fusing joints. All joints that do not pass visual inspection shall be removed, shall have a new joint fabricated, and will be re-inspected.

All liner pipe joints shall have sufficient mechanical strength to withstand the liner pipe installation and cellular concrete grouting operations.

(a) Welder, Butt Fuser, or Joiner Joint Testing

Welding, butt fusing, or joining shall be performed at all times by an operator trained and certified by either the manufacturer of the liner pipe or the manufacturer of the welding, butt fusing, or joining equipment. A copy of the operator's certification shall be provided to the Engineer prior to the start of work. Prior to fabricating a production joint on a liner pipe, each operator who is performing welding, butt fusing, or joining, shall demonstrate that they can produce a joint that will withstand a destructive test prior to being allowed to join liner pipe. This test shall be repeated as many times as necessary in order to produce a joint that will pass the destructive test. One passing joint test is required per operator per contract. The method of joint testing shall be in accordance with section (b) or (c) below.

(b) Solid Wall HDPE Liner Pipe

Solid Wall HDPE liner pipe joined using butt fusion shall be in accordance with ASTM F 2620.

Solid wall HDPE liner pipe that is to have extrusion welded joints shall have destructive testing performed on a test section of liner pipe of the same material as the liner pipe being installed. The Contractor shall propose and describe in the QCP a destructive test, such as but not limited to a bend strap test, to demonstrate that an operator can produce an extrusion welded joint that will not fail. Once an extrusion welded joint is produced on a test section that passes the destructive test, each subsequent joint fabricated that same day by that operator will be visually inspected for acceptance. A destructive test in accordance with the approved QCP shall be conducted on the test section at the beginning of each day that solid wall HDPE liner pipe joining is being done.

(c) Profile Wall HDPE Liner Pipe

Profile Wall HDPE liner pipe joined using extrusion welding shall be in accordance with ASTM F 894. The Contractor shall propose and describe in the QCP a destructive test, such as but not limited to a bend strap test, to demonstrate that an operator can produce an extrusion welded joint that will not fail. Destructive testing shall be performed on two flat pieces of HDPE sheet stock that has been butt welded together to verify the extrusion gun is working properly and that the operator can produce an extrusion welded joint that will not fail. Once an extrusion welded joint is produced on a test section that passes the destructive test, each subsequent joint fabricated that same day by that operator will be visually inspected for acceptance. A destructive test in accordance with the approved QCP shall be conducted on the test section at the beginning of each day that profile wall HDPE liner pipe joining is being done.

725.07 Cellular Concrete Grout

The cellular concrete grout shall be designed 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 either the foam concentrate supplier or the certified or licensed grouting contractor for approval prior to use on the contract. The mix shall have a minimum 28-day compressive strength of 150 psi. The mix shall be tested by a laboratory approved by the Department or shall be approved based on prior acceptable performance on Department contracts.

The cellular concrete grout pump gauges shall be calibrated a minimum of once per month in the presence of the Engineer by the method described in the QCP.

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 foaming agent 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 cu yd shall be mixed and pumped in a continuous operation.

For each day worked or for each 100 cu yds placed, four test cylinders measuring 3 in. by 6 in. shall be cast at the point of placement of the grout. Sampling, molding, curing, and compressive strength testing of the cylinders shall be in accordance with ASTM C 495, except as modified herein.

Initial curing shall be at a temperature of 70°F ± 10°F and shall be from two to five 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 prepared for testing in accordance with ASTM C 495 except the bearing surface may be ground or cut with a dry saw to meet surface tolerance. The specimens shall not be capped. Specimens shall be 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. The Contractor shall provide a type A certification in accordance with 916 that provides the compressive strength results.

725.08 Liner Pipe Installation

Prior to commencing the liner pipe installation, all jagged existing pipe edges or other deformities shall be repaired. All debris and foreign material shall be removed from the existing pipe. A visual walk-through inspection shall be performed after all debris and foreign material has been removed from the existing pipe in order to assess the current condition of the pipe. If visual inspection is not possible, a video inspection of the existing pipe shall be performed. A copy of the video inspection shall be provided to the Engineer. If, upon completion of the inspection of the existing pipe, the Contractor believes that they cannot proceed with the work as shown on the plans, the Engineer shall be notified.

The cross-sectional area of the liner pipe shall be as shown on the plans.

Prior to commencing the liner pipe installation operation, steps shall be taken to verify that a liner pipe meeting the required cross-sectional area can be successfully placed inside the existing pipe. If it is discovered prior to installation that a liner pipe with the required opening area cannot fit, the inside and outside diameters of a substitute liner pipe shall be submitted to the Engineer for approval. If this discovery is not made until after the liner pipe installation has begun, the partially installed liner pipe shall be removed. Inside and outside diameters for a substitute liner pipe shall then be submitted to the Engineer for approval.

After the liner pipe installation is complete and the liner pipe has cooled to the temperature of the existing pipe, the liner pipe shall be cut so that each end is 8 in. outside the end of the existing pipe.

The cellular concrete grout within the annular space between the existing pipe and the liner pipe shall be contained by bulkheads. The bulkheads shall be constructed at each end of the structure. Each bulkhead shall be constructed to withstand the pressure of the grouting operation. The bulkhead shall be free from leaks and the exterior surface shall be given a smooth trowel finish. The bulkhead shall extend from the end of the existing pipe inward a minimum depth of 18 in.

Cellular concrete grout shall be injected into the annular space between the existing pipe and the liner pipe. The injection operation shall provide sufficient cellular concrete grout to fill all voids between the existing pipe and the liner pipe over the entire structure length, but shall also be performed in a manner that does not distort the liner pipe. Injection of the cellular concrete grout in lifts, use of spacers, or other safeguards shall be taken in order to keep the liner pipe in position and prevent the liner pipe from floating. The pressure developed in the annular space between the liner pipe and the existing pipe shall not exceed the liner pipe 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. Cellular concrete grout shall not leak through the liner pipe at these connections.

725.09 Method of Measurement

All thermoplastic liner pipe will be measured by the linear foot, for the shape and cross-sectional area of the liner pipe, complete in place. Perpetuation of existing pipes through the liner pipe will be measured by the number of existing pipes perpetuated.

No measurement will be made of liner pipe joints or the length of joint welding or fusing, or other incidentals necessary to join sections of liner pipe in accordance with the manufacturer's recommendations. The liner pipe or flat sheet stock used for destructive testing will not be measured for payment. No measurement will be made of a liner pipe meeting the required opening area that does not fit.

No measurement will be made for debris removal, filling existing voids, or trimming, cutting, jacking, or other corrective measures performed on jagged edges or other deformities of the existing pipe in order to facilitate installation of the liner pipe. No measurement will be made for visual or video inspection of the existing pipe.

No measurement will be made for the bulkhead.

725.10 Basis of Payment

The accepted quantities of thermoplastic liner pipe will be paid for at the contract unit price per linear foot for the shape and cross-sectional area of the liner pipe, complete in place. Perpetuation of existing pipes through the liner pipe will be paid for by the number of existing pipes perpetuated.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Liner Pipe, Thermoplastic, Circular, _____sq ft cross-sectional area	LFT
Liner Pipe, Thermoplastic, Deformed, _____ sq ft cross-sectional area	LFT
Perpetuation, Existing Pipe	EACH

The cost of repairing, trimming, or cutting jagged edges or deformities to existing pipe, filling cavities around the existing pipe with cellular concrete grout, acquisition and restoration of right-of-entry areas, acquiring all necessary new permits or amendments to existing permits to work in areas accessible via Contractor-obtained right-of-entry, erection, maintenance, and removal of temporary fence, removing debris and foreign material from the existing pipe, visual or video inspection of the existing pipe, deforming a circular liner pipe, supplying and constructing the bulkheads, grouting the annular space between the existing pipe and

the liner pipe, and other incidentals will not be paid separately, but shall be included in the cost of the pay items in this section.

The cost of liner pipe joints other incidentals necessary to join sections of liner pipe in accordance with the manufacturer's recommendations, and all test sections of liner pipe and test sections of HDPE sheet stock shall be included in the cost of the pay items in this section. All costs associated with having a QC representative on site shall be included in the cost of the pay items in this section.

The cost of training and certifying an operator, destructive and non-destructive testing, liner pipe, and incidentals used in destructive testing, and all costs associated with the development of an acceptable QCP shall be included in the cost of the pay items in this section.

Any joint that does not pass the visual inspection and needs to be re-fused, re-welded, or re-joined shall be done at no additional cost to the Department.

In situations where the condition of the existing pipe requires that a substitute liner pipe be utilized, there will be no reduction in payment for the installation of the substitute liner pipe. There will be no additional payment for the additional cellular concrete grout required to fill the larger void between the existing pipe and the smaller liner pipe.

There will be no payment for the installation or removal of any liner pipe that cannot be successfully installed due to the condition of the existing pipe. There will be no payment for a liner pipe meeting the required cross-sectional area that does not fit.

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.

SECTION 726 – BEARING ASSEMBLIES

726.01 Description

This work shall consist of furnishing and installing bearing assemblies in accordance with 105.03. Elastomeric bearings shall include plain bearings consisting of elastomer only, and laminated bearings consisting of layers of elastomer restrained at their interfaces by bonded laminates.

MATERIALS

726.02 Materials

The materials shall be in accordance with the following:

Anchor Bolts..... 910.02(g)

Elastomer 915.04
Grout 707.09
Polytetrafluoroethylene Sliding Surfaces 915.05
Side Retainers ..... 910.02(a)
Shim and Fill Plates ..... 910.02(a)
Threaded Studs and Hex Nuts ..... 910.02(c)

CONSTRUCTION REQUIREMENTS

726.03 Construction Requirements

Elastomeric bearings without external load plates may be placed directly on a concrete or steel surface provided the surface is flat to within a tolerance of 0.005 of the nominal dimension for steel reinforced bearings or 0.01 of the nominal dimension for other types. Bearings shall be installed on surfaces that are horizontal and parallel between the top of the bearing and the underside of the girder.

The elastomer or the bond shall not be subjected to temperatures higher than 390ºF.

Masonry plates for polytetrafluoroethylene, PTFE, bearings shall be perfectly level. The tolerance between the top face of the masonry plate and the bottom face of the top plate shall be a maximum of 1/16 in., measured at the ends of a diameter of the bottom plate of the bearing assembly. Other dimensional tolerances shall be as shown on the plans or in accordance with 915.04(d).

Immediately prior to setting bearings, the concrete and metal surfaces that are to be in contact shall be cleaned.

726.04 Method of Measurement

Elastomeric bearing pads will not be measured for payment. PTFE bearing devices will be measured by the number of devices placed.

726.05 Basis of Payment

Elastomeric bearing pads will not be paid for separately.

PTFE bearing devices will be paid for at the contract unit price per each device, complete and in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Bearing Assembly, PTFE	EACH

The cost of the pads, side retainers, anchor bolts, shim plates, and other incidentals shall be included in the cost of the structural member, or for PTFE bearing assemblies, the cost of the pay item.

SECTION 727 – STRUCTURAL CONCRETE REPAIR BY EPOXY INJECTION

727.01 Description

This work shall consist of structurally rebonding concrete cracks, fractures, or delaminations by means of an epoxy injection system in accordance with 105.03.

727.02 Materials

Materials shall be accordance with the following:

Epoxy Resin Additives 909.12

727.03 Approvals

The epoxy injection system proposed for use shall be subject to approval prior to the start of the repair work. One copy of preparation, mixing, and application instructions shall be furnished. Such instructions shall have been developed especially for use with the proposed epoxy injection system.

CONSTRUCTION REQUIREMENTS

727.04 Construction Requirements

The location and extent of cracks to be repaired by epoxy injection will be determined.

The work shall be performed with two-component automatic metering and mixing equipment.

Concrete surfaces adjacent to the cracks shall be cleaned to the extent necessary to achieve adequate bond of the surface seal material. Entry ports shall be provided along the crack at intervals determined in the field to ensure full depth penetration of the injection resin. Surface seal shall be applied between entry ports, and on both faces of through cracks when possible.

Epoxy injection shall begin at the lower entry port and continue until there is an appearance of epoxy at the adjacent entry port. Injection shall continue until all cracks are filled. If port to port travel is not apparent, the work shall be stopped immediately. The Engineer shall be notified.

Upon completion of the injection, the adhesive shall cure for sufficient time to enable removal of surface seal without draining or runback of material from the cracks. Surface seal material and injection adhesive runs or spills shall be removed from concrete surfaces. The face of the crack shall be finished flush to the adjacent concrete. The face of the concrete shall show no indentations or protrusions caused by the placement of entry ports.

727.05 Method of Measurement

Furnishing equipment for epoxy injection will not be measured for payment. Crack preparation for epoxy injection will be measured by the linear foot of prepared crack. Epoxy material will be measured by the gallon placed.

727.06 Basis of Payment

This work will be paid for at the contract lump sum price for epoxy injection, furnishing equipment. Crack preparation will be paid for at the contract unit price per linear foot for epoxy injection, crack preparation. Epoxy resin adhesive will be paid for at the contract unit price per gallon for epoxy injection, epoxy material.

Payment will be made under:

Pay Item	Pay Unit Symbol
Epoxy Injection, Crack Preparation	LFT
Epoxy Injection, Epoxy Material	GAL.
Epoxy Injection, Furnishing Equipment	LS

SECTION 728 – BLANK

SECTION 729 – BLANK

SECTION 730 – BLANK

SECTION 731 – MECHANICALLY STABILIZED EARTH RETAINING WALLS

731.01 Description

This work shall consist of the design, furnishing materials, and placement of MSE retaining walls in accordance with 105.03.

731.02 General Design Requirements

An MSE retaining wall shall consist of a non-structural concrete leveling pad, concrete face panels, precast or cast-in-place concrete coping, ground reinforcement elements mechanically connected to each panel, and accommodations for appurtenances behind, in front of, under, mounted upon, or passing through the wall. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by design. If a drainage system is shown on the plans, the wall design shall accommodate the drainage system.

The MSE retaining wall system shall be selected from the Department's list of approved retaining wall systems. A retaining wall system manufacturer will be considered for inclusion on the Department's list by following ITM 806, procedure J. The quantities shown in the Schedule of Pay Items will be the same for each MSE

retaining wall system. The MSE retaining wall panels shall be constructed as shown on the panels' working drawings, based on the requirements herein.

If the wall manufacturer needs additional information to complete the design, the Contractor shall be responsible for obtaining such information.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the plans, shall be accounted for in the design of the wall.

The Contractor shall determine the final leveling-pad layout and step elevations that provide the wall envelope shown on the plans. The Contractor shall use this information to provide a final horizontal plan and vertical elevation profile along the front face of the wall to account for the wall envelope shown on the plans. The final coping or top-of-wall elevations shall be at or above those shown on control line 1 on the plans. The final top-of-leveling-pad elevations shall be at or below those shown on control line 3 on the plans.

Where a coping or barrier is utilized, the wall face panel shall extend up into the coping or barrier a minimum of 2 in. The top of the face panels may be level or sloped to meet the top of the face panel line shown. Cast-in-place concrete will not be an acceptable replacement for panel areas indicated by the wall envelope.

Where walls or wall sections intersect with an included angle of 130° or less, a vertical corner element separate from the standard panel face shall abut and interact with the opposing panels. The corner element shall have ground reinforcement connected specifically to that panel. All turn-point locations where the wall forms an angle that are shown on the working drawings shall correspond to those shown on the plans unless otherwise approved in writing by the Engineer.

Face panels shall be designed to accommodate a differential settlement of 1 linear unit in 100. Face panels of an area greater than 32 sq ft through 64 sq ft shall be designed to accommodate differential settlement of 1 linear unit in 200. Where shown on the plans, slip joints to accommodate excessive or differential settlement shall be included.

Only one typical face panel shape and architectural finish shall be used per contract.

731.03 Design Criteria

The internal and external stability shall be the responsibility of the Contractor. The global stability of the wall mass will be the responsibility of the Engineer.

The Contractor shall use the information supplied in the contract documents including but not limited to the plans and the geotechnical report when designing the wall. The design of the wall including the internal and external stability shall be in

accordance with the AASHTO LRFD Bridge Design Specifications and the requirements specified herein.

The design for internal stability shall include connection strength design. Each design case shall present maximum tension capacity, soil overburden pressure, and horizontal pressure at each reinforcement level, pullout capacity at each reinforcement level, the length of embedment in the resisting zone, and the total length of reinforcement at each level.

The design for the external stability shall include applied bearing pressure, overturning, sliding, and stability of temporary construction slopes.

The value of the pullout resistance factor, F*, used in design calculations shall be obtained from the AASHTO LRFD Bridge Design Specifications figure 11.10.6.3.2-1.

An MSE wall shall be designed for a service life of 75 years. If a wall is supporting a spread footing for a bridge, the wall's design life shall be 100 years.

(a) Geotechnical Considerations

The theoretical failure plane within the soil mass shall be analyzed so that the soil-stabilizing component extends sufficiently beyond the failure plane to stabilize the material. External loads which affect the internal stability such as those applied through piling, bridge footings, traffic, crashwall, or slope surcharge, shall be accounted for in the design. The sizes of all structural elements shall be determined such that the design load stresses do not exceed the factored stresses shown in the AASHTO LRFD Bridge Design Specifications.

The material used as backfill in the reinforced backfill zone shall be assumed to have a unit weight of at least 120 lb/cu ft unless lightweight fill has been specified. The φ angle for the internal design of the reinforced backfill shall be 34°. The φ angle of the retained backfill zone shall be 30° for design. For the external design parameters, such as but not limited to, bearing capacity, sliding, overturning, eccentricity, and global stability, the actual soil strength parameters and the expected settlement of the existing soil under the reinforced backfill zone shall be obtained from the geotechnical report.

The coefficient of uniformity, c_u, of the reinforced backfill for all designs using the ribbed steel strips curve from AASHTO LRFD Bridge Design Specifications figure 11.10.6.3.2-1 shall be 4.0.

(b) Height of Wall

The wall limits shall be defined by the wall envelope shown on the plans. For internal stability design purposes, the design height of wall shall be as follows:

1. For a wall with a level surcharge, the design height of the wall, H, shall be measured from the theoretical top of the leveling pad to the top of the coping or to the gutter line of the traffic barrier. The top of the wall shall be the theoretical top of the face panels only where a coping or barrier is not used.

2. For a wall with a sloping surcharge, the design height of the wall, Z, shall be measured from the theoretical top of the leveling pad to a point above the top of the wall as calculated from the formula as follows:

$$Z = H + \frac{0.3H \tan\beta}{1\text{-}0.3 \tan\beta}$$

where:

β = surcharge slope angle as measured from the top of the coping, and
H = height of the wall from the theoretical top of the leveling pad to the top of the coping.

3. For an abutment face, the design height of the wall, H, shall be measured from the theoretical top of the leveling pad to the top of the roadway surface.

(c) Ground Reinforcement

The ground reinforcement length shall be the controlling length resulting from the internal or external design.

The ground reinforcement shall be the same length from the bottom to the top of each wall section regardless of the type of ground reinforcement used. Differing ground reinforcement elements shall be marked for ease of construction. This element may be used individually or in a prefabricated grouping.

The ground reinforcement for the MSE volume shall be sized using the lesser of the factored loads for each specific connection and each specific reinforcing element. The connection's applied factored load and effective pullout length shall be determined in accordance with the AASHTO LRFD Bridge Design Specifications.

For mats, grids, or strip steel, the minimum zinc coating thickness shall be 2 oz/sq ft. Such thickness shall be assumed to be 4 mils for purpose of calculation of reduced structural section.

The factored applied bearing pressures under the stabilized mass for each reinforcement unit's length shall be shown on the working drawings. It shall not exceed the maximum factored soil bearing resistance shown on the plans. Passive pressure in front of the wall mass shall be assumed to be zero for design purposes.

(d) Other Criteria

1. Traffic Load Considerations

Traffic load shall be considered as live load surcharge. The load factor of traffic load shall be 1.75 in accordance with AASHTO LRFD Bridge Design Specifications table 3.4.1-1.

2. Traffic Impact Considerations

Where traffic barriers are constructed above an MSE wall or reinforced backfill zone, the MSE wall supporting traffic shall include computations showing that the Extreme Event II limit state due to traffic impact has been met.

Loadings for MSE wall design for the Extreme Event II limit state shall be in accordance with the following table:

MAXIMUM NOMINAL TENSION RUPTURE AND PULLOUT IMPACT LOADS		
Layer	Tension Impact Load	Pullout Impact Load
First Top Layer	2,300 lbs/ft	1,300 lbs/ft
Second Top Layer	600 lbs/ft	600 lbs/ft

The Extreme Event II design for the top two layers shall be separately prepared and compared with the routine internal stability design.

3. Tributary Area – Design Basis

For internal stability analysis of MSE walls, each layer of reinforcement is assigned a tributary area, A_{trib} in accordance with FHWA publication No. FHWA-NHI-10-025, Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Volume II and as follows:

$$A_{trib} = (w_p)\,(S_{vt})$$

where:

w_p = the wall system concrete panel width of the precast facing element, and

S_{vt} = the vertical tributary spacing of the reinforcement based on the location of the reinforcement above and below the level of the reinforcement under consideration.

For a wall system with steel reinforcement, within each tributary area, the factored reinforcement tensile resistance, T_r, and the factored pullout resistance, P_{rr}, shall be no less than the maximum factored tension load, T_{max}. If the calculated minimum number of strips is a decimal number, the minimum number required shall be rounded up to the next whole number.

731.04 Submittals

The Contractor shall submit working drawings in accordance with 105.02. The Contractor shall submit design calculations in accordance with 105.02 and the following additional requirements. In case of discrepancy, the requirements listed below supersede those listed in 105.02. Design calculations shall include each design case of the MSE wall analyzed. Calculations may be in either longhand or computer-printout format and shall follow a systematic and logical methodology. A summary sheet that shows design assumptions and their source, controlling parameters and load cases, and other pertinent input and output information shall be included with the calculations package. Wall construction operations shall not begin until the Contractor receives written notice that the working drawings are approved.

(a) The working drawings shall include all details, dimensions, quantities and cross-sections necessary to construct the wall. They shall include, but shall not be limited to, the following:

1. Plan and elevation views along the front face of wall alignment, which shall include the following:

   a. A final profile along the front face of the wall.

   b. A plan layout of the front face of the wall showing all alignment points with stations and offsets.

2. A plan view of the wall that indicates the offsets from the construction centerline to the face of the wall at all changes in horizontal alignment. A plan view and elevation view which detail the placing position and connection of all ground reinforcement units in areas where piling, utility, or other structures are near the wall.

3. An elevation view along the front face of the wall with respect to the wall alignment, which shall include the following:

   a. The elevation at the top of the wall at all horizontal and vertical break points at least every 50 ft along the face of the wall.

   b. All steps in the leveling pad.

   c. The designation as to the type of wall unit.

   d. The length of ground reinforcement units.

   e. A wall-elevation envelope that encompasses such envelope shown on the plans.

4. All general notes required for constructing the wall.

(b) Panel details shall show all dimensions necessary to construct the element, all reinforcement in the element, and the location of ground reinforcement connection devices embedded in the panels.

(c) Details for construction of the wall around drainage facilities including outletting of internal drainage from the MSE volume.

(d) Details of the architectural treatment.

(e) Details for diverting ground reinforcement around obstructions such as piles, catch basins, or utilities.

(f) Details for the connections between the concrete panel and the ground reinforcement.

(g) Determination of φ angle for reinforced materials and retained materials.

MATERIALS

731.05 Materials

Materials shall be in accordance with the following:

Admixtures for Concrete	912.03
Air Cooled Blast Furnace Slag	901.09
Alignment Pins	910.07(d)
B Borrow	211.02
Coarse Aggregate, Class A or Higher, Size No. 8 or 91	904
Components of MSE Retaining Walls	901.10
Concrete, Class A or Class C	702
Deformed and Smooth Steel WWR	910.01(b)5
Fine Aggregate, Size No. 23	904
Fly Ash	901.02
Geotextile for Use Under Riprap	918.02
Joint Spacers and Joint Covering	901.10(b)
Portland Cement	901.01(b)
Rapid Setting Patch Materials	901.07
Reinforcing Bars	910.01
Steel Components	910.07
Structure Backfill	211.03.1, 904.05
Underdrains	718
Underdrains for MSE Walls	718.03
Water	913.01

MSE wall backfill shall consist of structure backfill type 3 in the reinforced backfill zone in accordance with 211, except that nominal size aggregate No. 30 shall not be used. Structure backfill in the retained backfill zone shall be type 3 or B borrow as shown on the plans.

If coarse aggregate No. 5, No. 8, No. 9, or No. 11 is used in the reinforced backfill zone and the Contractor elects to use a different material in the retained backfill zone, geotextiles shall be installed at the interface between the reinforced and retained backfill zones. If the Contractor elects to use coarse aggregate No. 5, No. 8, No. 9, or No. 11 in both the reinforced and retained backfill zones, geotextiles shall be installed along the interface between the retained backfill zone and the adjacent soil. In addition, geotextiles shall be installed over the top of the No. 5, No. 8, No. 9, or No. 11 aggregate used in the reinforced or retained backfill zones.

Concrete for the leveling pad and coping shall be class A. Concrete used in openings to accommodate appurtenances behind, in front of, under, mounted upon, or passing through the wall shall be class C.

The Contractor shall supply the MSE retaining wall components listed above, including tie strips, fasteners, bearing pads, and all necessary incidentals, through a manufacturer listed on the Department's list of approved retaining wall systems.

CONSTRUCTION REQUIREMENTS

731.06 General Requirements

The wall manufacturer's representative shall provide technical instruction, guidance in preconstruction activities including the preconstruction conference, and on-site technical assistance to the Contractor during construction.

731.07 Foundation Preparation

Prior to wall construction, the foundation for the structure shall be graded for a width equal to or exceeding the length of the ground reinforcement or as shown on the plans. The foundation, if not in rock, shall then be compacted in accordance with 203. After the foundation has been compacted, the resulting grade of the foundation shall be 1 in. per foot sloped from the back of the foundation downward toward the leveling pad. The portion of the foundation beneath the leveling pad shall not be sloped. The foundation shall be proofrolled in accordance with 203.26. If unsuitable foundation material is encountered, it shall be removed and replaced with B borrow in accordance with 211.02 and compacted in accordance with 211.04.

After proofrolling has been completed and all unsuitable foundation material has been removed and replaced, compaction of the portion of the foundation beneath the reinforced backfill zone will be verified by dynamic cone penetrometer, DCP, testing in accordance with ITM 509.

One DCP measurement for every 500 sq ft within the reinforced backfill zone and five DCP measurements per end bent will be performed.

A DCP measurement is defined as the number of blows per 6 in. increment for a total penetration of 30 in., based on five sets of DCP readings at each location. A minimum of five blows of the DCP for each 6 in. increment is considered acceptable.

Unsuitable areas shall be removed, replaced, and compacted in accordance with 203 and 211. DCP verification of compaction beneath the reinforced backfill zone will not be required if the foundation is in an embankment section that is constructed in accordance with 203.

An unreinforced concrete leveling pad shall be provided at each foundation level as shown on the plans. The leveling pad shall be cured in accordance with 702.22 for a minimum of 12 h before placement of concrete face panels.

731.08 Retaining Wall Excavation

The Contractor shall notify the Engineer a minimum of 7 calendar days or other time as mutually agreed upon before beginning the excavation so that measurements can be taken of the undisturbed ground.

Prior to starting excavation operations at the wall site, clearing and grubbing shall be in accordance with 201.03. The area shall be cleared and grubbed to the excavation in accordance with the limits shown on the plans. All timber, stumps, or debris shall be disposed of in accordance with 201.03. Excavation shall include the construction and subsequent removal of all necessary bracing, shoring, sheeting, and cribbing. Excavation shall also include all pumping, bailing, and draining.

The excavation shall be shored or braced in accordance with State and local safety requirements. Excavation and related work shall be performed such that no portion of the wall is endangered by subsequent operations.

Where excavation for the wall requires shoring, sheeting, or bracing, the method shall be shown on the working drawings. Excavation operations shall not begin until the Contractor receives notice that the working drawings are approved

After the excavation for the wall has been performed, the Contractor shall notify the Engineer. The material beneath the leveling pad shall be compacted in accordance with 203. Concrete for the leveling pad shall not be placed until the Engineer has approved the depth of the excavation and the foundation material. The leveling pad shall be in accordance with 731.07.

When an internal drainage system is shown on the plans, the drain pipe shall be 6 in. underdrain pipe in accordance with 715.02(d). The remainder of the internal drainage system shall be in accordance with 718, longitudinal underdrains. Video inspection will not be required.

731.09 Wall Erection

Concrete face panels shall be handled by means of a lifting device set into the upper edge of each panel. Panels shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds. As backfill material is placed behind the panels, the panels shall be maintained in vertical position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall. External bracing will be required for the initial lift.

Panels shall be stored on blocking to minimize contact with the ground or being covered by standing water. Panels placed in contact with the ground or covered by standing water shall have face discoloration removed by means of a chemical wash.

Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed 3/4 in. as measured with a 10 ft straightedge. The maximum allowable offset in panel joints shall be 3/4 in. For a wall of over 10 ft height, the overall plumb from top to bottom of the wall shall not exceed 0.05 in./ft of wall height.

For aesthetic considerations and to make differential settlement unnoticeable, the panels shall be erected such that the horizontal site line is discontinuous at every other panel. This shall be accomplished by starting erection with the lower panel level of each wall by alternating full-height and half-height panels. Panels above the lowest level shall be of a uniform size, except as required to top out the wall, to be in accordance with the plan elevations.

The Contractor shall perform the necessary work to verify that the foundation is at the correct elevation, that the wall is constructed to the correct alignment, and that the work is in accordance with the specified tolerances. The checking of alignments and tolerances shall include verifying that the plumb of the face panels is in accordance with 731.10 over the entire height of the wall. Alignment shall be checked at each layer of panels after the backfill behind the panels has been compacted, and the results shall be recorded.

The connections of the ground reinforcement to the panels shall be in two elevations for full height panels. The connections shall not be more than 30 in. vertically apart. To prevent out-of-plane rotation, full height face panels shall be connected to the ground reinforcement on at least three different points in two different planes. However, a preapproved system utilizing a horizontal stabilizing leg to prevent rotation shall require only ground reinforcement attachments in one plane. Partial size panels shall have three different connection points, but only one plane shall be attached to the ground reinforcement. Panels located at the top of the wall shall not be attached to the coping or traffic barrier.

Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed. Prior to placement of the ground reinforcement, backfill shall be compacted in accordance with 731.11.

731.10 Joint Spacers and Joint Covering for Wall Panels

Horizontal and vertical joint spacers shall be provided between adjacent face panels to prevent concrete-to-concrete contact and chipping if differential settlement occurs. Panels without an uninterrupted vertical joint shall have a minimum joint thickness of 3/4 in. Joint covering shall be provided and attached to the rear face of the panels.

731.11 Backfill Placement

Backfill placement shall follow erection of each course of panels and ground reinforcement. All sheeting and bracing shall be removed as the backfilling progresses. Backfill shall be placed so as to avoid damage or disturbance to the wall materials or misalignment of the concrete face panels. All material for backfill shall be subject to approval and shall be free from lumps, wood, or other undesirable material. Wall materials that become damaged or disturbed during backfill placement shall be removed and replaced or corrected as directed. All misalignment or distortion of the concrete face panels due to placement of backfill outside the limits described herein shall be corrected as directed.

B borrow and No. 4 size structure backfill shall be compacted to 95% of the maximum dry density in accordance with AASHTO T 99. Density of the B borrow and No. 4 size structure backfill will be determined in accordance with 203.24(b). Compaction equipment shall be in accordance with 409.03(d). For all other structure backfill material used, compaction shall consist of four passes with a vibratory roller and one pass with the same roller in static mode. The vibratory roller shall be equipped with a variable amplitude system and a speed control device. It shall have a minimum vibration frequency of 1,000 vibrations per minute. A roller in accordance with 409.03(d)4 may be used. All displacement or rutting of the aggregate shall be repaired prior to placing subsequent material.

The maximum loose lift thickness shall not exceed 8 in. However, lifts within 3 ft of the wall shall not exceed 5 in. in loose thickness. This lift thickness shall be decreased if necessary, to obtain the specified density.

Compaction within 3 ft of the back face of the concrete face panels shall be achieved by means of a minimum of five passes with a lightweight mechanical tamper, roller, or an alternative vibratory system.

At the end of each day's operation, the last level of backfill shall be sloped away from the wall units. Surface runoff from adjacent areas shall not enter the wall construction site.

Subsurface drainage for the pavement section shall be underdrains for MSE walls and shall be as shown on the plans.

Cutting or altering of the basic structural section of ground reinforcement at the site will be prohibited, unless the cutting is preplanned and detailed on the approved working drawings. Cutting shall be considered only if adequate additional ground reinforcement is provided to produce the required strength shown in the approved calculations. If the ground reinforcement is shortened in the field, the cut ends shall be covered with a galvanized paint or coal tar to prevent corrosion of the metal.

731.12 Method of Measurement

The measurement of concrete face panels and wall erection will be based on the square foot of area contained within the neat line limits of the wall envelope shown on the plans and not that of the wall system supplier.

Concrete leveling pad will be measured by the linear foot. Common excavation will be measured by the cubic yard in accordance with 203.27(a) to the neat lines shown on the plans. Structure backfill and B borrow will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09. Geotextile used in conjunction with MSE wall construction will not be measured for payment. Underdrains for MSE walls and components of the internal drainage system will be measured in accordance with 718.09. If unsuitable foundation material is encountered in the portion of the foundation beneath the leveling pad in a section constructed on original ground or in a cut section, the removal, replacement, and compaction of the new material will be measured in accordance with 203 and 211.

Precast or cast-in-place concrete coping will not be measured.

731.13 Basis of Payment

The accepted quantities of concrete face panels will be paid for at the contract unit price per square foot. Wall erection will be paid for at the contract unit price per square foot. Concrete leveling pad, complete and in place, will be paid for at the contract unit price per linear foot for leveling pad. Common excavation will be paid for in accordance with 203.28. Structure backfill and B borrow will be paid for in accordance with 211.10, except that structure backfill used in the retained backfill zone will be paid for as B borrow. Unsuitable foundation materials, if found, will be paid for in accordance with 211.10. Underdrains for MSE walls and components of an internal drainage system will be paid for in accordance with 718.10.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Face Panels, Concrete	SFT
Leveling Pad, Concrete	LFT
Wall Erection	SFT

The cost of designing the wall system, services including the testing laboratory, certified testing personnel, and the testing and inspection of the concrete panels shall be included in the cost of face panels, concrete.

The cost of all wall materials including concrete face panels, ground reinforcement, tie strips, fasteners, joint materials, joint covering, precast or cast-in-place concrete coping, repair or replacement of face panels damaged or removed due to backfill placement, and incidentals shall be included in the cost of face panels, concrete.

The cost of all labor and materials required to prepare the wall foundation, place the ground reinforcement, and erect the concrete face panels shall be included in the cost of wall erection.

If unsuitable foundation material is encountered in the portion of the foundation beneath the reinforced backfill zone in a section constructed on original ground or in a cut section, the cost of removal, replacement, and compaction of new material will be paid for in accordance with 203 and 211.

If unsuitable foundation material is encountered in the portion of the foundation beneath the reinforced backfill zone that is constructed on an embankment section that is constructed under the same contract, the cost of removal, replacement, and compaction of new material will not be considered for payment.

The cost for geotextile used in MSE wall construction shall be included in the cost of the pay items in this section.

The cost of refilling and refinishing of the core holes from verification coring shall be included in the cost of face panels, concrete.

The cost of performing the laboratory tests by an approved geotechnical laboratory for structure backfill or ACBF slag shall be included in the cost of the pay items in this section.

The cost of cutting, altering, or recoating the ground reinforcement at the site shall be included in the cost of wall erection.

SECTION 732 – MODULAR CONCRETE BLOCK RETAINING WALL

732.01 Description

This work shall consist of design as required, furnishing materials, and placement of modular block wall units in accordance with 105.03. The modular block wall unit shall have ground reinforcement if shown on the plans or required by the manufacturer.

732.02 General Design Requirements

The modular block wall shall consist of an aggregate leveling pad, concrete modular block wall units, and if specified, ground reinforcement elements. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by design, and shall be mechanically connected to the facing units.

Modular block wall units shall be constructed as shown on the approved working drawings based on the requirements herein. The recommendations of the wall system supplier shall not override the minimum performance requirements shown herein.

The top of the modular block wall shall be designed to prevent the removal of the top course of blocks.

If the wall system provider needs additional information to complete the design, the Contractor shall be responsible for obtaining such information.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the plans shall be accounted for in the stability design of the wall.

The modular block wall design shall follow the general dimensions of the wall envelope shown on the plans. The working drawings shall show the location of the leveling pad at or below the theoretical leveling pad elevation shown on the plans. The top of the modular block wall unit shall be at or above the top of the wall elevation shown on the plans.

Cast-in-place concrete will not be an acceptable replacement for modular block wall unit areas indicated by the wall envelope.

Modular block wall units shall be designed to accommodate a differential settlement of 1 linear unit in 100. Where shown on the plans, slip joints to accommodate excessive or differential settlement shall be included.

Only one typical modular block face finish shall be used per contract.

732.03 Design Criteria

The maximum modular block wall unit face area shall be 1 sq ft. The minimum depth of modular block wall units shall be 9 in.

Modular block wall units shall be dry stacked in a running bond configuration. Vertically adjacent units shall be connected with an approved shear connection. Approved shear connections consist of steel pins, concrete lips on the blocks, or other connections as approved by the Engineer.

The internal stability shall be the responsibility of the Contractor. The design for internal stability shall be in accordance with the AASHTO LRFD Bridge Design Specifications. The design by the Engineer will consider the external stability of the modular block wall mass including the applied bearing pressure, overturning, sliding, and stability of temporary construction slopes.

(a) Geotechnical Considerations

The theoretical failure plane within the soil mass shall be analyzed so that the soil-stabilizing component extends sufficiently beyond the failure plane to stabilize the material. External loads which affect the internal stability such as those applied through piling, bridge footings, traffic, crashwall, or slope surcharge, shall be accounted for in the design. The sizes of all structural elements shall be determined such that the design load stresses do not exceed the factored stresses shown in the AASHTO LRFD Bridge Design Specifications.

The internal friction angle, φ, for the internal design of the modular block wall backfill volume shall be assumed to be 34°. The φ of the backfill behind the modular block wall backfill volume shall be assumed to be 30°. The φ for the internal design of the foundation soils shall be assumed to be 30°. For the external design parameters, such as but not limited to, bearing capacity, sliding, overturning, eccentricity, and global stability, the actual soil strength parameters used shall be obtained from the geotechnical report.

The factored applied bearing pressures under the stabilized mass for each reinforcement unit's length shall be indicated on the working drawings. It shall not exceed the maximum factored soil bearing resistance shown on the plans. Passive pressure in front of the wall mass shall be assumed to be zero for design purposes.

(b) Height of Wall for Internal Stability

The wall limits shall be defined by the wall envelope shown on the plans.

1. For a wall with a level surcharge, the design height of the wall, H, shall be measured from the theoretical top of the leveling pad to the top of the coping or to the gutter line of the traffic barrier. The top of the wall shall be the theoretical top of the face panels only where a coping or barrier is not used.

2. For a wall with a sloping surcharge, the design height of the wall, Z, shall be measured from the theoretical top of the leveling pad to a point above the top of the wall as calculated from the formula as follows:

$$Z = H + \frac{0.3H \tan \beta}{1\text{-}0.3 \tan \beta}$$

where:

β = surcharge slope angle as measured from the top of the coping, and

H = height of the wall from the theoretical top of the leveling pad to the top of the coping.

3. For an abutment face, the design height of the wall, H, shall be measured from the theoretical top of the leveling pad to the top of the roadway surface.

(c) Ground Reinforcement

The ground reinforcement length shall be the controlling length resulting from the internal or external design or as shown on the plans. All of the ground reinforcement shall extend to and shall be connected to the modular block wall units.

The ground reinforcement shall be the same length from the bottom to the top of each wall section regardless of the type of ground reinforcement used. Differing ground reinforcement elements shall be marked for ease of construction. This element may be used individually or in a prefabricated grouping.

The ground reinforcement for modular block wall sections shall be sized using the lesser of the factored loads for each specific connection and each specific reinforcing element. The connection's applied factored load and effective pullout length shall be determined in accordance with the AASHTO LRFD Bridge Design Specifications.

For mats, grids, or strip steel, the minimum zinc coating thickness shall be 2 oz/sq ft. Such thickness shall be assumed to be 4 mils for purpose of calculation of reduced structural section.

Where the presence of opposing walls limits the length of ground reinforcing, the design shall account for the reduced length and internal and external stability calculations shall be made to check for adequate factor of safety.

732.04 Submittals

The Contractor shall submit working drawings and design calculations in accordance with 105.02. Wall construction operations shall not begin until the Contractor receives written notice that the working drawings are approved.

(a) The working drawings shall include all details, dimensions, quantities, cross-sections, and general notes necessary to construct the wall and shall include, but shall not be limited to the following:

1. Plan and elevation sheets showing views which detail the placing position and connection of all ground reinforcing elements in areas where piling, utility, or other structures are near the wall.

2. Plan sheets of the wall that indicate the offsets from the construction centerline to the face of the wall at all changes in horizontal alignment.

3. Elevation views of the wall which shall include the following:

   a. elevations at the top of the wall at all horizontal and vertical break points at least every 50 ft along the face of the wall;

   b. all steps in the aggregate leveling pad;

   c. the designation as to the type of modular block wall unit;

   d. the length of ground reinforcement units;

   e. the distance along the face of the wall to where changes in length of the ground reinforcement occur;

   f. an indication of the original and final ground lines and maximum bearing pressures.

(b) All modular block wall units shall show all dimensions necessary to construct the element and the location of soil reinforcing system devices embedded in the units.

(c) The details for construction of walls around drainage facilities and the outletting of internal drainage from the modular block wall volume.

(d) All details of the architectural treatment.

(e) The details for diverting ground reinforcement around obstructions such as piles, catch basins, landscape plantings where the bottom of the root ball extends below the top level of ground reinforcement, and other obstructions.

(f) The details for mechanical connection between the modular block wall unit and the ground reinforcement.

MATERIALS

732.05 Materials
Materials shall be in accordance with the following:

Admixtures for Concrete* 912.03
Air Cooled Blast Furnace Slag 901.09
B Borrow 211.02

Coarse Aggregate, Class A or Higher, Size No. 91	904
Coarse Aggregate, Class D or Higher, Size No. 8	904
Concrete	702
Fine Aggregate, Size No. 23	904
Fly Ash	901.02
Geogrid, Type III	918.05
Geotextile	918.03
Portland Cement	901.01(b)
Structure Backfill	211.03.1
Water	913.01

* Admixtures in accordance with ASTM C 1372 may be used for the modular block if approved by the Engineer.

Aggregate for the leveling pad shall be compacted aggregate No. 53 and shall be in accordance with applicable requirements of 303. Drainage fill used immediately behind the modular block wall, as shown on the plans, shall be coarse aggregate No. 8 crushed stone or ACBF in accordance with 904.03.

Backfill material used in the modular block wall volume shall be structure backfill, type 3, in accordance with 211. Where ground reinforcement is required, nominal size aggregate No. 30 shall not be used. The size of the structure backfill selected for use in the reinforced area of the modular block volume shall remain the same for that wall's volume. If ACBF or coarse aggregate No. 8 are used, and soil, B borrow, structural backfill, or coarse aggregate No. 53 are to be placed above the ACBF or coarse aggregate No. 8, a single layer of geotextile shall be placed on top of the ACBF or coarse aggregate No. 8 in accordance with 616.11. A type C certification in accordance with 916 for the geotextile materials shall be furnished to the Engineer prior to use.

If ground reinforcement is required, it shall be either steel in accordance with 910.07 or geogrid. The ground reinforcement supplied shall be the same type as that used with the pullout test and shall be consistent throughout the contract work. If the ground reinforcement is steel, structure backfill shall be in accordance with the backfill requirements for retaining wall systems contained in 211.03.1.

(a) Concrete Modular Block Wall Units

Concrete modular block retaining wall units shall be in accordance with ASTM C 1372, except for the modifications below, and shall have a minimum compressive strength of 4,000 psi at 28 days. Modular block wall units utilizing type I or II cement will be considered acceptable for placement in the wall when 7-day strengths exceed 3,500 psi. The modular block wall unit's compressive strength shall be considered acceptable regardless of curing age when compressive test results indicate that the compressive strength is in accordance with the requirements stated above.

Retarding agents, accelerating agents, coloring pigments, or additives containing chloride shall not be used without approval.

1. Testing and Inspection

a. Material properties shall be in accordance with the requirements of 732.05 in lieu of Section 4.

b. Table 1, "Strength and Absorption Requirements", shall be modified to require that the average compressive strength, when sampled and tested in accordance with ASTM C 140, of a three CMU compressive strength sample shall be 4,000 psi with no individual unit less than 3,500 psi. Maximum absorption shall be 6%.

c. Freeze-thaw durability testing shall be completed in accordance with Section 8.3 by a laboratory approved by the Department. Test results on all mix designs used in the manufacture of modular blocks shall have been completed in accordance with ASTM C 1372. If a change to the mix design, such as proportioning or material source, is desired, the modified mix design shall be retested for freeze-thaw. A type A certification in accordance with 916 for the freeze-thaw durability testing shall be submitted to the Engineer prior to use of the blocks.

d. Sampling and testing of the manufacturer's production lots will be conducted by the Engineer in accordance with ASTM C 140. If the compressive strength test result does not meet the requirements of 732.05(a), the production lot units may not be used. The manufacturer may resample the same production lot in the presence of the Engineer for retesting. The Engineer will test the additional samples in accordance with ASTM C 140. If the retested samples meet the requirements of 732.05(a), the production lot may be used. If the retested samples do not meet the requirements of 732.05(a), all the units from the production lot may not be used.

2. Rejection

Units shall be subject to rejection due to failure to be in accordance with the requirements specified above. In addition, the following defects may be sufficient cause for rejection.

a. Defects which indicate imperfect molding.

b. Defects which indicate honeycombed or open texture concrete.

c. Defects in the physical characteristics of the concrete, such as broken or chipped concrete, or color variations, or dunnage

marks on the front face due to excessive form oil or other reasons.

The Engineer will determine whether spalled, honeycombed, chipped, or otherwise defective concrete shall be repaired or be cause for rejection. Repair of concrete, if allowed, shall be completed in a satisfactory manner. Repair to concrete surfaces, which are to be exposed to view after completion of construction shall be subject to approval.

3. Marking

The date of manufacture, the production lot number, and the place mark shall be clearly scribed on the rear face of each unit or on each shipping pallet.

4. Handling, Storage, and Shipping

All modular block wall units shall be handled, stored, and shipped so as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses.

(b) Blank

CONSTRUCTION REQUIREMENTS

732.06 General Requirements

The wall supplier representative shall provide technical instruction, guidance in preconstruction activities including the preconstruction conference, and on-site technical assistance to the Contractor during construction.

732.07 Foundation Preparation

The foundation for the modular block wall shall be graded level for the width shown on the plans. Foundation preparation shall otherwise be in accordance with 731.07.

At each foundation level, an aggregate leveling pad shall be provided as shown on the plans.

732.08 Retaining Wall Excavation

Excavation shall be in accordance with 731.08.

732.09 Wall Erection

Modular block wall units shall be stored to minimize contact with the ground or being covered by standing water. Modular block wall units having face discoloration shall not be used.

The Contractor shall perform the necessary work to verify that the foundation is at the correct elevation, that the wall is constructed to the correct alignment, and that the work is in accordance with the specified tolerances.

Modular block wall units shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds. As backfill material is placed behind the units, the units shall be maintained in vertical position. Horizontal alignment tolerances shall not exceed 3/4 in. when measured with a 10 ft straightedge. Alignment shall be checked at each layer of modular block wall units after the backfill behind the modular block wall units has been compacted, and the results shall be recorded. Checking of alignments and tolerances shall include verifying that the modular block wall units are plumb over the entire height of the wall.

Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans and shall be constructed in accordance with 214.04.

732.10 Backfill Placement

Backfill placement shall follow erection of each course of modular block wall units. All sheeting and bracing shall be removed as the backfilling progresses. Backfill shall be placed so as to avoid damage or disturbance to the wall materials or misalignment of the modular block wall units. All material for backfill shall be subject to approval and shall be free from large or frozen lumps, wood, or other undesirable material. Wall materials that become damaged or disturbed during backfill placement shall be removed and replaced or corrected as directed. All misalignment or distortion of the modular block wall units due to placement of backfill outside the limits described herein shall be corrected as directed.

The work shall also include backfilling beyond the theoretical length of the ground reinforcement in accordance with the details shown on the plans, and the disposal of surplus of unsuitable excavated materials, as allowed.

Backfill placement and compaction shall otherwise be in accordance with 731.11.

732.11 Method of Measurement

The measurement of concrete modular block wall units with or without ground reinforcement and wall erection will be based on the square foot area contained within the neat line limits of the wall envelope shown on the plans and not that of the wall system supplier.

Common excavation will be measured by the cubic yard in accordance with 203.27(a) to the neat lines shown on the plans. Structure backfill and B borrow will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09. Coarse aggregate No. 8 used as drainage fill will be measured by the cubic yard based on the theoretical volume to the neat lines as shown on the plans. Compacted aggregate No. 53, and ground reinforcement will not be measured. Geotextile materials will not be measured. Drainage of the backfill including piping and geotextile materials used in the drainage system will not be measured.

732.12 Stockpiled Modular Block Units

Partial payment may be made for block wall units stockpiled on the project site or at the Contractor's approved storage location. Partial payment will include the delivered cost of the units, as verified by invoices that include freight charges. The Contractor shall furnish the invoices. The partial payment will not exceed 75% of the contract unit price for modular block wall with or without ground reinforcement. Prior to authorizing partial payment, the Engineer will verify that the units are in accordance with 732.05(a).

732.13 Basis of Payment

The accepted quantities of modular block wall units with or without ground reinforcement will be paid for at the contract unit price per square foot. Erection of modular block wall units will be paid for by the square foot. Common excavation will be paid for in accordance with 203.28. Structure backfill and B borrow will be paid for in accordance with 211.10. Unsuitable foundation materials will be paid for in accordance with 211.10. The accepted quantities of coarse aggregate No. 8 used as drainage fill will be paid for as aggregate for drainage fill at the contract unit price per cubic yard, complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Aggregate for Drainage Fill	CYS
Modular Block Wall Erection	SFT
Modular Block Wall with Ground Reinforcement	SFT
Modular Block Wall	SFT

The cost of designing the wall system, services including the testing laboratory, certified testing personnel, and the testing and inspection of modular block wall units shall be included in the cost of the pay items of this section.

The cost of materials, ground reinforcement if required, fasteners, cutting or altering the ground reinforcement at the site, repair or replacement of units damaged or removed due to backfill placement, compressive-strength retesting if required, retesting or replacing failed block units, and incidentals shall be included in the cost of the pay items of this section.

The cost of all labor and materials required for preparing the wall foundation, compacted aggregate No. 53, coarse aggregate No. 8 placed outside the neat lines as shown on the plans, replacement materials damaged during backfill placement if required, and erecting the modular block units shall be included in the cost of wall erection.

The cost of all labor and materials for geotextiles shall be included in the cost of the pay items of this section.

SECTION 733 – STEEL BIN-TYPE RETAINING WALL

733.01 Description

This work shall consist of furnishing materials and placement of steel bin-type retaining walls in accordance with 105.03.

MATERIALS

733.02 Materials

Materials shall be in accordance with the following:

Fasteners	910.02(g)1
Steel Bin-Type Retaining Wall Units	910.08
Structure Backfill	211.03.1, 904.05

Backfill material used in the bin-wall sections shall be structure backfill, type 3, in accordance with 211.

CONSTRUCTION REQUIREMENTS

733.03 General

All units shall be fabricated such that units of the same nominal size shall be fully interchangeable. Drilling, punching, or drifting to correct defects in manufacture will not be allowed. Each unit with unauthorized holes shall be replaced. The ends of all stringers and spacers shall be bolted to corner columns by means of connecting channels.

The proper curvature for the face of a wall constructed on a curve shall be obtained through the use of shorter stringers in the front or rear panels of retaining walls as shown on the plans or as otherwise directed.

The wall height and depth may be varied. Two or more retaining wall designs may be incorporated in the same wall by the use of standard split columns to make the connection on the step back.

733.04 Foundation Preparation

The foundation for the structure shall be graded level or as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be compacted in accordance with 203. The base of the wall excavation shall be proofrolled with a vibratory roller weighing not less than 10 t, or with other approved compacting equipment. If unsuitable foundation material is encountered, it shall be removed and replaced with B borrow in accordance with 211.02 and compacted in accordance with 211.04.

733.05 Retaining Wall Excavation

Retaining wall excavation shall be in accordance with 731.08.

733.06 Backfill Placement

The fill material for the interior of the bin and behind the wall shall be structure backfill placed in layers not to exceed 6 in. in thickness. Backfilling behind the wall shall progress with the filling of the bins and shall not be carried ahead of the interior bins. Existing slopes, which are shaped so as to cause a wedge action in the backfill, shall be benched before backfilling.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill material shall have placement moisture content between optimum and -3 percentage points of the optimum moisture content. Backfill material with placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable through the entire lift.

Compaction within 3 ft of the back face of the bins shall be achieved by means of a minimum of three passes with a lightweight mechanical tamper, roller, or an alternative vibratory system.

Backfill placement shall otherwise be in accordance with 731.11.

733.07 Method of Measurement

The measurement of steel bin walls will be based on the square foot of area contained within the neat line limits of the wall envelope shown on the plans and not that of the wall system supplier. Common excavation will be measured in accordance with 203.27. Structure backfill will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09.

733.08 Basis of Payment

This work will be paid for at the contract unit price per square foot for binwall, steel. Common excavation will be paid for in accordance with 203.28. Structure backfill will be paid for in accordance with 211.10. Unsuitable foundation materials will be paid for in accordance with 211.10.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Binwall, Steel	SFT

The cost of furnishing, handling, and installing the steel units, including all materials, bolts, and appurtenances; necessary excavation and structure backfill testing; and all labor, equipment, all necessary incidentals, or replacement of steel units with unauthorized holes, or those damaged and replaced during construction shall be included in the cost of the pay item.

SECTION 734 – PERMANENT EARTH RETENTION SYSTEM FOR CUT-WALL APPLICATION

734.01 Description

This work shall consist of designing and constructing a permanent earth retention system utilizing a cut-wall application in accordance with 105.03. Cut-wall applications refer to a class of earth retention systems in which construction of the system is performed from the top of the wall to the base utilizing either externally or internally stabilized elements or a combination of both. Geotechnical Engineering Circular No. 2 – Earth Retaining Systems, Report No. FHWA-SA-96-038 provides further discussion of cut-wall applications.

734.02 Contractor Design Requirements

The permanent earth retention system utilizing a cut-wall application shall be designed by a professional engineer having experience in the design of at least three completed permanent earth retention systems involving cut-wall applications. The permanent earth retention system shall be designed using the procedure described in the AASHTO LRFD Bridge Design Specifications, or in the FHWA-IF-03-017, Soil Nail Walls. The required partial safety factors or allowable strength factors for Service Load Design, SLD, and load and resistance factors for LRFD, shall be in accordance with the above-referenced publications. The minimum factor of safety for SLD global stability or minimum required LRFD global stability shall be in accordance with the above-referenced publications, unless specified otherwise. Structural design of an individual wall element not addressed in the FHWA report shall be designed in accordance with the AASHTO specifications. Geometric data and design criteria including shear strength parameters and unit weights for soil and rock, corrosion protection, internal and external drainage requirements, horizontal and vertical alignment of the wall, and all known site and construction constraints, wall facing, and facing architectural requirements shall be as shown on the plans.

(a) Design Calculations

Design calculations shall include, but not be limited to, the following:

1. A written summary report which describes the overall design.

2. Applicable code requirements and design references.

3. Design cross-section geometry including soil and rock strata and location, magnitude and direction of design slope, external surcharge loads, and piezometric levels with the most critical slip surface shown along with the minimum calculated SLD factor of safety for global stability or minimum required LRFD global stability soil resistance to load ratio.

4. Design criteria including the undrained and drained shear strength parameters and unit weights for soil and rock.

5. Unit bond resistances for externally and internally stabilized elements.

6. Partial safety factors and strength factors for SLD or load and resistance factors for LRFD used in the design on the pullout resistance, surcharges, unit weights of soil and rock, and all materials proposed for the system including, but not limited to shotcrete, steel and concrete.

7. Seismic design acceleration coefficient.

8. Design calculation sheets with the contract number, designation number, wall location and designation, date of preparation, initials of designer and checker, page number shown on each page, and an index page.

9. Design notes including an explanation of all symbols and computer programs used in the design.

10. Structural design calculations for all temporary and permanent facing and facing connections, including consideration of flexural and shear strength of the facing and all externally stabilized elements, tensile strength of all headed studs, upper cantilever, minimum reinforcement ratio, mechanical splices, welds, built-up sections, and cover and splice requirements.

(b) Working Drawings

The limits of the wall and ground survey data shall be verified before preparing the drawings. Working drawings shall include all details, dimensions, quantities, ground profiles, cross sections necessary to construct the wall, and the following:

1. A plan view of the wall identifying the following:

   a. A reference centerline and elevation datum.

   b. The offset from the construction centerline to the finished face of the wall at its base and at all changes in horizontal alignment.

   c. Beginning and ending stations of the wall.

   d. Right-of-way and permanent or temporary construction easement limits, location of all known active and abandoned existing utilities, adjacent structures, or other potential interferences.

e. The centerline of each drainage structure or drainage pipe behind, passing through, or passing under the wall.

f. Limit of externally and internally stabilized elements.

g. Subsurface exploratory locations with appropriate reference base lines to fix the locations of the explorations relative to the wall.

2. An elevation view of the wall identifying the following:

a. The elevations at the top of the wall, at all horizontal and vertical break points, and at least every 30 ft along the wall.

b. Elevations at the base and top of the wall for casting the facing.

c. Beginning and ending stations of the wall.

d. The distance along the face of the wall to all steps in the base of the wall.

e. All externally and internally stabilized elements as well as vertical and horizontal spacing.

f. The location of drainage elements and permanent facing expansion and contraction joints along the wall length.

g. Existing and finished grade profiles, both behind and in front of the wall.

3. Design parameters and applicable codes.

4. General notes for constructing the wall including sequencing and all special construction requirements, such as dewatering, if required.

5. Horizontal and vertical curve data affecting the wall and control points.

6. Match lines or other details to relate the wall stationing to centerline stationing.

7. A listing of the summary of quantities on the elevation drawing of each wall showing estimated square feet of exposed wall face areas and other pay items.

8. Typical sections including staged excavation elevations, wall elements, and corrosion protection details.

9. Typical details of production and test anchors or nails defining the orientation and dimensional relationships of the unbonded and bonded lengths.

10. Details, dimensions, and schedules for all externally and internally stabilized elements, reinforcing bars, steel welded wire reinforcement, bearing plates, headed studs, and attachment devices for pneumatically placed mortar, cast-in-place, or prefabricated facings.

11. Details and dimensions for appurtenances such as barriers, coping, drainage gutters, and fences.

12. Details for constructing the wall around drainage facilities.

13. Details for terminating the wall and adjacent slope construction.

14. Facing finishes, color and architectural treatment requirements for permanent facing elements.

(c) Submittals

The Contractor shall submit working drawings and design calculations in accordance with 105.02.

At least 30 calendar days before the start of the wall construction, the Contractor shall submit a quality control plan, QCP, for approval. The QCP shall include, but not be limited to, personnel qualifications, wall construction procedures and sequencing, a verification testing program, and a performance monitoring program. Work shall not begin until written notice has been received from the Engineer that the QCP has been accepted.

1. Personnel Qualifications

The field superintendent or field foreman shall have supervised the construction of a minimum of three completed walls of the same type as that submitted by the Contractor.

2. Verification Testing Program

The program shall include a verification testing program of all production and test anchors and nails. The program shall identify the test locations, the type of test, i.e., proof, performance, or pullout, testing procedures, acceptance criteria, and load and measuring devices to be used.

MATERIALS

734.03 Materials

Materials shall be in accordance with the following:

Geotextile Under Riprap	918.02
Pneumatically Placed Mortar	708
Reinforcing Bars	703
Steel H Piles	915.02
Steel Pipe Piles	915.01
Steel Sheet Piling	910.21
WWR, Smooth and Deformed	910.01
Structural Concrete	702
Structural Steel	910.02
Structure Backfill	904.05
Uncoated Seven-Wire Strand	910.01(b)7

Drainage pipe shall be underdrain pipe in accordance with 715.02(d).

CONSTRUCTION REQUIREMENTS

734.04 General Requirements

Excavation and embankment shall be in accordance with 203.

Welding shall be in accordance with 711.32.

734.05 Performance Monitoring During Construction

The program shall identify points of monitoring interest, in accordance with Geotechnical Engineering Circular No. 2 – Earth Retaining Systems, Report No. FHWA-SA-96-038, and the frequency of monitoring during and following construction of the wall. The program shall also include a baseline survey for points of monitoring interest.

The Contractor shall notify the Engineer if indications of ground movement in the vicinity of the wall, increased size of old cracks, or separation of joints in structures, foundations, streets, or paved or unpaved surfaces are observed. The Contractor shall monitor the performance of the wall and movements of buildings, roads, or other facilities within a distance of three times the excavation depth for the wall. If the Engineer determines that the movements exceed those anticipated for construction, the Contractor shall take corrective actions necessary to arrest the movement, or make repairs.

Within 30 days after completion of the work, as-built drawings shall be submitted to the Engineer. Revised design calculations signed by the professional engineer shall be provided for all design changes made during the construction of the permanent earth retention system.

734.06 Performance Monitoring After Construction

Performance monitoring by the Contractor shall be done during construction and for a period of one year from the date the Contractor has been relieved of further maintenance, as set out in the final acceptance letter from the Department. The Contractor shall post a warranty bond for the performance monitoring that occurs after the Contractor has been relieved of further maintenance. The Contractor shall make evaluations of the test and monitoring data and performance of the wall at the frequency defined in the approved performance monitoring program. The Contractor, if necessary during the monitoring period or as directed, shall correct deficiencies in the capacities of individual elements or take other corrective measures which may be required to prevent damage or excessive movement of the wall and adjacent facilities. The Contractor shall submit all test and monitoring data to the Engineer on a weekly basis or as otherwise directed.

734.07 Method of Measurement

Cut wall will be measured by the square foot of exposed face area of wall above finished grade as shown on the plans.

734.08 Basis of Payment

The accepted quantities of cut wall will be paid for at the contract unit price per square foot for cut wall.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Cut-Wall, No. ____	SFT

The costs of all professional services, labor, excavation, structure backfill, equipment, materials, tests, QCP, and incidentals necessary to design, construct, and monitor the wall including all drainage required by the wall design and all temporary construction facing or permanent facing, if applicable, and correction required by the wall design of deficiencies which may be required to prevent damage or excessive movement of the wall shall be included in the cost of this work. No additional payment will be made for the costs of providing and taking corrective actions.

SECTION 735 – TEMPORARY WIRE-FACED MECHANICALLY STABILIZED EARTH RETAINING WALLS

735.01 Description

This work shall consist of the design, furnishing materials, and placement of temporary wire-faced mechanically stabilized earth retaining walls in accordance with 105.03.

735.02 General Design Requirements

A temporary wire-faced MSE wall shall consist of wire-facing elements, ground reinforcement elements mechanically connected to the wire-facing elements, and a drainage system if required. Concrete face panels will be required for the lower course of the wall if shown on the plans. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by the design.

A temporary wire-faced MSE wall shall be constructed in accordance with the approved plans and panels working drawings based on the requirements herein. The recommendations of the wall system supplier shall meet or exceed the minimum performance requirements included herein.

If appurtenances interfere with connecting ground reinforcement to face panels, back up panels shall be provided.

The top of the wire-facing elements shall be at or above the top of the wall envelope shown on the plans.

The maximum dimensions for wire-face panels shall be limited to 2 ft vertical and 8 ft horizontal.

735.03 Design Criteria

The design life of the wall shall be 36 months. The minimum allowable yield stress for reinforcement shall be 65 ksi. The maximum allowable stress in the reduced section after sacrificial steel has been removed at the end of the design life shall be 0.55Fy for WWR. The maximum allowable stress may be increased to 0.77Fy if the design life does not exceed 36 months. The reduced section of ground reinforcement shall be limited to the allowable stress shown above at the end of the 36-month design life.

The connections of the ground-reinforcing steel to the wire-facing shall not be more than 24 in. apart vertically.

The design shall otherwise be in accordance with 731.02 and 731.03.

735.04 Submittals

The Contractor shall submit working drawings in accordance with 105.02. The Contractor shall submit design calculations in accordance with 105.02 and the following additional requirements. In case of discrepancy, the requirements listed below supersede those listed in 105.02. Design calculations shall show the complete design of the temporary wire-faced wall. Calculations may be in either longhand or computer-printout format and shall follow a systematic and logical methodology. A summary sheet that shows design assumptions and their source, controlling parameters and load cases, and other pertinent input and output information shall be attached to the calculations package. Wall construction operations shall not begin until the Contractor receives written notice that the working drawings are approved.

(a) The working drawings shall include all details, dimensions, quantities and cross sections necessary to construct the wall. They shall include, but shall not be limited to, that listed in 731.04(a) and (b).

(b) Wire-facing details shall show all dimensions necessary to construct the element, all wire in the element, and the location of ground-reinforcing-system devices attached to the wire-facing.

MATERIALS

735.05 Materials

Materials shall be in accordance with the following:

Admixtures for Use in Concrete	912.03
Air-Cooled Blast-Furnace Slag	901.09
Alignment Pins	910.07(d)
B Borrow	211.02
Coarse Aggregate, Class A or Higher, Size No. 8 or 91	904
Components of MSE Retaining Walls	901.10
Concrete, Class A	702
Fine Aggregate, Size No. 23	904
Fly Ash	901.02
Geotextile for Underdrains	918.03
Joint Spacers and Joint Covering	901.10(b)
PCC Components	901.10
Portland Cement	901.01(b)
Rapid Setting Patch Materials	901.07
Reinforcing Bars	910.01
Steel Components	910.07
Steel WWR, Smooth	910.01(b)5
Water	913.01

Backfill material used in the temporary wire-faced MSE wall volume shall be structure backfill, type 3 in accordance with 211 with the exception that nominal size aggregate No. 30 shall not be used.

All retention fabric or filter cloth shall be geotextile for use with underdrains.

The Contractor shall supply the MSE retaining wall components described above, including wire-facing, concrete face panels, retaining strips or mesh, tie strips, fasteners, earth-retention materials, drainage system components, and all necessary incidentals, through a manufacturer shown on the Department's list of approved retaining wall systems.

CONSTRUCTION REQUIREMENTS

735.06 General Requirements

Foundation preparation shall be in accordance with 731.07. Retaining-wall excavation shall be in accordance with 731.08.

735.07 Wall Erection

The wall system components shall be constructed in accordance with the wall system supplier's recommendations and construction manual.

The Contractor shall perform the necessary work to verify that the foundation is at the correct elevation, that the wall is constructed to the correct alignment, and that the work is in accordance with the specified tolerances.

Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed. Prior to placement of the ground reinforcement, backfill shall be placed and compacted in accordance with 731.11.

Where shown on the plans, backing mats shall be placed behind the wire-facing.

Where shown on the plans, galvanized screens with openings not exceeding 1/2 in. shall be placed behind the wire-facing to retain the earth.

735.08 Method of Measurement

The measurement of temporary wire-facing and temporary wall erection will be based on the square foot of area contained within the neat line limits of the wall envelope shown on the plans and not that of the wall system supplier.

Common excavation will be measured in accordance with 203.27. Structure backfill and B borrow will be measured in accordance with 211.09. Unsuitable foundation materials, if found, will be measured in accordance with 211.09. If unsuitable foundation material is encountered in the portion of the foundation beneath the reinforced backfill zone in a section constructed on original ground or in a cut section, the removal, replacement, and compaction of the new material will be measured in accordance with 203.27 and 211.09.

Geotextile materials will not be measured. Drainage of the backfill including piping, aggregates, and incidentals will not be measured.

735.09 Basis of Payment

The accepted quantities of temporary wire-facing and temporary wall erection will be paid for at the contract unit price per square foot. Common excavation will be paid for in accordance with 203.28. Structure backfill and B borrow will be paid for in accordance with 211.10. Unsuitable foundation materials will be paid for in accordance with 211.10.

Payment will be made under:

Pay Item	Pay Unit Symbol
Temporary Wire-Facing	SFT
Temporary Wall Erection	SFT

The cost of all MSE retaining wall components including wire-facing elements, concrete face panels, ground reinforcing, tie strips, fasteners, soil retention materials, repair or replacement of wire-facing elements damaged or removed due to backfill placement, and incidentals shall be included in the cost of temporary wire-facing.

If unsuitable foundation material is encountered in the portion of the foundation beneath the reinforced backfill zone in a section constructed on original ground or in a cut section, the cost of removal, replacement, and compaction of new material will be paid for in accordance with 203.28 and 211.10.

If unsuitable foundation material is encountered in the portion of the foundation beneath the reinforced backfill zone that is constructed on an embankment section that is constructed under the same contract, the cost of removal, replacement, and compaction of new material will not be considered for payment.

The cost of geotextiles shall be included in the cost of the pay items in this section.

The cost of all labor and materials required to prepare the wall foundation, to place the ground reinforcement, and to erect the concrete face panels shall be included in the cost of temporary wall erection.

The cost of labor and materials required to provide for the drainage of the backfill including piping, aggregates, or geotextile materials shall be included in the cost of temporary wire-facing.

The cost of performing the laboratory tests by an approved geotechnical laboratory for structure backfill or ACBF slag shall be included in the cost of the pay items in this section.

The cost of all labor and materials for geotextile materials used shall be included in the cost of the pay items in this section.

The cost of cutting, altering, and recoating of the ground reinforcement at the site shall be included in the cost of temporary wall erection.

SECTION 736 – BLANK

SECTION 737 - WELDED WIRE REINFORCEMENT, WWR

737.01 Description

This work shall consist of furnishing and placing WWR as an alternative to furnishing and placing reinforcing bars in concrete superstructures, reinforced concrete bridge approaches, crash walls, and cast-in-place retaining walls in accordance with 105.03.

MATERIALS

737.02 Materials

Materials shall be in accordance with the following:

Deformed and Smooth Steel WWR..... 910.01(b)5

CONSTRUCTION REQUIREMENTS

737.03 Design Requirements

The nominal yield strength shall be the minimum as specified for the grade of steel selected, except that the maximum nominal yield strength used for design purposes shall not exceed 75 ksi. The nominal yield strength shall not be less than 65 ksi for smooth WWR and 70 ksi for deformed WWR. The area of steel in the longitudinal and transverse directions may be reduced in proportion to the nominal yield strength specified for the grade of steel up to the maximum allowable. For purposes of crack control, spacing of reinforcement in the WWR sheet shall not be greater than 8 in. in either direction.

If the plans show uncoated reinforcing bars, the Contractor shall use uncoated WWR. If the plans show epoxy coated reinforcing bars, the Contractor may elect to supply either epoxy coated or galvanized WWR.

737.04 Working Drawings

Working drawings shall be submitted for approval in accordance with 105.02. Fabrication shall not begin until the working drawings are approved.

737.05 Fabrication

WWR shall be cut and bent to the shapes shown on the working drawings. All WWR shall be cold bent, unless otherwise approved by the Engineer. Hook dimensions and diameters of bends shall be as shown on the working drawings. WWR partially embedded in concrete shall not be field bent, except as shown on the approved working drawings or allowed by the Engineer. Coated WWR shall not be field cut, unless allowed by the Engineer. If allowed, field cutting of coated WWR shall be performed using hydraulic-powered or friction cutting tools to minimize coating damage and field touch-up. Field cut coated WWR shall be repaired with compatible patching material that is deemed suitable for repairs in the field. Flame cutting of coated WWR will not be allowed.

737.06 Handling and Storage

All WWR shall be handled and stored by methods that will not damage the coating or WWR, and in accordance with the applicable requirements of 703.04. Bundles shall not be dropped or dragged. WWR shall be transported and stored so as to not damage the applied coating. The coated WWR shall not be exposed to fire or flame.

Prior to placement of concrete, all WWR shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other materials that can reduce bond. Coated WWR shall be free from cracks or laminations. For uncoated WWR, bonded rust, surface irregularities, or mill scale will not be cause for rejection, provided the minimum dimensions, cross sectional area, and tensile properties of the WWR specimen satisfy the physical requirements for the size and grade of WWR specified.

737.07 Placing and Securing

WWR shall be placed as shown on the approved working drawings and held in position during the placing and finishing of concrete. WWR shall be lapped and tied around the perimeter of each sheet in order to maintain proper positioning of the WWR. Lap splices shall have a minimum of two ties per spliced length. Unless otherwise shown on the approved working drawings, WWR sheets shall overlap a minimum of 8 in. in each direction to make a splice. Plastic or wire bar supports, such as chairs and bolsters, shall be in accordance with the requirements herein and industry practice as described in the Wire Reinforcing Institute, WRI, WWR-500, Manual of Standard Practice. All metal bolsters or chairs which bear against the forms for exposed surfaces shall be equipped with snug fitting, high density, polyethylene tips which provide 1/2 in. minimum clearance between the metal and an exposed surface. The spacing of slab bolster rows and high chair rows for deck slabs shall be as described in the WRI WWR-500, Manual of Standard Practice unless otherwise directed. For epoxy-coated WWR, tie wires, chair and bar supports, and metal clips shall be epoxy, plastic, or nylon coated. For galvanized WWR, tie wires, chair and bar supports, and metal clips shall be plastic coated or hot dipped galvanized after fabrication in accordance with ASTM A 1060. Tie-down bars shall be placed as shown on the approved working drawings. With the exception of tie-down bars, tack welding will not be allowed, unless shown on the approved working drawings.

WWR shall be supported in its specified position by use of plastic or wire bar supports, supplementary tie-down bars, side-form spacers, or other approved devices. Such devices shall be placed at intervals so as to maintain the WWR cover as shown on the approved working drawings. Platforms for the support of workers and equipment during concrete placement shall be supported directly by the forms and shall not alter the positioning of the WWR.

737.08 Repair of Coated WWR

All damaged, cut, or otherwise compromised areas of the coating shall be repaired.

(a) Epoxy-Coated

In addition to the requirements of ASTM A 884, all visible damage, including but not limited to scratches, nicks and cracks to the epoxy coating caused during shipment, storage, or placement shall be repaired on the project site with approved patching material. Ends of WWR that have been sheared, sawed, or cut by other means shall be coated with approved patching material. Areas on the WWR sheets and tie-down bars damaged due to welding shall be repaired with approved patching material. Patching of damaged areas shall be performed in accordance with the patching material manufacturer's recommendations. If the damaged surface area exceeds 10% of the total WWR sheet surface area, the sheet shall be removed and replaced with an acceptable sheet. All patching material shall be fully cured prior to placing concrete. Patching material shall be compatible with the epoxy coating, deemed inert in concrete, and deemed suitable for repairs in the field. Patching material shall be identified on the container as satisfying ASTM A 775, Annex A2, or shall be accompanied by a type C certification in accordance with 916 certifying that the material satisfies or exceeds the requirements of Annex A2.

(b) Galvanized

All visible damage, including but not limited to scratches, nicks and cracks to the galvanized coating caused during shipment, storage, or placement shall be repaired on the project site in accordance with ASTM A 1060. Ends of WWR that have been sheared, sawed, or cut by other means shall be coated. Areas on the WWR sheets and tie-down bars damaged due to welding shall be repaired and recoated. Field coating of damaged areas shall be performed in accordance with the coating manufacturer's recommendations. Galvanized coating shall be in accordance with ASTM A 1060. It shall be applied to achieve a dry film equal to or exceeding that designated in ASTM A 1060. All touchup coating material shall be fully cured prior to placing concrete.

737.09 Final Inspection

After being placed, WWR shall be subject to approval of the Engineer before beginning concrete placement. Concrete placed prior to approval of the WWR will be subject to rejection and removal.

737.10 Method of Measurement

This work will not be measured for payment.

737.11 Basis of Payment

The accepted quantity for payment will be the quantity for reinforcing bars or epoxy-coated reinforcing bars shown on the plans. This work will be paid for as reinforcing bars or epoxy-coated reinforcing bars in accordance with 703.08, regardless of whether the WWR design results in a reinforcement weight that is different from that shown on the plans.

If galvanized WWR is supplied, it will be paid for as epoxy-coated reinforcing bars.

The cost of tie wires, chair and bar supports, metal clips, spacers, or other mechanical means used for fastening or holding WWR in place, and laps shall be included in the cost of WWR. The cost of epoxy-coating materials or galvanizing materials and repair of damaged or removed coating materials on WWR and on tie wires, chair and bar supports, metal clips, spacers, or other mechanical means used for fastening or holding WWR in place, and laps shall be included in the cost of WWR.

150 If reinforcing bars or epoxy-coated reinforcing bars are not paid for separately, but instead included in the cost of a pay item, and WWR is substituted for reinforcing bars or epoxy-coated reinforcing bars, the WWR will not be paid separately, but shall be included in the cost of the pay item.