# SECTION 550 BRIDGE CONSTRUCTION

# Section 551 - Piling

## DESCRIPTION

551.01
Work

This work shall consist of furnishing and driving or placing piling.

The contractor shall furnish the piles in accordance with an itemized list that will be furnished by the Engineer, showing the number and lengths of all piles. No list will be furnished when cast-in-place concrete piles are specified. When test piles and load tests are required in accordance with Subsections 551.02 and 551.03, respectively, the data obtained from driving test piles and making load tests will be used in conjunction with other available subsoil information to determine the number and lengths of piles to be furnished. The Engineer will not prepare the itemized list of piles for any portion of the foundation area until all required load tests and test pile driving in that portion have been completed.

Lengths of piles given in the order list will be based on the lengths that are assumed to remain in the completed structure. The contractor shall, without added compensation, increase the lengths to provide for fresh heading and for such additional length as might be necessary to suit the contractor's method of operation.

551.02
Test Piles

For information, the contractor may drive as many test piles as necessary. When called for in the SCHEDULE OF ITEMS or when needed for calibrating hammers in accordance with Subsection 551.03, the contractor shall furnish and drive test piles of the dimensions and at the locations SHOWN ON THE DRAWINGS or ordered by the Engineer. They shall be of the material shown in the SCHEDULE OF ITEMS and shall be driven to refusal or to such tip elevation or approximate bearing value SHOWN ON THE DRAWINGS or ordered by the Engineer. When test piles are to be incorporated in the completed structure, they shall be driven with the same type of hammer that will be used for driving the contract piles.

When the Engineer requests a load test to determine a bearing value, the first load test pile shall be driven to the specified bearing value as determined by the applicable formula indicated in Subsection 551.04. Subsequent test piles to be load tested shall be driven to the specified bearing values as determined by the applicable formula modified by the results of prior load tests and foundation data. It is the intent of these specifications that test piles to be load tested shall fail between two and three times the specified bearing value except for piles driven to refusal, rock, or a specified tip elevation. The ground at each test pile shall be excavated to the elevation at the bottom of the footing before the pile is driven. The hammer used shall meet the requirements of Subsection 551.16.

551.03
Load Tests

When called for in the SCHEDULE OF ITEMS, load tests shall be made where SHOWN ON THE DRAWINGS or required in the SPECIAL PROJECT SPECIFICATIONS. When diesel or other types of hammers requiring calibration are to be used, the contractor shall make load tests even though no load tests are called for in the SCHEDULE OF ITEMS, except that load tests will not be required when the hammer is to be used only for driving piles to refusal, rock, or a fixed tip elevation, or when the hammer is of a type and model that has been previously calibrated for similar type, size, and length of pile, and foundation material. Calibration data must have been obtained from sources acceptable to the Engineer.

Load tests shall be made by methods approved by the Engineer. The contractor shall submit to the Engineer for approval detailed drawings of the loading apparatus he intends to use. The apparatus shall be constructed to allow the various increments of

the load to be placed gradually without causing vibration to the test piles. If the approved method requires the use of tension (anchor) piles, such tension piles shall be of the same type and size as the permanent piles and shall be driven in the location of permanent piles when feasible. Permanent piling used as anchor piling that is raised during the load test shall be redriven to original grade and bearing.

After the completion of load tests, the load used shall be removed, and the piles, including tension piles, shall be used in the structure if they are found by the Engineer to be satisfactory for such use. Test piles not loaded shall be used similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for use in the structure, it shall be removed or cut off at least 1 foot below the ground line or footings, whichever is applicable.

551.04 Timber Pile Bearing Values by Formula

When load tests are called for in the SCHEDULE OF ITEMS, and when diesel or other hammers to be calibrated are used, the minimum number of hammer blows per unit of pile penetration needed to obtain the specified bearing value of piles will be determined by load tests in accordance with Subsections 551.02 and 551.03. In the absence of load tests, the safe bearing value of each timber pile will be determined by whichever of the following approximate formulas is applicable.

For gravity hammers:

$$P = \frac{2WH}{S + 1}$$

For single-acting steam or air hammers and for diesel hammers having unrestricted rebound of ram:

$$P = \frac{2WH}{S + 0.1}$$

For double-acting steam or air hammers and diesel hammers having enclosed rams:

$$P = \frac{2E}{S + 0.1}$$

*where*

$P$ = *safe load per pile in pounds;*

$W$ = *weight of the striking part of the hammer in pounds;*

$H$ = *height of fall in feet for gravity, steam, and air hammers; and observed average height of fall, in feet, of blows used to determine penetration for diesel hammers with unrestricted rebound of ram;*

$S$ = *average penetration per blow in inches for the last 5 to 10 blows of a gravity hammer or the last 10 to 20 blows of a steam, air, or diesel hammer; and*

$E$ = *the manufacturer's rating for foot-pounds of energy developed by double-acting steam or air hammers, and*

= *90 percent of the average equivalent energy in foot-pounds as determined by gauge attached to the pile hammer and recorded during the period when the average penetration per blow is recorded for diesel hammers having enclosed rams. Hammers of this type shall be equipped with a gauge, and applicable charts shall be supplied that will evaluate the equivalent energy being produced under any driving condition.*

The above formulas are applicable only when:

(a) The hammer has a free fall.

(b) The head of the pile is free from broomed or crushed wood fiber or other serious impairment.

(c) The penetration is at a reasonably quick and uniform rate.

(d) There is no measurable bounce after the blow.

(e) If a gravity hammer is used, its weight shall be at least 3,000 pounds and equal to or greater than the weight of the pile plus the weight of the driving head, but shall not be greater than three times the weight of the pile.

(f) A follower is not used.

If there is a measurable bounce, twice the height of bounce shall be deducted from H to determine the value in the formula. The bearing power as determined by the appropriate formula in the foregoing list will be considered effective only when it is less than the crushing strength of the pile.

In all cases, when bearing power is determined by a formula, timber piles shall be driven until the computed safe bearing power of each is not less than the design value SHOWN ON THE DRAWINGS. Piles shall be driven to a pile tip elevation at least as low as SHOWN ON THE DRAWINGS.

551.05
Concrete & Steel
Pile Bearing Values

The formulas specified above for timber piling may be used to approximate the bearing value of precast concrete piles, cast-in-place concrete piles, and structural steel piles.

Wave Equation Analysis. Wave Equation Analysis shall be used to determine pile bearing values when specified in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS. When wave equation analysis is specified, all pile driving equipment to be used in the work shall be subject to approval by the Engineer. Prerequisite to the Engineer's approval, the contractor shall submit the following:

(a) The pile hammer operating specifications. The specifications shall include the weight, diameter, and length of the ram; drive head and anvil (if applicable) dimensions and weights; capblock and cushion data (such as material thickness, area, modulus of elasticity, and coefficient of restitution); net weight of hammer, net weight of cylinder, and piston areas for doubleacting or differential acting air or steam hammers; bounce chamber pressure versus equivalent energy graphs for closed-end diesel hammers; and mandrel type and weight, when applicable.

(b) A wave equation analysis bearing the approval of a registered professional engineer for each hammer proposed for use to determine the soil resistance value SHOWN ON THE DRAWINGS unless otherwise provided in the SPECIAL PROJECT SPECIFICATIONS.

The pile hammer operating specifications and wave equation analysis shall be submitted to the Engineer at least 21 days prior to commencing pile driving operations. The Engineer will approve or deny the submittal within 7 days of receipt from the contractor.

Approval of the proposed pile hammer shall not relieve the contractor of responsibility for stress-damaged piles due to misalignment of the leads, failure of capblock or cushion material, failure of splices, malfunctioning of the pile hammer, or other improper construction methods. Piles damaged for such reasons shall be rejected if the damage impairs the strength of the pile as determined by the Engineer.

In all cases where the bearing value of concrete and steel piles is determined by formula, the piles shall be driven until the safe bearing value of each is computed to be not less than the design value SHOWN ON THE DRAWINGS. Piles shall be driven to a tip elevation at least as low as SHOWN ON THE DRAWINGS.

551.06 Minimum Penetration

All piles shall penetrate at least 10 feet into the natural ground, and when a pile tip elevation is specified shall penetrate at least to the specified tip elevation. When the blow count approaches refusal without reaching the required penetration, additional aids shall be used to obtain the specified penetration, unless otherwise permitted in writing by the Engineer. These aids may include the use of waterjets or larger hammer and ram striking with low velocity. Driving equipment that damages the pile shall not be used.

551.07 Jetted Piles

The safe bearing value of jetted piles will be determined by actual tests or by the appropriate method and formulas given above. No jet shall be used during the test blows.

## MATERIALS

551.08 Requirements

Materials for piling shall meet the requirements of the following Subsections:

| | |
|---|---|
| Untreated Timber Piles | 715.01 |
| Treated Timber Piles | 715.02 |
| Concrete Piles | 552.03-04 |
| Steel Shells | 715.04 |
| Steel Pipes | 715.05 |
| Steel H-Piles | 715.06 |
| Sheet Piles | 715.07 |
| Pile Shoes | 715.08 |
| Paint | 708.03 |
| Reinforcing Steel | 709.01 |
| Prestessing Reinforcing Steel | 709.03 |

## CONSTRUCTION

551.09 Precast Concrete Piles

Precast concrete piles shall be of the design or designs SHOWN ON THE DRAWINGS. They shall be constructed of Portland cement concrete meeting the requirements of Section 552. Prestressed concrete piles shall be prestressed in accordance with Section 553.

The piles shall be cast separately or if alternate piles are cast in a tier, the intermediate piles shall not be cast until 4 days after the adjacent piles have been poured. Piles cast in tiers shall be separated by tar paper or other suitable separating materials. The concrete in each pile shall be placed continuously. The completed piles shall be free from stone pockets, honeycombs, or other defects, and shall be straight and true to the form specified. The forms shall be true to line and built of metal, plywood, or dressed lumber. A 1-inch chamfer strip shall be used in all corners unless otherwise SHOWN ON THE DRAWINGS. Forms shall be watertight and shall not be removed until at least 24 hours after the concrete is placed. Exposed surfaces of piles shall be given a Class 1 ordinary surface finish. Piles shall be cured and finished in accordance with the applicable requirements of Section 552 or 553.

Test cylinders shall be made in accordance with AASHTO T 23 and tested for compressive strength in accordance with AASHTO T 22.

Piles shall not be moved until the tests indicate a compressive strength of 80 percent of the required 28-day compressive stength, and they shall not be transported or driven until the tests indicate a compressive strength of the required 28-day compressive strength.

When concrete piles are lifted or removed, they shall be supported at the points SHOWN ON THE DRAWINGS or, if not so shown, they shall be supported at the quarter points.

551.10 Cast-In-Place Concrete Piles

Cast-in-place concrete piles shall be of the design or designs SHOWN ON THE DRAWINGS. They shall consist of concrete cast-in-steel shells or pipes driven to the required bearing. Concrete shall meet the requirements of Section 552.

The inside of shells and pipes shall be cleaned and all loose material removed before concrete is placed. The concrete shall be placed in one continuous operation from tip to cutoff elevation avoiding segregation. The top 15 feet of concrete-filled shells shall be consolidated by vibratory equipment.

Pipes shall be of the diameter SHOWN ON THE DRAWINGS. The wall thickness for shell pipes shall not be less than that SHOWN ON THE DRAWINGS but in no case less than 16 gauge (0.064 inch). The pipe, including end closures, shall be of sufficient strength to be driven by the specified methods without distortion.

Closure plates and connecting welds shall not project more than 1/2 inch beyond the perimeter of the pile tips.

Shells or pipes shall not be filled with concrete until all adjacent shells, pipes, or piles within a radius of 15 feet have been driven to the required resistance, or until all shells or pipes for any one bent or abutment have been completely driven.

No shell, pipe, or pile shall be driven within 20 feet of a shell or pipe that has been filled with concrete until at least seven days have elapsed.

551.11 Steel H-Piles

Steel H-piles shall consist of structural steel shapes of the sections SHOWN ON THE DRAWINGS.

When placed in the leads, the pile shall not exceed the camber and sweep permitted by allowable mill tolerance. Piles bent or otherwise damaged will be rejected.

The loading, transporting, unloading, storing, and handling of steel H-pile shall be conducted so that the metal will be kept free from damage.

551.12 Open End Tubular Steel Piles

Piles with an outside diameter of less than 14 inches shall have a minimum wall thickness of 1/4 inch. Piles with an outside diameter of 14 inches and greater shall have a minimum wall thickness of 3/8 inch. The pipe shall be of sufficient strength to be driven by the specified methods without distortion.

551.13 Timber Piles

(a) General. The heads of treated timber piles shall be shaped to fit the driving head.

(b) Strapping. Treated timber piles shall be strapped with a minimum of three straps: one approximately 18 inches from the butt, one approximately 24 inches from the butt, and one approximately 12 inches from the tip. In addition, piles shall be strapped at an interval not to exceed 15 feet. Straps shall be approximately 1.25 inches wide, 0.03 inch thick, and manufactured from cold-rolled, heat-treated steel. The strap shall have an ultimate tensile strength of 5,100 pounds. The strap shall encircle the pile once and shall be fastened with a clip so crimped that the joint will have a minimum tensile strength of 80 percent of the tensile strength of the strap. The strap shall be installed after pressure treating of the pile.

(c) Storage and Handling of Timber Piles. The method of storage and handling shall be such as to avoid injury to the piles. Special care shall be taken to avoid breaking of the surface of treated piles. Cuts or breaks in the surface of treated piles

shall be protected in accordance with AWPA Standard M-4. If the treatment is damaged so that the integrity of the pile is in jeopardy, the pile will be rejected and a replacement pile shall be furnished by the contractor at no expense to the Government.

(d) Minimum Diameter. The minimum diameter of timber piling shall be as SHOWN ON THE DRAWINGS.

551.14 Extensions

Extensions, when approved by the Engineer, shall be made in accordance with this Subsection.

(a) Precast Concrete Piles. Extensions of precast concrete piles shall be made by cutting away the concrete at the end of the pile, leaving the reinforcement steel exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement of the same size as used in the pile shall be fastened securely to the projecting steel and the necessary form work shall be placed. Care shall be taken to prevent leakage along the pile. Just prior to placing concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement, or other bonding material. The forms shall remain in place until the concrete has attained at least two-thirds of its required strength. If tests are not available, forms shall remain in place until the concrete is set and will not be damaged, but not less than 7 days. Curing and finishing operations shall be in accordance with Sections 552 and 553.

(b) Prestressed Piles. Extensions of prestressed precast piles will generally not be permitted, but when permitted they shall be made in accordance with (a) above, but only after driving has been completed. Reinforcement bars shall be included in the pile head for splicing to the extension bars. No additional driving will be permitted. The contractor has the option of submitting alternative plans of extensions for approval by the Engineer.

(c) Steel H-Piles, Pipes, Shells, and Open-End Tubular Steel Pipes. If the ordered length of a steel H-pile, pipe, or open-end tubular steel pile shell is insufficient to obtain the specified bearing value, an extension of the same cross section shall be spliced to it. Unless otherwise SHOWN ON THE DRAWINGS, splices shall be made by butt-welding the entire cross section, using the electric arc method in accordance with current AWS specifications. Butt-welded surfaces shall be flat or concave. Every effort shall be made to have welds below ground. Where exposed in pile bents, welds exceeding 1/16 inch in thickness above the base metal shall be ground off.

551.15 Timber Pile Bents

Piles for any one bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. However, care shall be exercised in the distribution of piles of various sizes to obtain uniform strength and rigidity in the bents of any given structure.

Cutoffs shall be made accurately to ensure full bearing between caps and piles of bents.

551.16 Driving Piles

At least 21 days before first use of any pile hammer, the contractor shall furnish the Engineer two copies of the manufacturer's specifications on the hammer. The specifications shall include all information necessary to properly use the appropriate bearing value formula in Subsection 551.04 and to verify that the hammer meets the other requirements of this Section. All piles shall be driven at locations SHOWN ON THE DRAWINGS. They shall be driven within an allowed variation of 1/4 inch per foot of pile length above the ground from the vertical or batter SHOWN ON THE DRAWINGS. The maximum allowable variation from the pile design location and batter shall be as SHOWN ON THE DRAWINGS.

Prior to driving piles, all structure excavation shall have been performed in accordance with Sections 203 and 206.

Predrilled holes to facilitate pile-driving operations shall be provided to the diameter and depths SHOWN ON THE DRAWINGS when required by the SPECIAL PROJECT SPECIFICATIONS. The diameter of the holes shall not be greater than 0.8 times the diameter of the piles unless permitted by the Engineer.

The heads of all piles shall be protected by caps of approved design, having a rope or other suitable cushion next to the pile head and fitting into a casting, which in turn supports a timber shock block.

For special types of piling, driving heads, mandrels, or other devices meeting the manufacturers' recommendations shall be provided so the pile can be driven without damage.

For steel piling, the heads shall be cut squarely and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer.

Full-length piles shall be used except when splices are permitted as provided by Subsection 551.14.

Piles shall be driven with steam, air, diesel hammers, or a combination of hammers with water jets. Gravity or drop hammers are permitted when driving timber piles unless excluded ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The boiler or tank shall be equipped with an accurate pressure gauge, and another gauge shall be supplied at the hammer intake to determine the drop in pressure between the gauges.

Gravity hammers permitted for driving timber piling shall weigh not less than the combined weight of the driving head and pile, nor less than 3,000 pounds. When gravity hammers are permitted for driving timber piles, the drop of the hammer should be regulated to avoid damage to the pile.

Pile hammers, except gravity or drop hammers, shall be steam, air, or diesel hammers that develop sufficient energy to drive the piles at a penetration rate of not less than 1/8 inch per blow at the required bearing value. When steam, air, or diesel hammers are used, the total energy developed by the hammer shall be not less than 7,000 foot-pounds per blow, except as specified below for concrete piles.

Diesel hammers shall be operated with wide-open throttles when blows are being counted for determination of penetration for use in the safe load formula, except that in the case of diesel hammers with enclosed rams, the throttle settings shall be just short of the settings that would cause nonstriking parts of the hammers to rise off the piles as the ram piston travels upward.

Piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed to afford freedom of movement of the hammer, and they shall be held in position by guys or steel braces to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary and shall be designed to permit proper placing of batter piles. The driving of piles with followers shall be allowed only with written approval from the Engineer.

Steam, diesel, or air hammers used for driving concrete piles shall develop an energy per blow at each full stroke of the piston of not less than 3,500 foot-pounds per cubic yard of concrete in the pile driven.

No driving of piles shall be done within 20 feet of concrete less than 7 days old.

551.17
Defective Piles

The method used in driving piles shall not produce crushing and spalling of the concrete, injurious splitting, splintering, and brooming of the wood, or deformation of the steel. Excessive manipulation of piles to force them into proper position will not be permitted. Any pile damaged by reason of internal defects, or by improper driving, or driven out of its proper location, or driven below the elevations SHOWN ON THE DRAWINGS or set by the Engineer, shall be corrected by the contractor, without added compensation, by one of the following methods approved by the Engineer for the pile in question:

(a) The pile shall be withdrawn and replaced by a new and, when necessary, longer pile.

(b) A second pile shall be driven adjacent to the defective pile.

(c) The pile shall be spliced or built up as otherwise provided herein or a sufficient portion of the footing extended to properly embed the pile. Piles shall not be spliced unless approved by the Engineer. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

A concrete pile will be considered defective if it has a visible crack, or cracks, extending around the entire periphery of the pile or any defect that affects the strength or life of the pile.

551.18
Cutting Off & Capping Piles

Piles shall be cut off level at the elevation SHOWN ON THE DRAWINGS. The length of pile cutoff shall be sufficient to permit the removal of all injured material. The distance from the side of any pile to the nearest edge of the footing shall be a minimum of 9 inches.

When the cutoff elevation for a precast concrete pile or for the steel shell or concrete casing for a cast-in-place concrete pile is below the elevation of the bottom of the cap, the pile shall be built up from the butt of the pile to the elevation of the bottom of the cap by means of a reinforced concrete extension as approved by the Engineer. Steel shells or concrete casings for cast-in-place concrete piles shall be cut off at the DESIGNATED elevation before being filled with concrete.

Cutoffs of steel bearing piles shall be made at right angles to the axis of the pile. The cuts shall be made in clean, straight lines.

Cutoffs of treated timber piles shall be protected in accordance with AWPA Standard M-4.

At the completion of the work, all unused pile cutoff lengths not included in the itemized order list furnished by the Engineer shall become the property of the contractor and shall be removed or disposed of by the contractor.

551.19
Protecting Untreated Timber Trestle Piles

The sawed surface of the heads of untreated piles shall be thoroughly brush coated with two applications of hot creosote oil or other approved preservative.

551.20
Painting Steel Piles

When steel piles extend above the ground surface or water surface, they shall be protected by three coats of paint in accordance with the systems for cleaning and painting metal surfaces in Section 555 as SHOWN ON THE DRAWINGS. This protection shall extend from the elevation SHOWN ON THE DRAWINGS to the top of the exposed steel.

## MEASUREMENT

551.21 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

551.22 Timber, Steel, & Precast Concrete Piles

(a) Piles Furnished. Measurement (in feet) will be the sum of the lengths, measured to the nearest foot, of the several types and lengths of piles furnished and stockpiled in good condition at the site of the work by the contractor and accepted by the Engineer. The number of feet to be measured will include the lengths of test and tension piles required, but not the lengths of those furnished at the contractor's option. No measurement will be made for footage of piles, including test piles, furnished by the contractor to replace piles previously accepted by the Engineer that are lost or damaged while in stockpile or during handling or driving, prior to completion of the contract and which are subsequently removed from the site of the work or disposed of otherwise.

If case extensions of piles are necessary, the extension length will be included in the linear footage of piling furnished, except for cutoff lengths used for extensions and otherwise measured for payment.

(b) Piles Driven. Driving of timber, steel, and precast concrete piles will be measured to the nearest foot of piling in place between the actual tip elevation and the elevation of the ground existing at the pile immediately prior to driving. Structure excavation, if required, shall have been performed prior to this measurement. Test piles driven at the option of the contractor will not be included unless they comply fully with the requirements specified herein and are accepted by the Engineer to become part of the completed structure.

Drilled or jetted holes for facilitating pile driving procedures will not be measured directly, but will be considered incidental to pay items on the SCHEDULE OF ITEMS.

551.23 Cast-In-Place Concrete Piles

Cast-in-place piles will be measured by the actual number of feet of piles cast and left in place in the completed and accepted work. Measurement to the nearest foot will be made from the point of the tip of the pile to the bottom of the cap or bottom of the footing, as the case may be. Portions of piles cast deeper than required will not be measured.

551.24 Pile Shoes

Pile shoes, including test pile shoes, will be measured as the number of pile shoes SHOWN ON THE DRAWINGS or ordered in writing by the Engineer, furnished and stockpiled by the contractor in good condition at the site of the work, and accepted by the Engineer. Pile shoes furnished at the contractor's option will not be included. No allowance will be made for pile shoes furnished by the contractor to replace pile shoes previously furnished and accepted by the Engineer that are lost or damaged while in stockpile or during handling prior to completion of the contract and which are subsequently removed from the site of the work or disposed of otherwise.

551.25 Load Tests

Load tests will be measured by the number of load tests completed and accepted. Load tests made at the option of the contractor and load tests made to calibrate diesel or other designated types of hammers will not be included in the quantity measured.

551.26 Splices

Splices for pipes, shells, or H-piles will be measured by the number of splices ordered and accepted by the Engineer. Splices made for the convenience of the contractor will not be measured.

**PAYMENT**

551.27
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 551(01) | Untreated Timber Piles, Furnished . . . . . | L.F. |
| 551(02) | Treated Timber Piles, _____ Preservative, Furnished . . . . . | L.F. |
| 551(03) | Steel H-Piles, Furnished . . . . . | L.F. |
| 551(04) | Precast Concrete Piles, Furnished . . . . . | L.F. |
| 551(05) | Precast Prestressed Concrete Piles, Furnished . | L.F. |
| 551(06) | Untreated Timber Sheet Piles, Furnished . . . . | L.F. |
| 551(07) | Treated Timber Sheet Piles, _____ Preservative, Furnished . . . . . | L.F. |
| 551(08) | Precast Concrete Sheet Piles, Furnished . . . . | L.F. |
| 551(09) | Steel Shells for Concrete Piles, Furnished . . . | L.F. |
| 551(10) | Steel Pipes for Concrete Piles, Furnished . . . | L.F. |
| 551(11) | Untreated Timber Piles, Driven . . . . . | L.F. |
| 551(12) | Treated Timber Piles, Driven . . . . . | L.F. |
| 551(13) | Steel H-Piles, Driven . . . . . | L.F. |
| 551(14) | Precast Concrete Piles, Driven . . . . . | L.F. |
| 551(15) | Untreated Timber Sheet Piles, Driven . . . . . | L.F. |
| 551(16) | Treated Timber Sheet Piles, Driven . . . . . | L.F. |
| 551(17) | Precast Concrete Sheet Piles, Driven . . . . . | L.F. |
| 551(18) | Precast Prestressed Concrete Piles, Driven . . . | L.F. |
| 551(19) | Test Piles, _____', Driven . . . . . | L.F. |
| 551(20) | Concrete Piles Cast in Steel Shells, Driven . . | L.F. |
| 551(21) | Concrete Piles Cast in Steel Pipes, Driven . . . | L.F. |
| 551(22) | Pile Shoes . . . . . | EA. |
| 551(23) | Splices . . . . . | EA. |
| 551(24) | Load Tests . . . . . | EA. |

# Section 552 - Structural Concrete

## DESCRIPTION

552.01 Work

This work shall consist of furnishing, placing, and finishing concrete in major structures. Concrete shall consist of a mixture of Portland cement or fly ash modified Portland cement, fine aggregate, coarse aggregate, admixtures when required, and water mixed in the proportions approved by the Engineer.

552.02 Classes, Composition, & Testing of Concrete

(a) Classes of Concrete. The class of concrete used in each part of the structure shall be as SHOWN ON THE DRAWINGS or approved by the Engineer.

Prestressed concrete shall be Class P. Concrete deposited under water shall be seal concrete. All other concrete shall be Class A and shall be air entrained.

(b) Composition of Concrete. The contractor, through an approved testing laboratory, shall design the mix for each class of concrete. The mix design proposed by the contractor shall meet the requirements in table 552-1 and the minimum strength requirements SHOWN IN THE DRAWINGS, in the SPECIAL PROJECT SPECIFICATIONS, or in Subsection 552.02(c). The testing laboratory engaged by the contractor shall be fully equipped and capable of performing the required tests and services. The mix design shall be based on representative samples of aggregates, cement, water, and admixtures to be used on the project. Aggregate samples shall be taken in accordance with AASHTO T 2 and reduced to testing size in accordance with AASHTO T 248. A separate proposed mix design for each class of concrete shall be submitted to the Engineer for review at least 21 days prior to placement of the concrete in the work. If the contractor elects to change aggregate source during the progress of work, new mix designs meeting these requirements shall be submitted to the Engineer at least 21 days before such material is to be placed in the work.

Where fly ash modified concrete is used, the water/cement ratio in table 552-1 shall be computed as the ratio of the weight of water to the combined weights of Portland cement and 60 percent of the weight of the fly ash.

Current mix designs for other projects may be acceptable provided all items required herein are covered by certified submittals. Mix-design and aggregate quality tests from other projects shall have been run within 12 months of the date of submittal, and the aggregate source must be the same.

*Table 552-1.--Classes of structural concrete--requirements.*

| Class of Concrete | Method of Placing | Minimum Cement Content Required (Pounds per cu yd) | Maximum Water/ Cement Ratio Allowed (Pounds per Pound) | Required Slump (Range) (Inches) | Required Entrained Air (Range) (Percent) |
|---|---|---|---|---|---|
| A[b] | Vibrated | 611 | 0.49 | 2-1/2 (±1) | 5(±1) |
| P[b] | Vibrated | 658 | 0.44 | 2(±1) | --  --[a] |
| Seal | Nonvibrated | 658 | 0.54 | 6(±2) | --  -- |

[a]Designated by 28-day compressive strength SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. See Subsection 552.02(c) for minimum strength requirements.
[b]Concrete used in prestressed concrete sections shall not be air-entrained unless SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

Each mix design shall include the following items:

(1) Location and identification of aggregate source.

(2) Batch quantities for 1 cubic yard of concrete, including:

a. Weight in pounds of fine aggregate in the saturated surface dry condition.

b. Weight in pounds of each coarse aggregate size in the saturated surface dry condition.

c. Weight in pounds of cement.

d. Weight in pounds and volume in gallons of water and the water/cement ratio in pounds per pound.

e. Amount and description (include manufacturer, specific product name, and number) of all admixtures, including fly ash.

(3) Test results on the proposed mix design, including the following:

a. Cement factor in pounds per cubic yard based on yield test.

b. Water/cement ratio expressed in pounds of water per pound of cement (aggregates in saturated surface dry condition).

c. Percent entrained air by volume.

d. Consistency in inches of slump.

e. At least three 7-day and three 28-day compressive strength tests.

(4) Brand, type, and place of manufacture of cement.

(5) Aggregate test results for grading, deleterious substances, and physical properties shall be in accordance with Section 703. In addition to the requirements of Section 703, bulk specific gravity and absorption of coarse and fine aggregate shall be given. Unless waived in writing by the Engineer, the following test results shall be submitted.

Fine Aggregate

| | | |
|---|---|---|
| a. | Sieve analysis . . . . . | AASHTO T 27 |
| b. | Fineness modulus . . . . . | AASHTO M 6 |
| c. | Deleterious substances | |
| | Clay lumps and friable particles . . . . . | AASHTO T 112 |
| | Material finer than the No. 200 Sieve . . . | AASHTO T 11 |
| | Coal and lignite, as defined in 7.1.6 of AASHTO M 80 . . . . . | AASHTO T 113 |
| | Organic impurities . . . . . | AASHTO T 21 |
| d. | Evaluation of potential aggregate reactivity . . . . . | AASHTO M 80 |
| e. | Bulk specific gravity and absorption capacity . . . . . | AASHTO T 84 |
| f. | Sand Equivalent (min. 75) . . . . . | AASHTO T 176 |

Coarse Aggregate

| | | |
|---|---|---|
| a. | Sieve analysis . . . . . | AASHTO T 27 |
| b. | Deleterious substances | |
| | Clay lumps and friable particles . . . . . | AASHTO T 112 |
| | Chert--less than 2.4 sp. gr. SSD . . . . . | AASHTO T 113 |
| | Material finer than the No. 200 sieve . . | AASHTO T 11 |
| | Coal and lignite, as defined in 7.1.6 of AASHTO M 80 . . . . . | AASHTO T 113 |
| c. | Evaluation of potential aggregate reactivity . . . . . | AASHTO M 80 |
| d. | Percentage of wear (L.A.R.) . . . . . | AASHTO T 96 |
| e. | Unit weight of aggregate . . . . . | AASHTO T 19 |
| f. | Bulk specific gravity and absorption capacity . . . . . | AASHTO T 85 |

(c) Concrete Compressive Strength. Unless otherwise SHOWN ON THE DRAWINGS, the specified minimum 28-day compressive strength in pounds per square inch for the given classes of concrete shall be the following:

| | Specified Strength | | |
|---|---|---|---|
| Class | At Time of Transfer of Prestress Force (Minimum) | 7-Day (Minimum) | 28-Day (Minimum) |
| A | ----- | 2,300 | 3,500 |
| P | 4,500 | ----- | 5,500 |
| P (air-entrained) | 4,500 | ----- | 5,000 |
| Seal | ----- | 2,000 | 3,000 |

For a strength test, two standard test specimens shall be made. For each structural element, enough specimens shall be taken to make at least one 7-day strength test and one 28-day strength test (total four specimens, minimum). The test result shall be the average of the strengths of the two specimens, except that if any specimen shows definite evidence, other than low strength, of improper sampling, molding, handling, curing, or testing, it shall be discarded, and the strength of the remaining cylinder shall be considered the test result.

The standard 28-day curing period for compressive strength tests shall be extended for fly ash modified concrete by 1 day (rounded to the nearest whole day) for each 1.5 percent of Portland cement replaced with fly ash at the selected rate. (Example: If the maximum of 20 percent cement is replaced, the curing period for cylinders would be 41 days.)

Prior to approval of the contractor's mix design, or approval of subsequent revised mix design(s), sampling and testing shall be the responsibility of the contractor. Field sampling and testing on the concrete being placed in the work will be made by the Engineer.

The average of all the strength tests representing the concrete in each structural element shall meet the following requirements:

(1) If seven or more strength tests are available, not more than 20 percent of the strength tests shall have values less than the specified strength, and the average of any six consecutive strength tests shall be equal to or greater than the specified strength.

(2) If six or fewer strength tests are available, the average of all the tests shall be equal to or greater than those shown in the following table:

| Number of Strength Tests | Required Average Strength (Percent of Specified Strength) | |
|---|---|---|
| | Class A & Seal | Class P |
| 1 | 79 | 86 |
| 2 | 90 | 97 |
| 3 | 94 | 102 |
| 4 | 97 | 105 |
| 5 | 99 | 107 |
| 6 | 100 | 108 |

(3) If the concrete strength tests fail to meet the requirements of this specification, the Engineer may order the contractor to have a testing laboratory, acceptable to the Forest Service, take and test core samples of questionable concrete. The Engineer may order all low-strength concrete removed and replaced if core strengths are below specified strengths. All costs connected with concrete coring and removal and replacement of concrete that fails to meet these requirements shall be borne by the contractor.

(d) Field Adjustment of Concrete Mix. Field adjustment of the concrete mix designs will be necessary to compensate for the free water content in the aggregates.

After initial mixing, if the consistency (slump) is outside the specification limits (table 552-1) by less than 1 inch, the Engineer may approve the addition of water or cement provided all the following conditions are met:

(1) Addition of Water.

a. The maximum allowable water content in pounds per cubic yard of concrete (table 552-1) is not exceeded.

b. The maximum allowable mixing time (or number of drum revolutions) is not exceeded.

c. Concrete is remixed for at least half of the minimum mixing time (or number of drum revolutions).

(2) Addition of Cement.

a. Amount of cement added does not exceed 94 pounds per cubic yard more than the mix design or a total of 705 pounds per cubic yard, unless otherwise specified in the SPECIAL PROJECT SPECIFICATIONS.

b. The maximum allowable mixing time (or number of drum revolutions) is not exceeded.

c. Concrete is remixed for at least half of the minimum mixing time (or number of drum revolutions).

d. Cement may not be added to Class P concrete.

(3) Adjustment for Variation in Yield. If the cement content of the concrete varies more than 19 pounds per cubic yard over the value in the approved mix design, the proportions may be adjusted at the request of the contractor. If the cement content varies more than 19 pounds per cubic yard below the value in the approved mix design, the proportions shall be adjusted. Adjustment of aggregate weights within the 2 percent allowed by the specification is the only adjustment of the proportions that shall be carried out in the field. Other adjustments of proportions shall be effected by the contractor obtaining a new mix design and securing approval of the new mix design from the Engineer.

(4) Adjustment for Percent Entrained Air. The amount of air-entraining admixture used in each batch will be varied as necessary from that given in the approved mix design to produce concrete having the percent entrained air specified in table 552-1.

(5) Concrete Test Methods. The following methods shall be used in making the indicated tests on concrete:

| | |
|---|---|
| Making and curing concrete compression test specimens in the laboratory | AASHTO T 126 |
| Sampling fresh concrete | AASHTO T 141 |
| Coring concrete and testing drilled concrete cores | AASHTO T 24 |
| Yield, cubic feet per batch; and cement content, pounds per cubic yard | AASHTO T 121 |
| Percent entrained air (pressure method) | AASHTO T 152 |
| (volume measure) | AASHTO T 196 |
| Compressive strength of concrete cylinders | AASHTO T 22 |
| Flexural strength of concrete | AASHTO T 97 |
| Consistency (slump) of concrete | AASHTO T 119 |
| Making and curing concrete compressive and flexural strength test specimens in the field | AASHTO T 23 |

## MATERIALS

552.03 Requirements

Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Portland Cement | 701.01 |
| Fine Aggregate | 703.01 |
| Coarse Aggregate | 703.02 |
| Joint Fillers | 705.01 |
| Curing Materials | 711.01 |
| Air-Entraining Admixtures | 711.02 |
| Chemical Admixtures | 711.03 |
| Water | 712.01 |
| Fly Ash | 712.14 |
| Epoxy Resin Adhesives | 712.10 |
| Bonding Agents | 712.12 |
| Elastomeric Bearing Pads | 717.13 |
| Elastomeric Compression Joint Seals | 717.18 |

552.04 Cement

Type II cement shall be used for all classes of concrete with the following exceptions:

(a) Type III cement may be used.

(b) When concrete work is permitted by the Engineer in air temperatures below 35 °F, Type III cement shall be used.

(c) Type I cement may be used if SHOWN ON THE DRAWINGS or specified in the SPECIAL PROJECT SPECIFICATIONS.

(d) Pozzolan (fly ash) concrete may be proposed for any mix design except for prestressed concrete, either pretensioned or posttensioned. If fly ash is proposed as an additive to a mix design containing Type I, II, or III cement, the fly ash shall be substituted for cement at a rate of 1.2 pounds of fly ash for 1.0 pounds of Portland cement. After substitution, design aggregate volumes shall be reduced by an amount equal to the net increase in volume of the combined cement and fly ash. Not less than 10 percent nor more than 20 percent of the minimum weight of Portland cement required by table 552-1 may be replaced with fly ash at the above rate.

An air-entraining admixture shall be used to obtain the specified air entrainment.

Cement acceptance may be based on mill certification as well as from pretested and approved bins.

The cement and fly ash shall be well protected from rain and moisture, and any cement or fly ash damaged by moisture or which fails to meet any of the specified requirements shall be rejected and removed from the work. Cement stored by the contractor for a period longer than 60 days shall require the Engineer's approval before being used on the work. Cement of different brands, types, or from different mills shall be stored separately.

## CONSTRUCTION

552.05 Performance

The contractor shall submit a written schedule of concreting operations, including personnel and equipment, when requested by the Engineer. The contractor shall give the Engineer 24-hour notice prior to placing any segment of the concrete work.

552.06 Batching

Measuring and batching of materials shall be done at a batching plant.

(a) Portland Cement. Either bagged or bulk cement may be used. No fraction of a bag 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 properly 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 will not lodge in it nor leak from it.

Accuracy of batching shall be within 1 percent of the required weight.

(b) Water. Water shall be measured by volume or by weight. The device for the measurement of the water shall be readily adjustable and shall be capable of being set to deliver the required amount and to cut off the flow automatically when this amount has been discharged. Under all operating conditions, the device shall have an accuracy within 1 percent of the quantity of water required for the batch. The device shall be so arranged that the measurements will not be affected by variable pressures in the water supply line. Measuring tanks shall be of adequate capacity to furnish the maximum mixing water required and shall be equipped with outside taps and valves to provide for checking their calibration unless other means are provided for readily and accurately determining the amount of water in the tank. Wash water is not permitted to be used as a portion of the mixing water for succeeding batches.

(c) Aggregates. Stockpiles of aggregates shall be built up in layers of not more than 3 feet in thickness. Each layer shall be completely in place before beginning the next and shall not be allowed to side cast down over the previous layer. Aggregates from different sources and of different gradings shall not be stockpiled together.

Aggregates shall be handled from stockpiles or other sources to the batching plant in a manner that secures a uniform grading of material.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods and washed aggregates shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning if the car bodies permit free drainage. If the aggregates contain high or nonuniform moisture content, storage or stockpile periods in excess of 12 hours may be required.

Accuracy of aggregate batching shall be plus or minus 2 percent of each aggregate's required weight, and plus or minus 2 percent of the total required aggregate weight.

(d) Bins and Scales. The batching plant shall include separate bins for the bulk cements, for fine aggregate, and for each size of coarse aggregate; a weighing hopper; and scales capable of determining accurately the weight of each component of the batch.

Scales shall be accurate to 0.5 percent throughout the range of use. To ensure continued accuracy, the contractor shall have scales inspected, tested, sealed, and certified by a representative of the State agency responsible for weights and measures or a qualified manufacturer's representative, as often as necessary.

(e) Batching. When batches are hauled to a jobsite stationary mixer, cement shall be transported either in bags, or in bulk in a separate waterproof compartment. When bulk cement is transported in contact with aggregates, mixing shall commence within one-half hour of such contact.

Truck mixers may be used to haul unmixed concrete batches to the construction site only when cement is hauled separately in bags or waterproof compartments.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss.

(f) Admixtures. The contractor shall submit to the Engineer, for approval, a written procedure for adding the specified amount of admixture. He shall provide separate scales for the admixtures that are to be proportioned by weight and accurate measures for those to be proportioned by volume. All admixtures shall be measured into the mixer with an accuracy of plus or minus 3 percent.

Set retarding and/or water reducing admixture may be used provided they conform to the requirements of Type B or Type D of AASHTO M 194 or ASTM C 494. The type and quantity of the admixture to be used must be included in the mix design submitted to the Engineer. The use of the admixture shall conform to the manufacturer's recommendations.

When an air-entraining agent is being added at the mixer, the quantity or the strength of solution shall be varied as might be necessary to ensure full compliance with the requirements for air content of the concrete given in table 552-1.

The air-entraining agent may be introduced by means of an automatic dispensing device approved by the Engineer, or it may be introduced manually by pouring it on the aggregates in the skip of the mixer. When added manually, a quantity shall first be diluted with water, in the proportions specified, so that a volume of not less than 1 quart of the diluted solution is measured and added to each batch of concrete.

Admixtures, including fly ash, shall not be used to reduce the cement content below the minimum shown in the table 552-1. Admixtures containing chlorides as Cl in excess of 1 percent by weight shall not be used.

552.07 Mixing & Delivery

Concrete may be mixed at the site of construction, at a central point, by a combination of central point and truck mixing, or by a combination of central point mixing and truck agitating.

When concrete is delivered to the work site, a ticket showing dispatch time and mix design identification shall be supplied by the contractor.

Mixing and delivery of concrete shall be in accordance with the appropriate requirements of AASHTO M 157, Sections 8 and 9 with the following modifications:

(a) In addition to the requirement of Section 9.4 regarding number of truck mixer drum revolutions, the sum of all drum revolutions at both mixing and agitating speeds shall not exceed 300 before all concrete has been discharged from the drum, except that the sum of all drum revolutions shall not exceed 200 if the outside air temperature is over 85 °F. If mixing is done before arrival of the truck at the point of delivery, the drum shall again be rotated at mixing speed for 10 to 15 revolutions to reblend possible stagnant spots.

(b) If set retarding admixture is used, the sum of all drum revolutions at both mixing and agitating speeds shall not exceed 550 before all concrete has been discharged from the drum, except that the sum of all drum revolutions shall not exceed 450 if the outside air temperature is over 85 °F. In addition, the time limits specified in Subsection 9.6 may be extended up to an additional 2 hours by the Engineer.

(c) The last sentence of Subsection 9.6.1 is deleted.

(d) Subsection 9.9 is replaced by the following:

(1) Concrete delivered in outdoor temperatures of 35 °F or below shall meet the requirements of Subsection 552.08 of this specification.

(2) At the time of placement, concrete temperature shall be as specified in Subsection 552.08.

(e) Delivery of concrete shall be so regulated that placing is at a continuous rate unless delayed by the placing operations. The intervals between delivery of batches shall not be so great as to allow the concrete in place to harden partially, and in no case shall such an interval exceed 30 minutes.

(f) The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand, and water to coat the inside of the drum without reducing the required mortar content of the mix.

(g) Handmixing shall not be permitted, except in case of emergency and with written approval from the Engineer. When permitted, it shall be performed only on watertight platforms. Handmixed batches shall not exceed 1/12 cubic yard volume. Handmixing shall not be permitted for concrete that is to be placed under water.

(h) Mixers and agitators shall meet the requirements of Subsections 8.1 and 8.1.1, except 8.1.1 is modified to allow the use of mechanically operated counters, and 8.1.3 is deleted.

(i) Truck-mixed concrete shall have the cement transported separately from the aggregate and water. Cement shall be added to the mixer at the project site.

For batch mixing at the site of construction or at a central point, a batch mixer of an approved type shall be used. No mixer having a rated capacity of less than a one-bag batch shall be used. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity as shown on the manufacturer's standard rating plate on the mixer. The batch shall be so charged into the drum that a portion of the water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. Mixing time shall be measured from the time all materials, except water, are in the drum. Mixing time shall be not less than 60 seconds for mixers having a capacity of 2 cubic yards or less. For mixers having a capacity greater than 2 cubic yards, the mixing time shall be not less than 90 seconds. If timing starts the instant the skip reaches its maximum raised position, 4 seconds shall be added to the specified mixing time. Mixing time ends when the discharge chute opens.

The mixer shall be operated at the drum speed shown on the manufacturer's name plate on the mixer. Any concrete mixed less than the specified time shall be discarded and disposed of by the contractor without compensation.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the contractor will be permitted to continue operations while it is being repaired, provided an approved timepiece equipped with minute and second hands is furnished. If the timing device is not repaired within 24 hours, further use of the mixer will be prohibited until repairs are made.

552.08
Adverse Weather
Concrete

(a) Cold Weather. The contractor shall furnish the Engineer with a detailed plan of equipment and material to be used for protection of the concrete during the curing period.

When the air temperature is 35 °F or less at the time of mixing or placing, or an air temperature of 35 °F or less can be expected in the 24-hour period immediately following the concrete placing, the mixing water or aggregates, or both, shall be heated. The temperature of water and aggregate, and the resulting batch of mixed concrete shall be within the temperature ranges specified below.

Aggregates that contain frozen lumps shall not be used. If either the aggregates or water is heated to a temperature in excess of 100 °F, the water and aggregates shall be premixed so that the resulting temperature of the combined water and aggregates is not in excess of 100 °F when the cement is added to the batch.

Heating equipment or methods that cause uneven heating or alter or prevent the entrainment of the required amount of air in the concrete shall not be used. 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.

When aggregates are heated in bins, steam-coil or water-coil heating or other methods that will not be detrimental to the aggregates may be used. The use of live steam on or through binned aggregates shall not be permitted.

Heating of the cement or the adding of salt or other chemicals to the mix to prevent freezing will not be permitted.

Forms and reinforcement shall be free of ice, snow, and frost at the time of concrete placement. When the atmospheric temperature is below 40 °F the interior surfaces of forms, all reinforcement, and the surface of the concrete adjacent to the pour shall be preheated to 40 °F or higher.

When placed in the forms, the mixed concrete shall have a temperature of not less than 50 °F nor more than 80 °F for concrete in deck slabs, girders, and sections less than 24 inches thick; and not less than 50 °F nor more than 90 °F for concrete in sections 24 inches or more in thickness. Where insulated forms are used for protecting the concrete, the allowable temperature range of all concrete placed shall be from 50 °F to 90 °F.

When the air temperature is 35 °F or less, or when an air temperature of 35 °F or less can be expected within a period of 6 days following placing of the concrete, the work shall be protected by insulated forms or blankets or heated housing.

(1) Insulated Forms and Blankets. The contractor may protect structural concrete by the use of insulated forms or blankets as hereafter described.

When housing of the structure or section thereof can be delayed, but is subsequently required in accordance with the specifications, the contractor may protect structural concrete in bridge decks or similar sections with insulating blankets instead of housing, heating, and curing for the remainder of the protection period. The curing method shall prevent moisture loss on all exposed surfaces protected by insulating blankets.

Insulation shall consist of bats or blankets of fiberglass, rock wool, balsam wool, insulation boards, or other approved material. Insulation used on placements having a thickness of 24 inches or less shall have an insulation value of not less than 7.0, and insulation used on placements having a thickness greater than 24 inches shall have an insulation value of not less than 5.0, based on the following formula:

$$R = \frac{T}{K}$$

*where*

$R$ = *Insulation value*
$T$ = *Thickness in inches*
$K$ = *Thermal conductivity in Btus per hour per square foot for a temperature gradient of 1 °F per inch of thickness.*

Upon the Engineer's request, the contractor shall furnish the K value, as determined by the manufacturer, for the type of insulation proposed for use in protecting the work.

The bats or blankets shall be completely encased in suitable wind- and water-resistant covers that shall be fastened securely to wood forms between the studs and wales, with edges and ends sealed to the framing to minimize heat loss. The insulation shall be attached to steel forms by adhesive or other approved methods. Ribs and flanges of steel forms shall be covered by the insulating blankets, or separate strips of insulation shall be applied to them. The edges and corners of concrete shall be well insulated. Horizontal surfaces of concrete shall be protected by a layer of the insulating material securely fastened in place. The tops of placements, such as bridge decks and similar flat slab sections, shall be protected by tarpaulins over the insulation. Large insulating blankets may be wrapped around and securely fastened in place for curing concrete columns cast in prefabricated forms and similar concrete items. All joints in the blankets shall be sealed with tape.

Any tears in the cover shall be repaired. Where tie rods extend through the insulated form, a suitable washer shall be placed over the hole outside of the insulation and fastened to the form.

When insulating blankets are applied directly to concrete masonry, the methods of applying and securing the insulation shall be approved in advance by the Engineer. All joints shall be sealed.

The insulated forms or blankets shall remain in place for a protection period of at least 6 days (4 days when Type III cement is used) after placement of the concrete.

The contractor shall provide approved facilities and shall measure the temperatures inside and outside of the insulation and within the mass of the concrete at various locations in the unit. Frequent thermometer readings shall be taken and recorded and shall be available to the Engineer at all times. Approved recording thermometers may be used to obtain temperature records. Forms or insulation shall be loosened as required to control the temperature of the concrete. The temperature of the concrete shall not be allowed to exceed 120 °F nor fall below 45 °F during the protection period. In addition, the temperature at the surface of the concrete shall not be allowed to exceed 90 °F.

At the close of the protection period, the temperature of the concrete shall be gradually decreased to the temperature of the outside air at a rate not to exceed 40 °F per 24-hour period or 5 °F in any hour by loosening the forms or blankets.

Electric heating blankets and other suitable materials may be used instead of insulated blankets or bats when specifically approved by the Engineer for each application.

The contractor shall assume entire responsibility for the proper protection and final satisfactory condition of all concrete placed during cold weather or exposed to cold weather within the required protection period. This responsibility shall extend to the adequacy of all equipment and methods necessary to conform to the requirements of the contract. Any concrete that has been frozen or damaged by other causes shall, upon order of the Engineer, be removed and replaced with satisfactory concrete at the contractor's expense.

(2) Housing, Heating, and Curing. If the concrete temperatures cannot be maintained within the limits specified above by insulated forms or blankets, adequate housing shall enclose each section of a structure before placing the concrete in such section, except as follows:

a. The contractor may delay the erection of such housing if the air temperature is not expected to fall to 35 °F or below during the 24 hours immediately following placement of the concrete. Housing may be delayed until the temperature is expected to fall to 35 °F or below during any 24 hours of the succeeding 5-day period, provided that an adequate supply of housing material is maintained at the site and sufficient men and equipment are available to ensure the erection of suitable housing before the temperature falls to 35 °F.

b. The protective housing shall be of sufficient size to allow all concrete placing and finishing operations for any one placement to proceed under cover without hindrance. However, to facilitate the placement of concrete, the covering material may be installed immediately following the depositing of the concrete. The housing shall be constructed weather-tight in a manner that will ensure that specified temperatures will be maintained uniformly throughout the enclosure during the protection period.

c. Before starting concreting operations, the contractor shall have available ample and suitable equipment, for heating, curing, and protecting the concrete during the protection period. Heating may be by steam or hot air. A humid condition must be maintained within the housing during the heating period. Stoves or open-burning salamanders will not be permitted within the housing.

d. Application of heat that will endanger forms, falsework, or any part of the structure, or that will subject the concrete to drying out or other injury due to excessive temperatures, will not be permitted. The concrete surface shall be heated to maintain a temperature between 50 °F and 90 °F.

e. When housing is required prior to placement of concrete, heat shall be admitted to the housing sufficiently in advance of placing the concrete to ensure that the temperature of the forms and reinforcing steel will not be less than 40 °F. Within the enclosure or housing, a temperature not less than 45 °F nor more than 70 °F shall be maintained during placing of the concrete and for a protection period of at least 6 days thereafter or for the remaining number of days of such 6-day period that housing is required. The temperature within the enclosure shall be reasonably uniform throughout.

f. The contractor shall provide adequate fire protection when heating is in progress and shall maintain watchmen or other attendants to keep heating units in continuous operation.

g. The contractor shall provide reliable thermometers and take temperature readings within the enclosure at such points and at such times as are necessary to show the true temperature conditions to which the concrete is subjected. Outside air temperature recordings shall be made at the time of making the recordings within the enclosure. A copy of the temperature records shall be available to the Engineer at all times. Approved recording thermometers may be used to obtain all temperature records at the contractor's option.

h. At the close of the heating period, the temperature within the enclosure shall be reduced in a manner that will avoid a sudden temperature change to the new concrete. The average rate of decrease shall not exceed 40 °F per 24-hour period until the outside air temperature is reached. The surface of the concrete shall be permitted to dry while temperatures are being equalized.

i. When pozzolan or fly ash cement is used, the required period of controlled temperature and moisture shall be:

| Percentage of Cement Replaced by Weight | Required Period of Controlled Temperature and Moisture |
|---|---|
| 10% | 9 days |
| 10-15% | 10 days |
| 16-20% | 11 days |

The above requirement for an extended period of controlled temperature and/or moisture may be waived if a compressive strength of 65 percent of the specified 28-day strength is achieved in 6 days.

(b) Hot Weather. Immediately prior to being placed, the temperature of plastic concrete shall not exceed 90 °F, except that bridge superstructure concrete shall not exceed 80 °F. Chipped or

crushed ice may be used in the mix as a portion of the mixing water on a pound-for-pound basis. If ice is used, all ice shall be entirely melted at the completion of the mixing period.

When placing concrete deck slabs, if the air temperature near the slab's surface is expected to rise above 80 °F, the contractor shall schedule his operations so that finishing of the top of the slab is completed before this occurs or use hot weather concreting practices to maintain the slab surface temperature 80 °F or less until finishing is completed. An evaporation rate in excess of 0.1 pound per square foot per hour (as determined by Portland Cement Association Bulletin "Design and Control of Concrete Mixtures," current edition) will be considered cause for requiring the use of a protective housing when making bridge deck placements.

The protective housing shall be covered by waterproof material and shall be of sufficient size to allow the concrete placing and finishing operations for any one pour to proceed under the housing without hindrance until final set. However, to facilitate the placement of concrete, the covering material may be installed immediately following the depositing of the concrete and shall remain in place for a period of 12 hours following the completion of the deck pour or until the adverse weather has passed, whichever is less.

Fogging equipment shall be capable of applying water to the concrete in the form of a fine mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the deck. Fogging nozzles and water supply methods shall be approved by the Engineer in advance. Nozzles shall produce a true mist that will not harm the surface finish of fresh concrete. The mist shall be applied at the times and in the manner approved by the Engineer.

When pozzolan or fly ash modified cement is used, the required period of controlled moisture shall be as shown above in 552.08 (a)(2)i.

552.09 Consistency

Slump will be measured in accordance with AASHTO T 119 and shall meet the requirements shown in table 552-1.

552.10 Foundations, Falsework, & Forms

Preparation of foundations shall meet the requirements in Section 206. The elevations of the bottoms of footings as SHOWN ON THE DRAWINGS are approximate, and changes in dimensions or elevations of footings may be ordered by the Engineer.

Two weeks prior to placement of the concrete supported by falsework, three copies of detailed drawings of the falsework and/or formwork for cast-in-place concrete decks and superstructure shall be submitted to the Engineer for approval.

Falsework shall be built on foundations of sufficient strength to carry the loads, without appreciable settlement. Falsework that cannot be founded on solid footings must be supported by ample falsework piling. Forms for cast-in-place concrete bridge decks supported on girders shall be completely supported by the girders upon which the deck is to be cast; shoring to the ground or substructures is not permitted.

Falsework shall be built on foundations of sufficient strength to carry the loads with a deflection not to exceed 1/500 of the falsework span and shall be set to give the finished structure the lines and grades SHOWN ON THE DRAWINGS. Suitable screw jacks or wedges shall be incorporated into the falsework and adjusted to take up any settlement in the formwork either before or during the placing of concrete. An arch centering shall be so constructed as to permit its being lowered gradually and uniformly.

Forms shall meet the requirements below:

(a) General. Forms shall be rigid enough to prevent distortion and deflection due to the pressure of the concrete and other loads including vibration, incident to the construction operations. Forms shall be so constructed and maintained as to prevent the opening of joints due to shrinkage of the lumber. Deflection of forms shall not exceed 1/360 of the span under full load.

Forms for concrete containing a retarding admixture, fly ash, or other pozzolan replacement for cement, shall be designed to contain the lateral pressure exerted by the full anticipated height of fluidized concrete, unless documented information on initial set is provided by the manufacturer.

(b) Forms. Forms for all exposed concrete surfaces shall be one of the following:

(1) Faced with exterior-type plywood with the face grain running perpendicular to the supports.

(2) Lumber dressed at least on one side and two edges.

(3) Metal.

(4) Fiberglass.

In all cases, forms shall be so constructed as to produce mortar-tight joints and smooth, even concrete surfaces. Forms shall be filleted and chamfered 3/4 inch or as SHOWN ON THE DRAWINGS, and they shall be given a bevel or draft in the case of all projections, such as girders and copings, to ensure easy removal.

Form sheets shall not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 inch at each end. Form supports shall be placed in direct contact with the flange of stringer or floor beam. All attachments shall be made by permissible welds, bolts, clips, or other means approved by the Engineer. However, welding of form supports to flanges of steel not considered weldable and to portions of flange subject to tensile stresses shall not be permitted. Welding and welds shall be in accordance with the provisions of AWS D1.1, Structural Welding Code, pertaining to fillet welds, except that 1/8 inch fillet welds will be permitted.

(c) Metal Ties. Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 1 inch from the face without injury to the concrete. In case wire ties are permitted, suitable cones shall be provided. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color.

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

(e) Surface Treatment. All forms shall be treated with form-release agent prior to placing reinforcement; and, in addition, woodforms shall be moistened with water immediately before placing concrete. No material or treatment that will be detrimental to, adhere to, or discolor concrete shall be used.

(f) Metal Forms. The specifications for forms, including design, mortar-tightness, filleted corners, beveled projections, bracing, alinement, removal, reuse, and oiling, apply to metal forms.

(g) Permanent Steel Bridge Deck Forms. Permanent or stay-in-place metal forms will not be permitted under deck slabs unless SHOWN ON THE DRAWINGS.

All forms shall be installed in accordance with approved fabrication and erection drawings.

Form support provisions in Subsection 552.10(b) shall apply to permanent steel deck forms.

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

Transverse construction joints shall be located at the bottom of a flute and 1/4-inch weep holes shall be field drilled at approximately 12 inches on center along the line of the joint.

552.11 Placing Concrete

(a) General. Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer. The forms shall be cleaned of all debris before concrete is placed. The method and sequence of placing concrete shall be as approved by the Engineer.

Concrete shall be placed and consolidated by methods that will not cause segregation of the aggregates and will result in a dense homogeneous concrete that is free of voids and rock pockets. All concrete shall be used while fresh and before it has taken an initial set. Retempering any partially hardened concrete shall not be permitted. No pumping lines, pipes, chutes, conveyors, etc., containing aluminum, which may be in contact with the mixed concrete, shall be permitted.

Surfaces on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

Mixed concrete, after being deposited, shall be consolidated until all voids are filled and free mortar appears on the surface.

Placing of concrete for roadway deck shall be commenced at a time that will permit all required finishing operations to be conducted during daylight hours; however, upon prior written approval of the Engineer, night finishing operations may be performed under artificial illumination of suitable character, distribution, and intensity.

(b) Chutes and Troughs. Concrete shall be so placed 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.

All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. The water used for flushing shall be discharged clear of the concrete already in place.

Concrete shall not be dropped into the forms a distance of more than 5 feet, unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form 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.

In thin sections where there is not sufficient space inside the form to place by chute, concrete shall be placed through form windows, or the Engineer may permit dropping more than 5 feet, provided that the placing is so controlled by short chutes, baffles, or other means that the concrete will be placed without segregation, and mortar splatter on reinforcing steel will be minimized.

(c) Pneumatic Placing. The equipment shall be so arranged that no vibrations result that might damage freshly placed concrete. Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 10 feet from the point of deposit. The discharge lines shall be horizontal or incline upwards from the machine.

(d) Pumping. The equipment shall be so arranged that no vibrations result that might damage freshly placed concrete. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall produce a continuous stream of concrete without air pockets. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected so that there will be no contamination of the concrete or separation of the ingredients.

(e) Vibrating. All concrete, except seal concrete, shall be consolidated with approved 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 capable of transmitting vibration to the concrete at frequencies of not less than 7,000 impulses per minute and visibly affecting a properly designed mixture with 1-inch slump for a distance of at least 8 inches from the vibrator.

Vibrators shall be manipulated to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms. The concrete shall be placed as nearly as possible in its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted. The vibration at any point shall be of sufficient duration to accomplish consolidation, but shall not be prolonged to the point where segregation occurs.

The contractor shall have a back-up vibrator at the site of the work.

(f) Depositing Concrete Under Water. Concrete shall be deposited under water only in the presence of the Engineer and by the method described in the following paragraphs:

Only seal concrete shall be deposited under water. The concrete shall be placed carefully in a compact mass in its final position by means of a tremie or by other approved means, and the concrete shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces.

Concrete seals shall be placed in one continuous operation.

When a tremie is used, it shall consist of a steel tube not less than 10 inches in diameter constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be designed to permit free movement of the discharge end over

the entire top of the concrete and to permit its being lowered rapidly when necessary to choke off or retard the flow. The tremie shall be filled by a method that will prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times.

The tremie tube shall be kept full to the top. When placing concrete through a tremie, two distinct handling devices shall be used; one to raise, lower, and place the tremie; the other to deliver concrete to the tremie. When a batch is dumped into the hopper at the top, the tremie shall be raised slightly, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper at the top of the tremie tube. The flow shall then be stopped by lowering the tremie.

When concrete is placed under water by pumping, the pump pipe shall be equipped with a bottom valve or other approved device to prevent mixing of water with the concrete in the pipe. The pump pipe shall be withdrawn as the concrete rises but the end shall, at all times, be below the surface of the concrete.

(g) Concrete Columns. Concrete in columns shall be placed in one continuous operation unless otherwise permitted by the Engineer. The concrete shall be allowed to set at least 12 hours before caps are placed, unless otherwise SHOWN ON THE DRAWINGS.

(h) Concrete Slab and Girder Spans. Slabs and girders having lengths of 30 feet or less shall be placed in one continuous operation.

Girders spanning more than 30 feet may be placed in two operations, the first operation being the placement of the girder stems to the bottom of the slab haunches. Adequate shear resistance shall be obtained by using a broom finish with 1/4-inch grooves on the surface of the first concrete pour.

The period between the first or girder placement and the second or slab placement shall be at least 24 hours. Immediately before the second placement, the contractor shall check all falsework for shrinkage and settlement and shall tighten all wedges to ensure minimum deflection of the stems due to the added weight of the slab.

The undersurface of cantilever brackets and overhanging slabs shall be provided with a drip groove, 1/2 inch in depth at a point not more than 6 inches from the outside face, to arrest the flow of moisture.

(i) Arches. Arch centering shall be constructed in accordance with construction drawings approved by the Engineer. Centering shall be lowered gradually and symmetrically to avoid overstresses in the arch.

Centering shall be placed upon approved jacks to provide means of correcting any slight settlement that may occur after concrete placement has begun. Any adjustments made necessary by settlement shall be made before the concrete has taken its initial set.

Railings and copings shall not be constructed until centering has been struck and the arch made self-supporting.

For closed-spandrel arches, portions of the spandrel walls necessary to avoid jamming of the expansion joints shall be left for construction subsequent to the striking of centers.

For filled-spandrel arches, the filling shall be placed as provided in Section 206, care being taken to load the ring uniformly and symmetrically. The filling material shall be acceptable to the Engineer and shall be placed in horizontal layers, carefully tamped, and brought up simultaneously from both haunches.

Wedge-shaped sections of filling material against spandrels, wings, or abutments will not be permitted.

(j) Concrete Railings, Parapets, and Curbs. Special care shall be exercised to obtain smooth, tight-fitting forms that can be held rigidly to line and grade and can be removed without injury to the concrete. All moldings, panel work, and bevel strips shall be constructed as SHOWN ON THE DRAWINGS, with neatly mitered joints. All corners in the finished work shall be true, sharp, clean-cut, and shall be free from cracks, spalls, or other defects.

Precast railing members shall be cast in mortar-tight forms. The precast members shall be removed from the molds as soon as the concrete is sufficiently hard and shall then be kept covered with water-saturated burlap or a tarpaulin for at least 3 days. After this treatment, the curing shall be completed by immersion in water or by spraying not less than twice a day for a period of not less than 7 days.

The method of storage and handling shall preserve the edges and corners true and even. Any precast members that become chipped, marred, or cracked before or during the process of placing shall be rejected and removed from the work.

In the construction of cast-in-place railing caps and copings built in connection with precast balusters, the balusters shall be protected from staining and disfigurement during the process of placing and finishing the concrete.

(k) Construction Joints. Construction joints shall be located where SHOWN ON THE DRAWINGS. Additional construction joints shall require written approval by the Engineer.

At all construction joints, gauge strips 1-1/2 inches thick shall be placed inside the forms along all exposed faces to give the joints straight lines. Before placing fresh concrete, the surfaces of construction joints shall be sandblasted or washed and scrubbed with a wire broom, drenched with water until saturated, and kept saturated until the new concrete is placed.

Immediately prior to placing new concrete, the forms shall be drawn tight against the concrete already in place and the old surface shall be coated thoroughly with a very thin coating of neat cement mortar. Concrete in substructures shall be placed so that all horizontal construction joints will be truly horizontal and, if possible, in locations so that they will not be exposed to view in the finished structure. Where vertical construction joints are necessary, reinforcing bars shall extend across the joint to make the structure monolithic.

Dowels, load-transfer devices, and bonding devices shall be placed as SHOWN ON THE DRAWINGS.

(l) Expansion Joints. Expansion joints shall be located and formed as SHOWN ON THE DRAWINGS.

(1) Open Joints. Open joints shall be constructed by insertion and subsequent removal of a wooden strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete.

(2) Filled Joints. Poured expansion joints shall be constructed similarly to open joints.

When premolded expansion joints are specified, the thickness of the filler installed shall be as SHOWN ON THE DRAWINGS. The joint filler shall be cut to the same shape and size as that of the surfaces being joined. It shall be fixed firmly against the surface of the concrete already in place so that it will not be

displaced when concrete is deposited against it. Where it is necessary to use more than one piece of filler to cover any surface, the abutting pieces shall be placed in close contact, and the joint between them shall be covered with a layer of asphalt-saturated roofing felt of not less than 40-pound grade, one side of which shall be covered with hot asphalt to ensure proper retention. Immediately after the forms are removed, the expansion joints shall be inspected carefully. Any concrete or mortar that has sealed across the joint shall be cut neatly and removed. When, during construction, an opening of 1/8 inch or more appears in any joint over which any traffic will occur, the opening shall be completely filled with asphalt.

Dowels, load-transfer devices, and other devices shall be placed as SHOWN ON THE DRAWINGS.

(3) Steel Joints. The plates, angles, or other structural shapes shall be accurately shaped at the shop to conform to the section of the concrete floor. Care shall be taken to ensure that the surface in the finished plane is true and free of warping. Positive methods shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be adjusted to compensate for the actual temperature of the structure at the time of concrete placement, and care shall be taken to avoid impairment of the clearance in any manner.

(4) Water Stops. Water stops shall be placed in accordance with Section 616.

(5) Compression Joint Seals. Compression joint seals shall be in one piece for the full length of transverse joints and in the longest practicable lengths for longitudinal joints. Joints shall be clean and dry and shall be made free of spalls and irregularities that would impair a tight seal in service. Seals shall be placed in the joint under compression, as recommended by the manufacturer, using the lubricant-adhesive as a covering film applied to both sides of the seal just prior to its installation. The top edges of the seal shall be set below the adjacent surfaces of the concrete, as SHOWN ON THE DRAWINGS, and the seal shall contact the walls of the joint throughout its length. Longitudinal elongation of an installed seal by 5 percent or more of its original length will be cause for its removal and reinstallation.

All lubricant-adhesive that comes to the top of an installed seal shall be removed before it dries, and all seals that show twist, curl, nicks, or other malformations as installed, shall be removed and replaced by a new seal.

(6) Elastomeric Expansion Joint Seal. The joint shall be furnished and installed in accordance with the details SHOWN ON THE DRAWINGS and with the manufacturer's recommendations.

(m) Anchor Bolts. All necessary anchor bolts in piers, abutments, or pedestals shall be accurately set either in the concrete as it is being placed, in holes formed while the concrete is being placed, or in holes drilled after the concrete has set, unless a specific method is SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. If a bolt is to be set in the concrete as it is being placed, the bolt shall be placed in a section of standard black pipe at least 2 inches larger in diameter than the bolt and shall be anchored by passing it through a heavy steel washer at the bottom of the pipe. Holes may be formed by inserting oiled wooden plugs, metal pipe sleeves, or other devices approved by the Engineer, into the fresh concrete and withdrawing them after the concrete has partially set. Holes so formed shall be at least 4 inches in diameter. If drilled, holes shall be at least 1 inch larger in diameter than the bolts used. During freezing conditions, anchor bolt holes shall be protected from water

accumulations at all times. Bolts shall be set accurately and fixed with grout completely filling the holes. A nonshrink grout approved by the Engineer shall be used.

Anchor bolts used in connection with expansion shoes, rollers, and rockers shall be located with due regard to the temperature at the time of erection. The nuts on anchor bolts at the expansion end of a span shall be adjusted to permit free movement of the span and then burred to prevent further tightening by vibration unless otherwise SHOWN ON THE DRAWINGS.

(n) Shoes and Bearing Plates. Preferably, bridge seat bearing areas shall be finished high and rubbed to grade. Shoes and bearing plates shall be set in accordance with Section 555.

(o) Drainage Holes and Weep Holes. Drainage holes and weep holes shall be constructed in the manner and at the locations SHOWN ON THE DRAWINGS. Ports or vents for equalizing hydrostatic pressure shall be placed below low water.

Forms for weep holes through concrete may be clay pipe, plastic pipe, concrete drain pipe, wooden boxes, or metal. If wooden forms are used, they shall be removed after the concrete is placed. Exposed surfaces of metal drains shall be coated or uncoated as SHOWN ON THE DRAWINGS.

(p) Pipes, Conduits, and Ducts. Pipes, conduits, and ducts that are to be encased in concrete shall be installed before the concrete is placed. Unless otherwise SHOWN ON THE DRAWINGS, pipes embedded in concrete shall be standard, lightweight galvanized steel or plastic pipes. Pipes shall be held or braced rigidly during concrete placement in order to prevent their displacement.

(q) Loads on New Concrete Structures. No load shall be placed upon new concrete structural elements until tests on concrete cylinders cast from the same concrete and cured under the same conditions as the structural element indicate that all concrete has attained a minimum of 80 percent of the specified 28-day design strength.

Traffic will not be permitted on concrete bridges until the concrete has attained the design strength SHOWN ON THE DRAWINGS.

In lieu of the above requirements, the minimum required time before a load may be placed on a new concrete structural element shall be 7 days after placement for concrete made with Type I or II cement or 3 days after placement for concrete made with Type III cement. However, when pozzolan or fly ash modified concrete is used, the placement of additional loads shall be based solely upon 80 percent of required 28-day compressive strength.

552.12
Removal of Forms & Falsework

Forms and falsework shall not be removed without approval of the Engineer. The Engineer's approval shall not relieve the contractor of responsibility for safety and protection of the work. Blocks and bracing shall be removed at the time the forms are removed, and in no case shall any portion of the wood forms be left in the concrete.

Falsework removal for continuous or cantilevered structures shall be performed so that the structure is gradually subjected to its working stress.

When concrete strength tests are used for removal of forms and supports, removal should not begin until the concrete has attained the percentage of the specified 28-day compressive strength shown in Column 3 below.

When fly ash modified concrete is used, removal of forms shall be based solely upon criteria shown in Column 3 below.

If field operations are not controlled by beam or cylinder tests, the forms and falsework for various parts of the structure shall not be removed before the number of days specified in Columns 1 and 2 of the following table have elapsed after the placing of the concrete, exclusive of days when the temperature is below 50 °F.

Forms and falsework shall not be released from under concrete that has been cured at a temperature continuously under 50 °F without first determining if the concrete has gained the specified strength, no matter how much time has passed.

Unless approved otherwise by the Engineer, substructure concrete shall reach the required 28-day compressive strength prior to erecting any superstructure or additional substructure elements.

| | Column 1 | Column 2 | Column 3 |
|---|---|---|---|
| Concrete Structure | Standard Concrete | Early Strength Concrete (Type III Cement) | Percent of Required 28-Day Comprehensive Strength |
| Columns and wall faces (not yet supporting loads) | 3 days | 2 days | 50% |
| Mass piers and mass abutments (not yet supporting loads) except pier caps | 3 days | N/A[b] | 50% |
| Sidewalk on bridges; sidewalk forms shall, in all cases, be released before the main girder and slab forms are released[a] | 10 days | 4 days | 70% |
| Box girders | 14 days | 7 days | 80% |
| T-beam girders, slabs, crossbeams, caps, pier caps not continuously supported, struts, and top slabs on concrete box culverts[a] | 14 days | 7 days | 80% |
| Trestle slabs, when supported on wood stringers[a] | 10 days | 4 days | 70% |
| Slabs, when supported on steel stringers or prestressed concrete girders[a] | 10 days | 4 days | 70% |
| Pier caps continuously supported[a] | 7 days | 3 days | 60% |
| Arches[a] | 21 days | 10 days | 95% |
| Rail bases, traffic railings, and median barriers | 3 days | 2 days | 50% |

[a]Items apply to falsework and forms supporting the full load of the concrete.
[b]Not applicable.

In continuous structures, falsework shall not be released in any span until the first and second adjoining spans on each side have reached the strength specified herein or in the SPECIAL PROJECT SPECIFICATIONS. When cast-in-place post-tensioned bridges are constructed, falsework shall remain in place until all post tensioning has been accomplished.

Falsework under all spans of continuous structures shall be completely released before concrete is placed in curbs, railings, and parapets.

In order to determine the condition of column concrete, forms shall be removed from columns before releasing supports from beneath beams and girders.

The forms for footings constructed within cofferdams or cribs may be left in place when their removal would endanger the safety of the cofferdam or crib, and when the form so left intact will not be exposed to view in the finished structure. All other forms shall be removed whether above or below the ground line or water level.

All removable forms shall be removed from the cells of concrete box girders unless otherwise SHOWN ON THE DRAWINGS or permitted by the Engineer. No forms shall be left that might jeopardize drainage or enclosed utilities.

To facilitate finishing, forms on exposed surfaces not supporting loads may be removed earlier than that specified above, when approved by the Engineer.

Falsework and centering for spandrel-filled arches shall not be struck until fills behind abutments have been placed up to the spring line. Falsework supporting the deck of rigid frame structures shall not be removed until fills have been placed behind the vertical legs.

552.13 Finishing Concrete Surfaces

Unless otherwise authorized, the formed surface of the concrete shall be finished immediately after form removal.

All formed concrete surfaces shall be given a Class 1 finish. If further finishing is required, exposed surfaces SHOWN ON THE DRAWINGS or DESIGNATED in the SPECIAL PROJECT SPECIFICATIONS shall be given a Class 2 finish. Other finish classes may be SHOWN ON THE DRAWINGS for DESIGNATED surfaces. All roadway and sidewalk surfaces shall be given a float finish in accordance with paragraph (c) below.

(a) Class 1, Ordinary Surface Finish. As soon as the forms are removed, all projecting wire or metal devices that have been used for holding the forms in place and that pass through the body of the concrete shall be removed or cut back at least 1 inch beneath the surface of the concrete. Lips of mortar and all irregularities caused by form joints shall be removed.

All small holes, depressions, and voids that show upon the removal of forms shall be filled with cement mortar mixed in the same proportions as that used in the body of the work. In patching larger holes and honeycombs, all coarse or broken materials shall be chipped away until a dense uniform surface of concrete exposing solid coarse aggregate is obtained. Feathered edges shall be cut away to form faces perpendicular to the surface. All surfaces of the cavity shall be saturated thoroughly with water, after which a thin layer of neat cement mortar shall be applied. The cavity shall then be filled with stiff mortar, composed of one part of Portland cement to two parts of sand, that shall be thoroughly tamped into place. The mortar shall be preshrunk by mixing it approximately 30 minutes before using. The length of time may be varied in accordance with the brand of cement used, temperature, humidity, and other local conditions. The surface of this mortar shall be floated with a wooden float before initial set takes place and shall be neat and workmanlike in appearance.

For patching large or deep areas, coarse aggregate shall be added to the patching material and special precautions shall be taken to ensure a dense, well-bonded, and properly cured patch.

Areas of honeycomb that exceed 2 percent of the surface area of a structural element may be considered sufficient cause for rejection of the structural element.

The mortar patches shall be cured in accordance with Subsection 552.14. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

All surfaces that cannot be repaired satisfactorily shall be rubbed as specified for a Class 2 finish.

(b) Class 2, Rubbed Finish. After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be thoroughly saturated with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the patch to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place.

After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

After the final rubbing is complete and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder, and objectionable marks.

(c) Float Finish.

(1) General. Immediately after the concrete has been struck off to the required grade, the horizontal surface shall be hand finished to smooth even surfaces by both longitudinal and transverse movement of wooden floats, or other suitable means.

After floating has been completed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 10-foot straightedge. The straightedge shall be held in contact with the surface in successive positions parallel to the slab centerline and the whole area gone over from one side of the slab to the other. Advancement along the slab shall be in successive stages of not more than one-half the length of the straightedge. Any depressions found shall be filled immediately with freshly mixed concrete, and any high areas shall be cut down. The surface shall be struck off, consolidated, and refinished. Special attention shall be given to ensure that the surface across joints fully meets the requirements for smoothness. The straightedge testing and refloating shall continue until the entire surface is found to be free from observable departures from the straightedge and the slab has the required grade and crown.

As soon as the concrete has hardened sufficiently, the surfaces shall be given a further test for trueness using a 10-foot straightedge or other specified device. Areas showing high spots of more than 1/8 inch shall be marked and immediately ground down with a diamond-faced, saw-type cutting machine, capable of cutting through mortar and aggregate without breaking or dislodging the aggregate or causing spalls, to an elevation where the area or spot will not show surface deviations in excess of 1/8 inch when tested with a 10-foot straightedge.

The 10-foot straightedge shall be provided by the contractor and the straightedge testing shall be performed by contractor personnel while the Engineer is present.

(2) Bridge Decks. On bridge decks, a smooth riding surface of uniform texture, true to the required grade and cross section, shall be obtained. The contractor shall use finishing machines meeting the requirements specified herein for finishing bridge roadway deck concrete. Hand-operated strike-off devices may be used for small areas or under special conditions when approved by the Engineer.

Finishing of concrete placed in bridge decks shall consist essentially of striking off the surface of the concrete as placed and floating the surface so struck off.

The placing of concrete in bridge decks will not be permitted unless the rate of producing and placing concrete will be sufficient to complete the proposed placing and finishing operations within the scheduled time, unless experienced finishing machine operators and concrete finishers are employed to finish the deck, and unless the fogging equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. Finishing machines shall be set up sufficiently in advance of use to permit inspection by the Engineer during the daylight hours before each placement.

The placing of concrete in bridge decks shall cease early enough to permit completion of finishing operations during daylight hours, unless night finishing operations have been approved in advance by the Engineer as specified in Subsection 552.05.

Rails for the support and operation of finishing machines and headers for hand-operated strike-off devices shall be completely in place and firmly secured for the scheduled length for concrete placement before placing of concrete will be permitted. Rails for finishing machines shall extend sufficient distance beyond both ends of the scheduled length for concrete placement to permit the float of the finishing machine to fully clear the concrete to be placed, unless otherwise approved by the Engineer. Rails or headers shall be adjustable for elevation and shall be set to elevations, with allowance for anticipated settlement, camber, and deflection of falsework, as required to obtain a bridge deck true to the required grade and cross section. Rails or headers shall be of a type and shall be so installed that no springing or deflection will occur under the weight of the finishing equipment and shall be so located that finishing equipment can operate without interruption over the entire bridge deck being finished. Rails or headers shall be adjusted as necessary to correct any unanticipated settlement or deflection that may occur during finishing operations.

Immediately prior to placing bridge deck concrete, the contractor shall check all falsework and wedges and shall make all necessary adjustments. Care shall be exercised to ensure that settlement and deflection due to the added weight of the bridge deck concrete will be at a minimum. Suitable means, such as telltales, shall be provided by the contractor to readily permit measurement of settlement and deflection by the Engineer as it occurs.

Should settlement or other unanticipated events occur that would prevent obtaining a bridge deck meeting the requirements of this specification, placing of deck concrete shall be discontinued until corrective measures are provided. If satisfactory measures are not provided prior to initial set of the concrete in the affected area, the placing of concrete shall be discontinued and a bulkhead installed at a location approved by the Engineer. All concrete in place beyond the bulkhead shall be removed.

Concrete for bridge decks shall be placed in a uniform heading approximately normal to the structure centerline. The rate of placing concrete shall be limited to that which can be finished before the beginning of initial set, but in no case shall concrete be placed more than 8 feet ahead of the finishing machine.

All concrete bridge decks shall be placed continuously full length of the structure or superstructure unit unless otherwise SHOWN ON THE DRAWINGS or approved in writing by the Engineer. The contractor shall provide sufficient material, equipment, and manpower to complete a finished bridge deck at a minimum rate of 20 linear feet per hour unless otherwise SHOWN ON THE DRAWINGS.

Immediately after the concrete has been placed and consolidated, the surface shall be struck off with the finishing machine or hand-operated screed until the required surface is obtained. The use of "jitterbugs" or similar devices will not be permitted. The strike-off method and equipment shall be subject to approval by the Engineer. Approval shall be withdrawn if performance is not satisfactory. The equipment shall be capable of finishing roadway decks within the surface tolerances set forth in these specifications. Improper adjustment and operation that results in unsatisfactory consolidation and smoothness shall be corrected immediately. Unsatisfactory performance may be cause for rejection of the equipment and removal of the in-place concrete. Following the completion of the strike-off, the roadway slab surface shall be floated to a smooth, uniform surface by means of floats 10 feet or more in length. Adequate floats shall be used to remove roughness and minor irregularities left by the strike board or finishing machine and to seal the concrete surface. Excessive working of the concrete surface will not be permitted. All floats shall be used so that each transverse pass overlaps the previous pass by a distance equal to at least one-half the length of the float.

When hand-operated float boards are used, they shall be from 12 feet to 16 feet long, ribbed and trussed as necessary to provide a rigid float, and equipped with adjustable handles at each end. The float shall be wood not less than 1 inch thick and a minimum of 8 inches wide. Adjusting screws, spaced not to exceed 24 inches on centers, shall be provided between the float and the rib. The float board shall be maintained free of twist and true at all times.

Hand-operated float boards shall be operated from transverse finishing bridges. The finishing bridges shall completely span the roadway area being floated, and a sufficient number of finishing bridges shall be provided to permit operation of the floats without undue delay. Not less than two transverse finishing bridges shall be provided when hand-operated float boards are used. When a finishing machine is used for longitudinal floating, one finishing bridge equivalent to the transverse finishing bridge specified herein shall be furnished for use by the Engineer.

All finishing bridges shall be of rigid construction, free of wobble and spring when used by the operators of longitudinal floats, and easily moved.

In advance of curing operations, the surface of the concrete shall be textured with metal tines to produce grooving 3/16 inch deep on 1/2-inch centers unless otherwise SHOWN ON THE DRAWINGS. The grooving shall be transverse unless otherwise SHOWN ON THE DRAWINGS. The operation shall produce a hardened surface having a uniform texture. Sidewalks and tops of curbs shall be given a fine broom or brush finish, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

(d) Special Finishes. Details for special finishes SHOWN ON THE DRAWINGS will be given in the SPECIAL PROJECT SPECIFICATIONS.

552.14
Curing of Concrete

(a) General. All newly placed concrete shall be cured, and curing shall begin immediately after finishing and continue for at least 7 days. For fly ash or pozzolan modified concrete, the curing period shall be as shown in Subsection 552.08(a)(2)i. Curing shall be done so that moisture is always present and shall be an integral part of the concreting operations. Improperly cured concrete will be considered defective and placing operations shall be suspended until proper procedures are put into effect.

If a formed surface is to be rubbed, the concrete shall be kept moist before and during the rubbing, and the curing shall be initiated immediately following the first rub, while the concrete surface is still moist.

When the air temperature is expected to fall below 35 °F, the contractor shall provide suitable measures to maintain the concrete surface temperature between 50 °F and 90 °F and comply with all other applicable provisions of Subsection 552.08. The contractor shall furnish recording thermometers with a range of 0 °F to 212 °F and a recording capability of at least 24 hours. If the structure is enclosed, combustion heaters shall not contact the concrete surface and shall be vented to the outside of the enclosure.

(b) Methods. Concrete shall be cured by any one method or combination of methods listed below, consistent with any limitations given within a particular method.

The top surface of bridge decks, approach slabs, sidewalks, and curbs shall be cured by the method of supplying additional moisture, by the curing compound method of preventing moisture loss, or by the method of water curing.

(1) Supplying Additional Moisture. This method shall include supplying additional moisture by ponding, sprinkling, or fogging. Coverings such as burlap shall be used to retain water. The use of sawdust will not be allowed, and coverings that cause unsightly discoloration of concrete shall not be used. Any method that results in the concrete being alternately wet and dry will be considered an improper curing procedure. Coverings shall be placed as soon as possible after finishing operations have been completed and there is no danger of surface damage. They shall be kept continuously moist. This method shall also be used for curing all construction joints.

Fogging equipment shall be approved by the Engineer in advance and shall be capable of applying water to the concrete in the form of a fine mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the deck resulting from wind, high temperature, low humidity, or a combination of these factors.

(2) Preventing Moisture Loss. This method shall consist of preventing moisture loss from the concrete. It may be done with the use of approved waterproof paper, plastic sheets, or liquid-membrane curing compound, except where other requirements prohibit the use of these compounds. If a formed surface is to be rubbed, the concrete shall be kept moist before and during the rubbing, and the curing shall be initiated immediately following the rubbing while the concrete surface is still moist. Unless a curing compound is used, bridge decks, approach slabs, sidewalks, and curbs shall be covered with burlap or sand blankets as soon as the concrete is sufficiently set to support this material without damage to the finish. This moisture-retaining material shall then be saturated with water and the entire area covered with waterproof paper or plastic sheeting.

a. Waterproof Paper. The paper shall be the widest practicable width, and adjacent sheets shall overlap a minimum of 6 inches and shall be tightly sealed with pressure-sensitive tape,

mastic, glue, or other methods approved by the Engineer to form a complete waterproof cover of the entire concrete surface. The paper shall be secured so wind will not displace it. Should any portion of the sheets be broken or damaged before expiration of the curing period, the broken or damaged portions shall be immediately repaired. Sections that have lost their waterproof qualities shall not be used.

b. Plastic Sheets. The sheets shall be used in the same manner as required above for waterproof paper. Care shall be taken not to exceed the maximum temperature requirements when nontransparent sheets are used.

c. Curing Compounds. Type 1-D or Type 2 liquid membrane curing compounds may be used as the initial and final curing agents on structural concrete subject to the following limitations:

1. If the membrane film is broken or damaged at any time during the curing period, the area or areas shall be recoated to the original requirements.

2. Curing compounds shall be applied to unformed areas as soon as the water sheen has practically disappeared from the finished concrete or as soon as the forms have been removed from surfaces not to be rubbed.

3. Areas receiving a rubbed finish shall be cured with Type 1-D curing compound only.

4. If there is any delay in applying curing compound, the surface shall be protected by supplying additional moisture until compound can be applied.

5. Curing compound shall be applied with equipment that will produce a fine spray, and all compounds shall be thoroughly agitated just prior to use. The surface shall be sprayed again immediately at right angles to the first application. The rate of each application shall be not less than 1 gallon for each 150 square feet of surface. Care shall be taken to prevent application to joints where concrete is required to be bonded to reinforcement steel and to joints where joint sealer is to be placed.

(3) Steam and Radiant Head Curing Methods. Steam and radiant heat curing methods may be used for Class P and precast concrete. The methods shall meet the requirements of Section 553.

(4) Water Curing. Concrete may be cured under water if the temperature of the water does not fall below 35 °F.

552.15
Opening to Traffic

No traffic shall be permitted on concrete bridge decks until:

(a) Curbs, bridge railing, guardrail, and object markers SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS are completely in place.

(b) The compressive strength of concrete in the deck reaches the specified 28-day strength, as determined by compressive strength tests on cylinders cured with the deck.

(c) In the absence of compressive tests specified in (b), no traffic shall be permitted on concrete bridge decks for at least 28 days after placement of all deck concrete, or longer if determined necessary by the Engineer.

Upon completion of placement of all bridge deck concrete, the contractor shall erect barricades at each end of the bridge if the road approaches have been constructed to the point the vehicles

could drive onto the bridge deck. Barricades shall be located to physically prevent vehicular access to the bridge deck. Barricades shall not be removed until the bridge deck is open to traffic.

552.16
(Reserved)

## MEASUREMENT

552.17
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

No deduction will be made for the volume occupied by pipes less than 8 inches in diameter nor for reinforcing steel, anchors, conduits, weep holes, piling, or chamfers less than 6 inches on a side. The volume of fillets less than 6 inches on a side and of varying thickness haunches between prefabricated girders and bridge decks shall not be included.

The quantity shall include Type III cement when used in place of Type I or II; furnishing mix designs and materials for testing; furnishing and placing joint fillers, sealers, and waterstops; and all formwork, falsework, finishing and curing, admixtures, and increased cement content.

Class A concrete placed where seal concrete was specified will be considered seal concrete.

## PAYMENT

552.18
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 552(01) | Structural Concrete, Class ____ . . . . . | C.Y. |
| 552(02) | Structural Concrete, Class ____, _____ . . . | C.Y. |
| 552(03) | Structural Concrete, Class ____ . . . . . | L.S. |
| 552(04) | Structural Concrete, Class ____, _____ . . . | L.S. |
| 552(05) | Seal Concrete . . . . . | C.Y. |

The following percentages of the price will be allowed for progress payments as the work progresses:

| Portion of Work Completed | Percent of Price |
|---|---|
| Formwork and Falsework in Place | 50 |
| Reinforcing Steel in Place | 65 |
| Concrete Placed, Finished, and Cured | 90 |
| Forms Removed and Cleanup Completed | 100 |

# Section 553 - Prestressed Concrete Structures

## DESCRIPTION

553.01
Work

This work shall consist of the construction of prestressed concrete structures and the prestressed concrete portions of composite structures. The work shall include the furnishing and installing of any appurtenant items necessary for the particular prestressing system to be used, including grout. For cast-in-place prestressed concrete, the term "member" as used in this section shall be considered to mean the concrete that is to be prestressed.

It shall include the manufacture, transportation, and storage of beams, slabs, piling, and other structural members. It shall also include the installation of all precast prestressed members except piling, which shall be placed as provided for in Section 551. Prestressed members shall be furnished complete, including all concrete, prestressing steel, bar reinforcing steel, and incidentals in connection therewith.

553.02
Prestressing Methods

Unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS, only the pretensioning method of stressing will be allowed. The method of pretensioning will be optional with the contractor, subject to the requirements hereinafter specified.

Prior to casting any prestressed members, the contractor shall submit to the Engineer complete details of the method, materials, and equipment proposed for use in the prestressing operations. Such details shall outline the method and sequence of stressing, complete specifications and details of the prestressing steel and anchoring devices proposed for use, anchoring stresses, type of enclosures, and all other data pertaining to the prestressing operations, including the proposed arrangement of the prestressing units in the members, pressure grouting materials, and equipment.

Shop drawings shall be required for all prestressed precast members. Four sets of all shop drawings or two sets plus one reproducible set of all shop drawings, including the concrete mix design for each class of concrete to be used, shall be submitted to the Engineer a minimum of 21 days in advance of planned construction. Mix designs shall have been reviewed and shop drawings shall have been approved by the Engineer and returned to the contractor prior to construction, including fabrication of prestressed members.

Shop drawings for prestressed members shall include the prestressing bed layout and overall length between grips at fixed and jacking ends, the type of equipment to be used, the specific prestressing method, and the strand tensioning sequence. They shall also include the strand pattern at midspan and at centerline of bearing; location of total strand center of gravity at midspan, at hold-down points, at quarter points, and at centerline of bearing; and lifting devices and threaded inserts (brand name and part number). These shop drawings shall be accompanied by the calibration curve for the gauge and jacking system, the prestressing strand certification, the stress-strain curve for the prestressed strands, and computations for strand geometry, pressure gauge readings, and strand elongation measurements.

553.03
Consulting Service

The contractor shall certify to the Engineer that a technician skilled in the approved prestressing method will be available to the contractor to give such aid and instruction in the use of the prestressing equipment and installation of materials as may be necessary to obtain required results.

## MATERIALS

553.04
Requirements

Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Concrete | 552.03-04 |
| Grout and Mortar | 701.02-03 |
| Reinforcing Steel | 709.01 |
| Prestressing Steel | 709.03 |
| Structural Steel | 717.01 |
| Hardware, Nuts, and Bolts | 717.02-03 |
| Joint Fillers | 705.01 |
| Elastomeric Bearing Pads | 717.13 |

The concrete shall be Class P unless otherwise SHOWN ON THE DRAWINGS. Concrete in prestressed members shall have a 28-day design compressive strength (f'c) as SHOWN ON THE DRAWINGS. The concrete mix shall be designed by the contractor in accordance with Subsection 552.02(b). Lightweight concrete will not be permitted unless otherwise SHOWN ON THE DRAWINGS.

All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times. Prestressing steel that has sustained physical damage other than that allowed by Subsection 553.10 shall be rejected.

Prestressing steel shall be packaged in containers or other shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete.

All wire shall be free from defects and shall have a smooth surface finish. Material that shows defects will be rejected.

553.05 Testing

All wire, strand, anchorage assemblies, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. All samples submitted shall be representative of the lot to be furnished and, in the case of wire or strand, shall be taken from the same master roll. All of the materials specified for testing shall be furnished free of cost and shall be delivered 30 days prior to the anticipated time of use.

If requested by the Engineer, the vendor shall furnish samples at least 7 feet long for each strand size. A sample shall be taken from each coil. The selection of samples will be made at the manufacturer's plant by the Engineer.

When prestressing systems have been previously tested and approved for similar projects by an agency acceptable to the Engineer, complete tendon samples need not be furnished, provided there is no change in the materials, design, or details previously approved.

The strength of precast concrete required prior to release of pretensioned strands or required prior to lowering of curing temperature of nonprestressed members shall be determined by tests on test cylinders cast and cured under conditions in which the time-temperature relationship of the cylinder will simulate as nearly as possible that obtained during the curing of the structural member. When the forms are heated by steam or hot air, the cylinder will be placed in the lowest heat zone during the curing period. When forms are heated by some other means, a recording of the time-temperature relationship of the test cylinder must be available for comparison with that of the prestressed unit.

The test cylinders shall be molded, cured, and tested in accordance with AASHTO T 126 and T 22 for 28-day test cylinders and AASHTO T 23 for test cylinders cured with the members. When accelerated curing methods are used, the cylinders shall be allowed to cool for at least 1/2 hour prior to capping and caps of sulfur compound shall be allowed to cure 1/2 hour before testing.

As a minimum, the following numbers of test cylinders shall be taken. More shall be taken if the Engineer judges it necessary.

Prestressed members (from the same placements):

| Number of Members/Day | Release Test Cylinders Taken[a] | Minimum Cylinders Broken (Release Test) | 28-Day Strength Test Cylinders Taken and Broken[a] |
|---|---|---|---|
| 1 | 3 | 2 | 3 |
| 2 | 3 | 1 per beam | 4[b] |
| 3 | 3[c] | 1 per beam | 6[b] |
| 4 | 4[c] | 1 per beam | 8[b] |
| 5 | 5[c] | 1 per beam | 10[b] |
| 6 | 6[c] | 1 per beam | 12[b] |
| 7 | 7[c] | 1 per beam | 14[b] |
| 8 | 8[c] | 1 per beam | 16[b] |

[a]Assumes all concrete is air-entrained or non-air-entrained. If both types of concrete are used in the same member, the number of test cylinders listed shall be taken from the air-entrained concrete and the same number of test cylinders shall be taken from the non-air-entrained concrete.
[b]Two test cylinders taken from each member.
[c]One test cylinder taken from each member.

## CONSTRUCTION

553.06 Performance

Prestressed concrete structural members shall be constructed in accordance with Section 552, and reinforcing steel shall be placed in accordance with Section 554.

The Engineer shall be notified a minimum of 7 days prior to fabrication of any prestressed members so that inspection of fabrication operations can be arranged. Dimensional tolerances for prestressed girders shall be as given in Division 5, Section 5 of PCI Manual 116-77 ("Manual for Quality Control: Precast Prestressed Concrete Products," Prestressed Concrete Institute, Chicago, Illinois).

553.07 Prestressing Equipment

Hydraulic jacks used to stress tendons shall be equipped with either a pressure gauge or a load cell for determining the jacking stress. The pressure gauge, if used, shall have an accurate reading dial at least 6 inches in diameter and each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force, and shall be accompanied by a certified calibration chart. The load cell, if used, shall be calibrated and shall be provided with an indicator by which the prestressing force in the tendon can be determined. The range of the load cell shall ensure that the lower 10 percent of the manufacturer's rated capacity will not be used in determining the jacking stress.

Safety measures shall be taken by the contractor to prevent accidents due to possible breaking of the prestressing steel or the slipping of the grips during the prestressing process.

553.08 Casting Yard

Prestressed concrete members shall be manufactured in commercial precasting yards unless otherwise approved in writing by the Engineer.

553.09 Placing Steel

All steel units shall be accurately placed in the position SHOWN ON THE DRAWINGS and in accordance with Section 554.

Threaded inserts shall develop the full tensile strength of bars or bolts they secure. Unless otherwise SHOWN ON THE DRAWINGS, lifting devices of adequate strength to safely lift the girders shall be provided within 2 feet of the girder ends.

No welds or grounds for welding equipment shall be made on the forms or on the steel in the member after the prestressing steel has been installed.

Wires, wire groups, parallel-lay cables, and any other prestressing elements shall be straightened to ensure proper position in the enclosures. Suitable horizontal and vertical spacers shall be provided, if required, to hold the wires in position.

553.10 Stressing

The prestressing element shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongations produced. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete nor end anchorages released until the concrete has attained a compressive strength, as shown by cylinder tests, of at least 4,000 psi unless otherwise SHOWN ON THE DRAWINGS. The elements shall be cut or released in such an order that lateral eccentricity of prestress will be at minimum.

Strands should be stressed when the Engineer is present. The contractor or his representative shall record the pretensioning gauge pressures and measured strand elongations and provide a copy to the Engineer.

A seven-wire strand, with one broken wire, may remain in the member, provided it is within the following limits established for the member:

For members with:

Less than 20 strands, no wire breaks permitted.
20 to 39 strands, 1 wire break permitted.
40 to 59 strands, 2 wire breaks permitted.
60 or more strands, 3 wire breaks permitted.

The occurrence of more than the permissible number of wire breaks or more than one broken wire in any individual strand shall require that the strand or strands be removed and replaced. Any wire breaks that are permitted to remain in the member shall be located and the broken ends shall be securely wrapped with tie wire to prevent ravelling.

553.11 Placing Concrete

Concrete should not be deposited in the forms until the Engineer has inspected the placing of the reinforcement, enclosures, anchorages, and prestressing steel. The concrete shall be vibrated in such a way to avoid displacement of reinforcement, conduits, or wires.

Prior to placing concrete, the contractor shall ensure that all ducts are unobstructed.

553.12 Curing

Steam curing or radiant heat with moisture process may be used as an alternative to water curing. The casting bed for any unit cured with steam shall be completely enclosed by a suitable type of housing, tightly constructed to prevent the escape of steam and exclude outside atmosphere. Two to 4 hours after the placement of concrete and after the concrete has undergone initial set, the first application of steam shall be made, unless retarders are used, in which case the waiting period before application of the steam shall be increased to 4 to 6 hours.

For accelerated curing, a minimum of one continuous temperature recording device shall be used per 100 feet of continuous bed length being used. Copies of the temperature records, with the identification of the girder, shall be furnished to the Engineer.

Curbs and diaphragms cast after the prestress member has been cured or separately placed may be steam cured for a minimum of 12 hours at 100 °F to 160 °F or moist cured for a minimum of 3 days in accordance with Subsection 552.14.

The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 40 °F per hour until a maximum temperature of from 140 °F to 160 °F is reached. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 40 °F per hour until a temperature has been reached of 20 °F above the temperature of the air to which the concrete will be exposed. The concrete shall not be exposed to temperatures below freezing until the specified 28-day strength has been achieved.

Radiant heat shall be applied to beds by means of pipes circulating steam, hot oil, or hot water, or by electric blankets or heating elements on forms. Pipes, blankets, or elements shall not be in contact with concrete, form surfaces, or test cylinders.

During the cycle of radiant heat curing, effective means shall be provided to prevent rapid loss of moisture in any part of the member. Moisture may be applied by a cover of moist burlap or cotton matting. Moisture may be retained by covering the member with a plastic sheet in combination with an insulating cover or by applying a liquid seal coat, approved by the Engineer, or membrane curing compound.

To prevent cracking of members, strands shall be detensioned and their stress transferred to the concrete immediately upon attainment of required release strengths and before the members have been allowed to dry and cool. Should this be impractical, the members shall be kept covered and moist and shall be held at a minimum temperature of 60 °F until strands are detensioned.

If the contractor proposes to cure by any other method, the method and its details shall be subject to the approval of the Engineer.

553.13
Bonding Steel

Unless otherwise SHOWN ON THE DRAWINGS, steel shall be bonded to the concrete.

553.14
Finishing

Unless otherwise SHOWN ON THE DRAWINGS, the exterior surface of the exterior girders and the bottom flanges of all girders shall be given a Class 2 Rubbed Finish as specified in Subsection 552.13. The rest of the girders shall be given a Class 1 Ordinary Surface finish.

Portions of prestressed members that will serve as bridge decks will be finished as SHOWN ON THE DRAWINGS.

The contractor, with the approval of the Engineer, will be allowed to repair rock pockets and other minor deficiencies of a nonstructural nature in the girders. Any girders that are repaired without the approval of the Engineer may be rejected regardless of the extent of the repair work.

553.15
Handling

Extreme care shall be exercised in handling, moving, and erecting precast, prestressed concrete members. Precast girders and slabs shall be transported in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position.

Precast, prestressed concrete members shall not be shipped from the casting plant for at least 72 hours after the prestressing strands have been released or the curbs and/or diaphragms have been cured as specified in Subsection 553.12.

553.16
Erecting &
Placement

The contractor shall advise the Engineer a minimum of 48 hours before prestressed girders for multi-beam bridges are to be field welded, and before any field grout or mortar is to be placed.

If necessary, multi-beam girders shall be adjusted, using galvanized steel shims the same length and width as the bearing pad or plate. No more than 1/8 inch vertical difference shall exist between top of adjacent beam edges at each end of the span. When an asphalt wearing surface or cast-in-place deck is to be placed on top of the prestressed beams, this vertical tolerance may be 1/2 inch. Beams will not be loaded to make them assume the same camber as an adjacent beam.

Mortar shall be used in keyways between multi-beam members and to patch defects, blockouts, or other areas on the concrete roadway portion of the structure 1 inch or more depth and over 1 inch in width. Smaller areas on the concrete roadway shall be patched with the grout.

Air and concrete keyway temperatures shall be between 45 °F and 85 °F before placement of mortar. The temperature must be expected to remain within these limits until mortar placement and application of curing method is completed.

Grout shall be used on all anchor bolts and dowels to make all repairs.

Air and concrete temperatures required for grout placement shall be the same as required for mortar. The area to be grouted shall be thoroughly saturated with water and all free-standing water removed just prior to grout placement.

Exposed grout surface shall be struck off flush and given the same surface texture finish as the surrounding concrete as soon as the grout has set sufficiently. The exposed surface shall be cured as specified in Subsection 552.14. When artificial means are used to control the curing temperature of the mortar or grout, as in hot or cold weather, the means shall be approved by the Engineer in advance. Combustion heaters may be used only if fully vented outside their enclosure. All dry mortar materials and mixing and placing equipment shall be stored such that their temperature is above freezing. Mixing water may be warmed to provide mortar or grout at desired temperature, but shall be 90 °F or less when mixed with the dry materials. Ice may be used as part of the mixing water provided it is completely melted prior to the introduction of the water to the dry materials.

Patching mortar and grout shall be the same color as the parent concrete.

Precast prestressed concrete piling shall be placed in accordance with the requirements for precast concrete piling in Section 551. Other precast prestressed structural members shall be placed in the structure as SHOWN ON THE DRAWINGS and in accordance with contract provisions governing the particular type of structure to be built.

Field welding shall meet the requirements of Section 555. When welding or burning on precast members, the ground lead shall be attached directly to the base metal; if a precast prestressed member is used as a conductor for the ground, the member will be rejected and shall be replaced by the contractor without compensation.

## MEASUREMENT

553.17
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS. Each member will include the concrete, reinforcement and prestressing steel, enclosures for prestressing steel, anchorages, plates, nuts, elastomeric bearing pads, and other material contained within or attached to the unit.

Piling will be measured as provided in Section 551.

**PAYMENT**

553.18 Basis

The accepted quantities will be paid at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

| Pay Item | | Pay Unit |
|---|---|---|
| 553(01) | Prestressed Concrete Structural Member _____ (Identification). . . . . | EA. |
| 553(02) | Prestressed Concrete Structure . . . . . | L.S. |

# Section 553A - Precast Concrete Structures

## DESCRIPTION

553A.01
Work

This work shall consist of the construction of precast concrete portions of composite structures. The work shall also include manufacture, materials testing, transportation, storage, and installation of all precast concrete portions, except piling, including all necessary grouting, welding, or other connections. Precast concrete members shall be furnished complete, in place, including all concrete reinforcing steel, and incidentals connected therewith.

## MATERIALS

553A.02
Requirements

Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Concrete | 552.03-04 |
| Reinforcing Steel | 554.02 |
| Grout and Mortar | 701.02-03 |
| Joint Fillers | 705.01 |
| Structural Steel | 717.01 |
| Hardware, Nuts, and Bolts | 717.02-03 |
| Elastomeric Bearing Pads | 717.13 |

The contractor shall perform all sampling, testing, and inspection necessary to ensure quality control of the component materials and the concrete. Sampling and testing for quality control and acceptance testing shall be in accordance with the AASHTO or ASTM test methods prescribed in Section 552.

The contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantitites approved and rejected, and the nature of any corrective action taken.

Every batch shall be sampled and tested (100 percent sampling and testing) for air content and slump at the start of concrete production. Random sampling and testing for air content and slump at the rate of one for every five successive batches may be substituted for 100 percent sampling and testing if the test results for three successive batches are within the specification limitations for air content or slump, except that 100 percent sampling and testing will be reinstated if a test result for any random sample is outside the specification limitations for either air content or slump.

Compression tests to determine the minimum strength requirements shall be made on cylinders. A minimum of three cylinders will be made from each day's production and cured in the same manner as the precast units. Testing methods shall be in accordance with AASHTO T 22.

The contractor or the supplier shall furnish the Engineer with a Certificate of Compliance certifying that the above materials comply with the applicable contract specifications. A copy of all test results performed by the contractor or supplier necessary to ensure contract compliance shall also be furnished to the Engineer.

## CONSTRUCTION

553A.03
Performance

Precast Concrete Structural Members shall be constructed in accordance with the applicable Sections of the following:

| | |
|---|---|
| Concrete | 552 |
| Curing | 552.14 |
| Steam Curing or Radiant Heat | 553.12 |

| | | |
|---|---|---|
| Finishing | . . . . . | 553.14 |
| Handling | . . . . . | 553.15 |
| Erecting and Placement | . . . . . | 553.16 |
| Reinforcing Steel | . . . . . | 554 |

Four sets of shop drawings or two sets plus one reproducible set shall be submitted to the Engineer for approval, including the concrete mix design for each class of concrete proposed for use, a minimum of 21 days in advance of fabrication of the precast member(s).

553A.04 Casting Yard

The precasting of concrete structural members may be done at a location selected by the contractor.

**MEASUREMENT**

553A.05 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Each member will include the concrete, reinforcement steel, anchorages, plates, nuts, and other material contained within or attached to the unit.

**PAYMENT**

553A.06 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

| Pay Item | | Pay Unit |
|---|---|---|
| 553A(01) | Precast Concrete Structural Member _____ . . . . | EA |
| 553A(02) | Precast Concrete Structure . . . . . | L.S. |

# Section 554 - Reinforcing Steel

## DESCRIPTION

554.01 Work

This work shall consist of furnishing and placing reinforcing steel of the shape and dimensions SHOWN ON THE DRAWINGS.

## MATERIALS

554.02 Requirements

Reinforcing steel and metal supports shall meet the requirements of Subsection 709.01. The grade of reinforcing steel shall be Grade 60 unless otherwise SHOWN ON THE DRAWINGS or the SPECIAL PROJECT SPECIFICATIONS.

## CONSTRUCTION

554.03 Order Lists

When SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS, all order lists and bending diagrams shall be submitted to the Engineer. Inspection of the reinforcing steel will be made after installation and prior to placing concrete.

554.04 Protection of Materials

Reinforcing steel shall be protected at all times from damage by storing on blocking racks or platforms. Prior to placing concrete, reinforcing steel that is to be embedded shall be free from rust that pits the surface or scales off, dirt, mud, loose mill scale, paint, oil, grease, or any other foreign substance.

554.05 Cutting & Bending

Cutting and bending of reinforcing bars shall be in accordance with the Manual of Standard Practice published by the CRSI, or ACI Detailing Manual SP-66, unless otherwise detailed. Bars partially embedded in concrete shall not be bent except as SHOWN ON THE DRAWINGS.

554.06 Placing & Fastening

Reinforcing steel shall be accurately placed as SHOWN ON THE DRAWINGS and shall be firmly and securely held in position by wiring at intersections and splices, and by using precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires, and other devices approved by the Engineer of sufficient strength to resist crushing under applied loads. Ferrous metal chairs that extend to within 1/2 inch of the surface shall have epoxy coated feet or be galvanized, or made of stainless steel. Supports made from wood, aluminum, plastic, brick, or rock shall not be used. For epoxy-coated reinforcing bars, use nylon-coated tie wires. Bar supports for epoxy-coated reinforcing bars shall be epoxy or plastic coated.

Unless otherwise SHOWN ON THE DRAWINGS, bars shall be lapped in accordance with the Building Code Requirements for Reinforced Concrete, ACI 318-83, Chapter 12, as published by the American Concrete Institute.

Main reinforcement shall be spliced only where SHOWN ON THE DRAWINGS. All welds shall meet the requirements of AWS D1.4-79.

Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted.

All reinforcement shall have a clear coverage of 2 inches, except as SHOWN ON THE DRAWINGS or specified herein.

In bridge decks, reinforcing shall be fastened at alternate intersections unless this results in ties being more than 12 inches apart, in which case, each intersection shall be tied. All intesections at the outside edges of decks shall be tied. In precast and/or prestressed concrete units, every reinforcing steel intersection shall be tied.

For a protective concrete covering of 1 to 3 inches, reinforcing steel may have an allowable concrete cover variation of 1/4 inch; for a protective concrete covering of 3 inches or more, a 1/2-inch variation in protective cover is allowed. Additionally, the allowable variation for center-to-center spacing and location of reinforcing steel shall be as follows, unless otherwise noted:

| | |
|---|---|
| Center-to-center spacing of all bars | ±1/2 inch parallel to the nearest surface. |
| Location of any bar | ±1 inch parallel to the nearest surface. |

Tack welding in lieu of wire ties will not be permitted. However, tack welding of nonstressed reinforcing bars in prestressed concrete that secure inserts, void ducts, and so forth, may be allowed when SHOWN ON THE DRAWINGS, or permitted in writing by the Engineer. In any case, all welding must be done prior to tensioning of the prestressing steel.

## MEASUREMENT

554.07 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

The weights of reinforcing steel calculated will be based upon the following table:

| Bar Size | Weight per Linear Foot in Pounds |
|---|---|
| #3 | 0.376 |
| #4 | 0.668 |
| #5 | 1.043 |
| #6 | 1.502 |
| #7 | 2.044 |
| #8 | 2.670 |
| #9 | 3.400 |
| #10 | 4.303 |
| #11 | 5.313 |
| #14 | 7.650 |
| #18 | 13.600 |

Approved splices added for the contractor's convenience will not be included in the quantity for payment.

## PAYMENT

554.08 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 554(01) | Reinforcing Steel . . . . . | LBS. |
| 554(02) | Reinforcing Steel . . . . . | L.S. |

# Section 555 - Steel Structures

## DESCRIPTION

555.01
Work

This work shall consist of furnishing and constructing steel structures and the steel structure portions of composite structures.

The work will include the furnishing, fabricating, erecting, and painting of structural metals. Structural metals will include structural, welding, special, and alloy steels; metallic electrodes; steel forgings and castings; and iron castings.

## MATERIALS

555.02
Requirements

Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Paint | 708.03 |
| Structural Steels | 717.01 |
| Bolts and Nuts | 717.02 |
| High-Tensile-Strength Bolts | 717.03 |
| Forgings | 717.05 |
| Pins and Rollers | 717.06 |
| Castings | 717.07 |
| Steel Grid Floors | 717.08 |
| Steel Pipe | 717.09 |
| Galvanized Metal | 717.10 |
| Sheet Lead | 717.11 |
| Welded Stud Shear Connectors | 717.12 |
| Elastomeric Bearing Pads | 717.13 |
| Structural Aluminum Alloy | 717.14 |
| Aluminum Alloy Materials for Bridge Rail | 717.15 |
| Aluminum Alloy Bolts and Nuts | 717.16 |
| Aluminum Alloy Welding Wire | 717.17 |

## CONSTRUCTION

555.03
Shop Drawings
& Inspection

The contractor shall give the Engineer a 30-day notice prior to the beginning of work in the shop so that inspection may be provided.

The contractor shall submit four sets of shop drawings or two sets plus one reproducible set of same of the structural steel work to the Engineer for approval. The shop drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer without delaying the work. Such time shall be proportional to the complexity of the work, but in no case shall such time be less than 21 days.

The shop drawings shall show any changes proposed in the work, details for connections not dimensioned or otherwise SHOWN ON THE DRAWINGS, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout drawing of the entire structure, the location of any temporary supports that are to be used, and the vertical alignment of the steel work at each stage of the erection. Substantiating camber calculations shall be submitted with the shop drawings.

555.04
Fabrication

These specifications apply to bolted and welded construction.

Workmanship and finish shall be in accordance with the best general practice in modern bridge shops. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

Structural material, either plain or fabricated, shall be stored above the ground upon platforms, skids, or other supports. It

shall be kept free from dirt, grease, or other foreign matter, and shall be protected as far as practicable from corrosion.

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

Preparation of material shall be in accordance with AWS D1.1, paragraph 3.2, as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.

555.05
Finishing & Shaping

Finished members shall be true to line and free from twists, bends, and open joints.

(a) Edge Planing. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stresses shall be planed to a depth of 1/4 inch. Reentrant cuts shall be filleted before cutting.

(b) Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the following American National Standards Institute surface roughness requirements as defined in ANSI B46.1-47, Surface Roughness, Waviness, and Lay, Part I:

| | |
|---|---|
| Steel Slabs | ANSI 2,000 |
| Heavy Plates in Contact in Shoes To Be Welded | ANSI 1,000 |
| Milled Ends of Compression Members, Stiffeners, and Fillers | ANSI 500 |
| Bridge Rollers and Rockers | ANSI 250 |
| Pins and Pin Holes | ANSI 125 |
| Sliding Bearings | ANSI 125 |

(c) Abutting Joints. Abutting joints in compression members and girder flanges, and in tension members where SHOWN ON THE DRAWINGS, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/4 inch.

(d) End Connection Angles. Floor beams, stringers, and girders having end connection angles shall be built to drawing length back to back of connection angle with a permissible tolerance of plus zero to minus 1/16 inch. If end connections are faced, the finished thickness of the angles shall not be less than that SHOWN ON THE DRAWINGS, but in no case less than 3/8 inch.

(e) Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

(f) Web Plates (Bolted). In girders having no cover plates and not to be encased in concrete, the top edge of the web shall not extend above the backs of the flange angles and shall not be more than 1/8 inch below at any point. Any portion of the plate projection beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be not more than 1/2 inch less in width than the distance back to back of flange angles.

Splices in webs of girders without cover plates shall be sealed on top with red lead paste prior to painting.

At web splices, the clearance between the ends of the web plates shall not exceed 3/8 inch. The clearance at the top and bottom ends of the web splice plates shall not exceed 1/4 inch.

(g) Bent Plates. Cold-bent, load-carrying, rolled-steel plates shall meet the following requirements:

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

(2) The radius of bends shall ensure that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in the following table for all grades of structural steel in this specification:

| Plate Thickness in Inches | Up to 1/2 | Over 1/2 to 1 | Over 1 to 1-1/2 | Over 1-1/2 to 2-1/2 | Over 2-1/2 to 4 |
|---|---|---|---|---|---|
| Minimum Bend Radius | 2t | 2-1/2t | 3t | 3-1/2t | 4t |

Note: Low-alloy steel in thickness of over 1/2 inch may require hot bending for small radii.

Allowance for springback of ASTM A 514 and A 517 steels should be approximately three times that for structural carbon steel. For brake press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1,200 °F, except for ASTM A 514 and A 517 steels. If ASTM A 514 and A 517 steel plates or shapes are bent at a temperature greater than 1,125 °F, they must be requenched and tempered in accordance with the producing mill's practice. Hot-bent plates shall meet requirement (1) above.

(3) Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout that portion of the plate where the bending is to occur.

(h) Fit of Stiffeners. End stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing (either milled, ground, or on weldable steel in compression areas of flanges, welded as SHOWN ON THE DRAWINGS) on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless SHOWN ON THE DRAWINGS or specified otherwise, fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

Welding will be permitted instead of milling or grinding if SHOWN ON THE DRAWINGS or SPECIAL PROJECT SPECIFICATIONS. Brackets, clips, gussets, stiffeners, and other detail material shall not be welded to members or parts subjected to tensile stress unless approved by the Engineer.

(i) Eyebars. Pin holes may be flame cut at least 2 inches 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 will be 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 that the marks will 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 accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/16 inch per foot.

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 a manner that will prevent distortion of the plates.

(j) Annealing and Stress Relieving. Structural members that are SHOWN ON THE DRAWINGS to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and annealing (full annealing) shall be in accordance with ASTM E 44. The temperatures shall be maintained uniformly throughout the furnace during heating and cooling so the temperature at any two points on the member will not differ by more than 100 °F at any one time.

Members of ASTM A 514 and A 517 steels shall not be annealed or normalized and shall be stress relieved only with the approval of the Engineer.

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 at any time the temperatures of members in the furnace. The records of the treatment operation shall be available to and meet the approval of the Engineer.

Members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plates together shall be stress relieved in accordance with Subsection 555.12 when SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

(k) Tests. When full-size tests of fabricated structural members or eyebars are required by the specifications, the number and nature of the tests, the results to be attained, and the measurements of strength, deformation, or other performances that are to be made will be SHOWN ON THE DRAWINGS or stated in SPECIAL PROJECT SPECIFICATIONS. The contractor shall provide suitable facilities, material, supervision, and labor necessary for making and recording the tests. The members tested in accordance with the contract will be measured in accordance with Subsection 555.26. The cost of testing, including equipment, handling, supervision, labor, and incidentals for making the tests, shall be included in the contract price for the fabrication or fabrication and erection of structural steel, whichever is the applicable pay item in the contract, unless otherwise specified.

555.06
Pins & Rollers

Pins and rollers shall be accurately turned to the dimensions SHOWN ON THE DRAWINGS and shall be straight, smooth, and free from flaws. Pins and rollers more than 9 inches in diameter shall be forged and annealed. Pins and rollers 9 inches or less in diameter may be either forged and annealed or cold-finished, carbon-steel shafting.

In pins larger than 9 inches in diameter, a hole not less than 2 inches 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 damage by too rapid cooling, and before being annealed.

Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles to 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 holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than 1/32 inch. Boring of holes in built-up members shall be done after the bolting is completed.

The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter, or 1/32 inch for larger pins.

Two pilot nuts and two driving nuts for each size of pin shall be furnished.

555.07
Fastener Holes

All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the fasteners whenever the thickness of the metal is not greater than 3/4 inch for structural steel or 5/8 inch for alloy steel.

When there are more than five thicknesses or when any of the main material is thicker than 3/4 inch (structural steel) or 5/8 inch (alloy steel), or when required under other provisions of this subsection, all the holes shall be subpunched or subdrilled 3/16 inch smaller than the nominal diameter of the fasteners. After assembling, holes shall be reamed 1/16 inch larger or drilled from the solid to 1/16 inch larger than the nominal diameter of the fasteners. For punched holes, the diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. If any holes must be enlarged to admit the fasteners, they shall be reamed. Holes shall be clean cut, without torn or ragged edges. Poor matching of holes will be cause for rejection.

Reamed holes shall be cylindrical, perpendicular to the member, and not more than 1/16 inch larger than the nominal diameter of the fasteners. Where practicable, reamers shall be directed by mechanical means. Drilled holes shall be 1/16 inch larger than the nominal diameter of the fasteners. 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. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match marked before disassembling.

Unless otherwise specified, holes for all field connections and field splices of main truss or arch members, continuous beams, towers (each face), bents, plate girders, and rigid frames shall be subpunched (or subdrilled if subdrilling is required) and subsequently reamed while assembled in the shop in accordance with Subsection 555.08.

All holes for floor beam and stringer field end connections shall be subpunched and reamed to a steel template while assembled.

Reaming or drilling full size of field connections through templates shall be done after the templates have been positioned and angled with the utmost accuracy and firmly bolted in place. Templates used for the reaming of matching members, or of the opposite faces of one member, shall be exact duplicates. Templates for connections that duplicate shall be so accurately located that like members are duplicates and require no matchmarking.

All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole can be entered perpendicular to the face of the member without drifting, in at least 75 percent of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin 3/16 inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thickness 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.

555.08
Shop Assembly

(a) Fitting for Bolting. Surfaces of metal in contact with each other 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.

Preparatory to the shop bolting of full-sized punched material, the bolt holes, if necessary, shall be spear reamed for the admission of the bolts. The reamed holes shall not be more than 1/16 inch larger than the nominal diameter of the bolts.

End connection angles, stiffener angles, and similar parts shall be carefully adjusted to correct positions and bolted, clamped, or otherwise firmly held in place until permanently connected.

Parts not completely bolted in the shop shall be secured by temporary bolts, insofar as practicable, to prevent damage in shipment and handling.

(b) Shop Assembling. The field connections of main members of trusses, arches, continuous beam spans, bents, towers (each face), 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 subsize holes reamed to the specified size while the connections are assembled. Assembly shall be "Full Truss or Girder Assembly" unless "Progressive Truss or Girder Assembly," "Full Chord Assembly," "Progressive Chord Assembly," or "Special Complete Structure Assembly" is specified in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS. Methods of assembly shall be as described below:

(1) "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.

(2) "Progressive Truss or Girder Assembly" shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame all members in at least three contiguous shop sections or panels, but not less than the number of panels associated with three contiguous chord lengths (that is, length between field splices), and not less than 150 feet in the case of structures longer than 150 feet. At least one shop section or panel, or as many panels as are associated with a chord length, shall be added at the advancing end of the assembly before any member is removed from the rearward end so that the assembled portion of the structure is never less than that specified above.

(3) "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; 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 and the templates at both ends of the member shall be accurately located from one of the milled ends or scribed lines.

(4) "Progressive Chord Asssembly" 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."

(5) "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.) The assembly, including camber, alinement, accuracy of holes, and fit of milled joints, shall be approved by the Engineer before reaming is commenced.

A camber diagram shall be furnished to the Engineer by the contractor showing the camber at each panel point of each truss, arch rib, continuous beam line, plate girder, or rigid frame. When 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.

555.09
(Reserved)

555.10
Bolted Connections, Unfinished, Turned, & Ribbed Bolts

(a) General. Bolts under this article shall meet the requirements of "Specification for Carbon Steel Externally and Internally Threaded Standard Fasteners," ASTM A 307. Specifications for high-strength bolts are covered under Subsection 555.11.

Bolts shall be unfinished, turned, or an approved form of ribbed bolt with hexagonal nuts and heads, except that ribbed bolts shall have button heads. Bolted connections shall be used only as SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Bolts not tightened to the proof load shall have single self-locking nuts or double nuts. Bevel washers shall be used where bearing faces have a slope of more than 1 to 20 with respect to a plane normal to the bolt axis. Bolts shall be long enough to extend entirely through their nuts, but not more than 1/4 inch beyond them.

Bolts shall be driven accurately into the holes without damage to the threads. A snap shall be used to prevent damage to the heads. The heads shall be drawn tight against the work with full effort of a man using a suitable wrench not less than 15 inches long for bolts of nominal 3/4 inch diameter and over. Heads of bolts shall be tapped with a hammer while the nuts are being tightened.

(b) Unfinished Bolts. Unfinished bolts shall be furnished unless other types are specified. The number of bolts furnished shall be 5 percent more than the actual number SHOWN ON THE DRAWINGS for each size and length.

(c) Turned Bolts. The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed to provide a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

(d) Ribbed Bolts. The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads meeting the requirements of ANSI B18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The ribs shall be sufficiently hard so that they do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement. The contractor shall provide oversized bolts and nuts for this replacement in an amount not less than 10 percent of the number of ribbed bolts specified.

555.11 Bolted Connections, High-Tensile-Strength Bolts

(a) Bolts. Bolts shall meet the requirements of AASHTO M 164. Other fasteners that meet the chemical requirements of AASHTO M 164, that meet the mechanical requirements of AASHTO M 164 in full-size tests, and that have a body diameter and bearing areas under the head and nut not less than those provided by a bolt and nut of the same nominal dimensions prescribed above, may be used subject to the approval of the Engineer.

Bolt lengths shall be determined by adding the grip-length values given in table 555-1 to the total thickness of connected material. The values of table 555-1 compensate for manufacturer's tolerance; the use of a heavy, semifinished hexagon nut; and a positive "stick-through" at the end of the bolt. For each hardened flat washer that is used, add 5/32 inch to the tabular value and for each beveled washer add 5/16 inch. The length determined should be adjusted to the next longer 1/4 inch.

(b) Parts and Assembly. Bolted parts shall fit solidly together when assembled. Contact surfaces, including those adjacent to the washers, shall be descaled or carry the normal tight mill scale. Contact surfaces shall be free of dirt, oil, loose scale, burrs, pits, and other defects that would prevent solid seating of the parts.

Contact surfaces of joints shall be free of paint, lacquer, galvanizing, or rust inhibitor unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

*Table 555-1.--Bolt length.*

| Bolt Size in Inches | To Determine Required Bolt Length, Add Grip, in Inches[a] |
|---|---|
| 1/2 | 11/16 |
| 5/8 | 7/8 |
| 3/4 | 1 |
| 7/8 | 1-1/8 |
| 1 | 1-1/4 |
| 1-1/8 | 1-1/2 |
| 1-1/4 | 1-5/8 |
| 1-3/8 | 1-3/4 |
| 1-1/2 | 1-7/8 |

[a]Does not include allowance for washer thickness.

Connections shall be assembled with a hardened washer under the element (nut or bolt head) turned in tightening. Where an outer face of the bolted parts has a slope of more than 1 to 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. In all cases of only one nonsloping surface, the turned element shall be adjacent to this surface. Where clearance is necessary, washers may be clipped on one side to a point not closer than seven-eighths of the bolt diameter from the center of the washer.

(1) Installation. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in table 555-2 for the size and grade of fastener used.

*Table 555-2.--Bolt tension (AASHTO M 164 bolts).*

| Bolt Size (Inches) | Minimum Bolt Tension[a] (Pounds) |
|---|---|
| 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 |

[a]Equal to the Proof Load (Length Measurement Method) given in AASHTO M 164.

Threaded bolts shall be tightened with properly calibrated wrenches, by the turn-of-nut method, a direct tension indicator, or other method approved by the Engineer. If required because of bolt entering and/or wrench operation clearances, tightening by any 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 seconds.

When calibrated wrenches are used to provide the bolt tension specified in table 555-2, their setting shall be sufficient to induce a bolt tension 5 to 10 percent 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, not less than three typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to stall or cutout at the selected tension. If manual torque wrenches are used, the torque indicator 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 returned to touch up bolts previously tightened, which might have been loosened by the tightening of subsequent bolts, until all are tightened to the prescribed amount.

When the turn-of-nut method is used to provide the bolt tension in lieu of that specified in table 555-2, 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" shall be 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 any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally to the applicable amount of nut rotation specified in table 555-3 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 555-3.--Nut rotation[a] from snug tight condition.*

| Bolt Length (Measured from Underside of Head to Extreme End of Point) | Disposition of Outer Faces of Bolted Parts | | |
|---|---|---|---|
| | Both Faces Normal to Bolt Axis | One Face Normal to Bolt Axis and Other Face Sloped not More Than 1:20 (Bevel Washer Not Used) | Both Faces Sloped Not More than 1:20 from Normal to Bolt Axis (Bevel Washers Not Used) |
| Up to and Including 4 Diameters | 1/3 turn | 1/2 turn | 2/3 turn |
| Over 4 Diameters but not Exceeding 8 Diameters | 1/2 turn | 2/3 turn | 5/6 turn |
| Over 8 Diameters but not Exceeding 12 Diameters[b] | 2/3 turn | 5/6 turn | 1 turn |

[a]Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance is plus or minus 30°; for bolts installed by 2/3 turn and more, the tolerance is plus or minus 45°.

[b]The required rotation must be determined by actual tests in a suitable tension device simulating the actual conditions.

(2) Inspection.

a. When the calibrated-wrench method of tightening is used, the Engineer shall have full opportunity to witness the calibration tests.

b. The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are tightened.

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

In the presence of the Engineer, the contractor shall use an inspecting wrench which may be either a torque wrench or a power wrench that can be accurately adjusted in accordance with Subsection 555.11(b)(1) above.

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 shall be representative of bolts used in the structure. There shall be a washer under the part turned in tightening each bolt.

When the inspecting wrench is a torque wrench, each of the three bolts specified above shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in table 555-2. The inspecting wrench shall then be applied to the tightened bolt and the torque necessary to run the nut or head 5 degrees (approximately 1 inch at 12-inch radius) in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspection torque to be used in the manner specified below.

When the inspecting wrench is a power wrench, it shall be adjusted so that it will tighten each of the three bolts specified to a tension of at least 5 percent but not more than 10 percent greater than the minimum tension specified for its size in table 555-2. This setting of wrench shall be taken as the job-inspecting torque to be used in the manner specified below.

Bolts, represented by the three sample bolts prescribed above, that have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench at its job-inspecting torque to 10 percent of the bolts, but not 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 any 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, and all bolts whose nut or head is turned by the job-inspecting torque shall be tightened and reinspected, or alternatively, the fabricator or erector may elect the option to retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

(3) Reuse. High-strength bolts, nuts, and washers shall not be reused. Retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts is not considered reuse.

555.12 Welding

Welding shall be done in accordance with the best modern practice and the applicable requirements of AWS D1.1 except as modified by AASHTO's "Standard Specifications for Welding of Structural Steel Highway Bridges."

555.13 Erection

The contractor shall provide the falsework and all tools, machinery, and appliances, including driftpins and fitting-up bolts, necessary for the expeditious handling of the work, and shall erect the metal work, remove the temporary construction, and do all work necessary to complete the structure.

555.14 Handling & Storing Materials

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 contractor shall check the material turned over to him against the shipping lists and report promptly in writing any shortage or injury discovered. The contractor shall be responsible for the loss of any material, or for any damage caused to it after being received.

555.15 Falsework

The falsework shall be properly designed and substantially constructed and maintained for the loads that it will bear. The contractor shall prepare and submit to the Engineer construction drawings for falsework and working drawings for changes in any existing structure necessary for maintaining traffic.

555.16 Method & Equipment

Before starting the work of erection, the contractor shall fully inform the Engineer of the proposed method of erection and the amount and character of equipment to be used.

555.17 Straightening Bent Materials

The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted in writing by the Engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry-red color. After heating, the metal shall be cooled as slowly as possible.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture. Fractured material will be rejected.

555.18 Assembling Steel

The parts shall be accurately assembled as per the shop drawings, and any matchmarks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering that will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans

shall be erected on blocking placed to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully connnected with permanent fasteners and all other truss connections pinned and erection bolted. Splices of butt joints of compression members that are milled to bear and of railing shall not be permanently fastened until the spans have been swung, except that such permanent fastening may be accomplished for the truss members at any time that joint holes are fair. Splices and field connections shall have one-half of the holes filled with erection bolts and cylindrical erection pins (half bolts and half pins) before placing permanent fasteners. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the permanent fasteners, and cylindrical erection pins will be 1/16 inch larger.

555.19
(Reserved)

555.20
Pin Connections

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

555.21
Setting Shoes & Bearings

Shoes and bearing plates shall not be placed on bridge seat bearing areas that are improperly finished, deformed, or irregular. They shall be set level in exact position and shall have full and even bearing. The shoes and bearing plates may be set by either of the following methods:

(a) The bridge seat bearing area shall be heavily coated with mastic and then covered with three layers of 12- to 14-ounce duck, each layer being coated thoroughly on its top surface with mastic. The shoes and bearing plates shall be placed in position while the mastic is plastic.

As alternatives to canvas and mastic, and when SHOWN ON THE DRAWINGS, the following may be used:

(1) Sheet lead of the DESIGNATED thickness.

(2) A preformed fabric pad composed of multiple layers of 8-ounce duck, impregnated and bound with high-quality natural rubber or of equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be sufficient to produce the specified thickness after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 pounds per square inch, without detrimental reduction in thickness or extension.

(3) Elastomeric bearing pads.

(b) The shoes and bearing plates shall be properly supported and fixed with approved nonshrink grout. No load shall be placed on them until the grout has cured in accordance with the manufacturer's instructions for at least 96 hours.

The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond to the temperature at the time of erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

555.22
Preparing Metal Surfaces for Painting

All surfaces of new structural steel that are to be painted shall be blast cleaned unless otherwise specified in the SPECIAL PROJECT SPECIFICATIONS. Where partial cleaning is required in repainting existing structures, the method of cleaning will be specified in

the SPECIAL PROJECT SPECIFICATIONS. The steel surfaces to be painted shall be prepared as outlined in the Steel Structures Painting Council (SSPC) specifications, meeting one of the following classes of surface preparation:

(a) SSPC-SP-5 White Metal Blast Cleaning

(b) SSPC-SP-6 Commercial Blast Cleaning

(c) SSPC-SP-8 Pickling

(d) SSPC-SP-10 Near-White Blast Cleaning

Corrosion-resistant (high-strength weathering) steel shall be blast cleaned as provided in SSPC-SP-6 Commercial Blast Cleaning. The surfaces to be cleaned shall be specified in the SPECIAL PROJECT SPECIFICATIONS.

Blast cleaning shall leave all surfaces with a dense and uniform anchor pattern of not less than 1-1/2 mils measured with an approved surface profile comparator or Testx Presse Tape.

Blast-cleaned surfaces shall be primed or treated the same day blast cleaning is done. If cleaned surfaces rust or are contaminated with foreign material before painting is accomplished, they shall be recleaned by the contractor.

When paint systems Number 1 or Number 3 are specified, the steel surfaces shall be blast cleaned in accordance with SSPC-SP-10; otherwise, blast cleaning shall meet the requirements of SSPC-SP-6.

555.23 Systems of Paint

The paint system to be applied shall consist of one as set forth in table 555-4.

*Table 555-4.--Paint systems.*

| Environment[b] | Paint System[a] | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| High Pollution or Coastal | X | X | X | | |
| Mild Climate | | | | X | X |

[a]Paint system shown for severe areas are satisfactory in less severe areas.

[b]Coastal--within 1,000 feet of ocean or tidal water. High pollution--air pollution environment such as industrial areas. Mild--other than coastal areas not in air pollution environment.

All structural steel shall be painted by one of the following systems. The required system or choice of systems including the color of the final coat will be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

System 4 is intended for use in mild climates or to repaint existing structures where the other systems are not compatible.

| Coating | Subsection | Min. Dry Film Thickness (Mils) |
|---|---|---|
| **System 1--Vinyl Paint System** | | |
| Wash primer | 708.03(b) | 0.5 |
| Intermediate coat | 708.03(b) | 1.5-2.0 |
| 3rd coat | 708.03(b) | 1.5-2.0 |
| 4th coat | 708.03(b) | 1.5-2.0 |
| Final coat | 708.03(b) | 1.5-2.0 |
| | Total Thickness | 6.5-8.5 |
| **System 2--Epoxy-Polyamide System** | | |
| Primer coat | 708.03(c) | 2.0-3.0 |
| Intermediate coat | 708.03(c) | 2.0-3.0 |
| 3rd coat[a] | 708.03(c) | 2.0-3.0 |
| Final coat | 708.03(c) | 1.5-2.0 |
| | Total Thickness | 7.5-11.0 |
| **System 3--Inorganic Zinc Silicate System** | | |
| Primer | 708.03(d) | 3.5-5.0 |
| Intermediate coat | 708.03(d) | 1.0-2.0 |
| Final coat | 708.03(d) | 3.0 min |
| | Total Thickness | 7.5-10.0 |
| **System 4--Alkyd-Oil Basic Lead Silico-Chromate System[b]** | | |
| Primer coat | 708.03(e) | 2.0-3.0 |
| Intermediate coat | 708.03(e) | 2.0-3.0 |
| Final coat | 708.03(e) | 2.0-3.0 |
| | Total Thickness | 6.0-9.0 |
| **System 5--Organic Zinc-Rich Paint System** | | |
| Primer coat | 708.03(f) | 1.5-2.0 |
| Intermediate coat | 708.03(f) | 2.0-2.5 |
| Wash prime tie coat | 708.03(f) | 0.5 |
| Final coat | 708.03(f) | 1.5-2.0 |
| | Total Thickness | 5.5-7.0 |

[a]The third coat may be eliminated in mild climates.
[b]This paint system may be specified as four coats for new structural steel, in mild climates, with a minimum thickness of 6.0 mils.

555.24
Painting Metal
Surfaces

(a) Time of Application. The prime coat of paint, or pretreatment when specified, shall be applied as soon as possible after the surface has been cleaned and before deterioration of the surface occurs. Any oil, grease, soil, dust, or foreign matter deposited on the surface after the surface preparation is completed shall be removed prior to painting. In the event rusting occurs after completion of the surface preparation, the surfaces shall be cleaned again.

Particular care shall be taken to prevent the contamination of cleaned surfaces with salts, acids, alkali, or other corrosive chemicals before the prime coat is applied and between applications of the remaining coats of paint. Such contaminants shall be removed from the surface. Under these circumstances, the pretreatments or, in the absence of a pretreatment, the prime coat of paint shall be applied immediately after the surface has been cleaned.

(b) Storage of Paint and Thinner. Preferably, all paint and thinner should be stored in a separate building or room that is well ventilated and free from excessive heat, sparks, flame, or the direct rays of the sun. Paints susceptible to damage from freezing shall be kept in a heated storage space when necessary.

All containers of paint should remain unopened until required for use.

Paint that has livered, jelled, or otherwise deteriorated during storage shall not be used. Thixotropic materials that can be stirred to attain normal consistency are satisfactory.

(c) Mixing and Thinning. All ingredients in any container of paint shall be thoroughly mixed before use and shall be agitated often enough during application to keep the pigment in suspension.

Paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the vehicle. This does not imply that part of the vehicle cannot be poured off temporarily to simplify the mixing.

Mixing shall be by mechanical methods, except that hand mixing will be permitted for containers up to 5 gallons in size.

Mixing in open containers shall be done in a well-ventilated area away from sparks or flames.

Paint shall not be mixed or kept in suspension by means of an air stream bubbling under the paint surface.

Where a skin has formed in the container, the skin shall be cut loose from the sides of the container, removed, and discarded. If such skins are thick enough to have a practical effect on the composition and quality of the paint, the paint shall not be used.

The paint shall be mixed in a manner that will ensure breaking up of all lumps, complete dispersion of settled pigment, and a uniform composition. If mixing is done by hand, most of the vehicle shall be poured off into a clean container. The pigment in the paint shall be lifted from the bottom of the container with a broad, flat paddle; lumps shall be broken up; and the pigment shall be thoroughly mixed with the vehicle. The poured-off vehicle shall be returned to the paint with simultaneous stirring or pouring from one container to another until the composition is uniform. The bottom of the container shall be inspected for unmixed pigment.

Tinting pastes or colors shall be wetted with a small amount of thinner, vehicle, or paint and thoroughly mixed. The thinned mixture shall then be added to the large container of paint and mixed until the color is uniform.

Paint that does not have a limited pot life or does not deteriorate on standing may be mixed at any time before using, but if settling has occurred it must be remixed immediately before using. Paint shall not remain in the spray pots, painter's buckets, etc., overnight, but shall be gathered into a container and remixed before use.

No thinner shall be added to the paint unless necessary for proper application. In no case shall more than one pint of thinner be added per gallon unless the paint is intentionally formulated for greater thinning. The type of thinner shall comply with the paint specification.

When the use of thinner is permissible, thinner shall be added to paint during the mixing process. Painters shall not add thinner to paint after it has been thinned to the correct consistency. All thinning shall be done under supervision of one acquainted with the correct amount and type of thinner to be added to the paint.

(d) Application of Paint

(1) General. Paint shall be applied by brushing or spraying or by a combination of these methods. Daubers or sheepskins may be used when no other method is practicable for proper application in places of difficult access. Dipping, roller coating, or flow coating shall be used only when specifically authorized.

When two coats of the same color are to be applied, the first coat shall be tinted darker with an approved tinting material.

Open seams at contact surfaces of built-up members that would retain moisture shall be caulked with approved material before the second undercoat of paint is applied.

Paint shall not be applied when the surrounding air temperature is below 40 °F. Paint shall not be applied when the temperature is expected to drop to 32 °F before the paint has dried. Paint shall not be applied to steel that is more than 5 °F below the air temperature or that is at a temperature less than 40 °F. Paint shall not be applied when the steel surface is less than 5 °F above the dew point. Paint shall not be applied to steel at a temperature over 125 °F unless the paint is specifically formulated for application at the proposed temperature, nor shall paint be applied to steel which is at a temperature that will cause blistering or porosity or otherwise will be detrimental to the life of the paint.

Paint shall not be applied in fog or mist, when it is raining or snowing, or when the relative humidity exceeds 85 percent. Paint shall not be applied to wet or damp surfaces. Paint shall not be applied on frosted or ice-coated surfaces.

When paint must be applied in damp or cold weather, the steel shall be painted under cover, or protected, or sheltered, or the surrounding air and the steel heated to a satisfactory temperature. In all such cases, the above temperature and humidity conditions shall be met. Steel shall remain under cover or be protected until dry or until weather conditions permit its exposure.

Any applied paint exposed to freezing, excess humidity, rain, snow, or condensation shall first be permitted to dry. Then, damaged areas of paint shall be removed, the surface again prepared, and repainted with the same number of coats of paint of the same kind as the undamaged areas.

If stripe painting is stipulated in the specifications or if the contractor chooses to do so, all edges, corners, crevices, bolts, welds, and sharp edges shall be painted with the priming

paint by brush before the steel receives its first full prime coat of paint. Such striping shall extend for at least 1 inch from the edge. When practicable, this stripe coat shall be permitted to dry before the prime coat is applied; otherwise, the stripe coat shall set to touch before the full prime coat is applied. However, the stripe coat shall not be permitted to dry for a period long enough to allow rusting of the unprimed steel. When desired, the stripe coat may be applied after a complete prime coat.

To the maximum extent practicable, each coat of paint shall be applied as a continuous film of uniform thickness free of pores. Any thin spots or areas missed in the application shall be repainted and permitted to dry before the next coat of paint is applied.

Film thicknesses are included in the description of paint systems.

Each coat of paint shall be in a proper state of cure or dryness before the application of the succeeding coat.

(2) Brush Application. Paint shall be worked into all crevices and corners, and surfaces not accessible to brushes shall be painted by spray, daubers, or sheepskins. All runs or sags shall be brushed out. There shall be a minimum of brush marks left in the applied paint.

(3) Spray Application of Paint. The equipment used for spray application of paint shall be suitable for the intended purpose, shall be capable of properly atomizing the paint to be applied, and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of the equipment for the material being sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application. In closed or recirculating paint spray systems, where gas under pressure is used over the liquid, the gas shall be an inert one, such as nitrogen.

Traps or separators shall be provided to remove oil and water from compressed air. These traps or separators shall be of adequate size and shall be drained periodically during operations. The air from the spray gun impinging against the surface shall show no water or oil.

Paint ingredients shall be kept properly mixed in the spray pots or containers during paint application either by continuous mechanical agitation or by intermittent agitation as frequently as necessary.

The pressure on the material in the pot and of the air at the guns shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to atomize the paint properly but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or loss by overspray.

Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before applying paint to the surface being painted.

Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern shall be adjusted so that the paint is deposited uniformly. During application, the gun shall be held perpendicular to the surface and at a distance that will ensure that a wet layer of paint is

deposited on the surface. The trigger of the gun should be released at the end of each stroke.

All runs and sags shall be brushed out immediately or the paint shall be removed and the surface repainted. Spray application of prime coats shall in all cases be immediately followed by brushing.

Areas inaccessible to the spray gun shall be painted by brush. If not accessible by brush, daubers or sheepskins shall be used. Brushes shall be used to work paint into cracks, crevices, and blind spots that are not adequately painted by spray.

(4) Shop Painting. Shop painting shall be done after fabrication and before any damage to the surface occurs from weather or other exposure. Shop contact surfaces shall not be painted unless specified.

Surfaces not to be in contact but that will be inaccessible after assembly shall receive either the full paint coats specified or three shop coats of the specified primer before assembly.

The areas of steel surfaces to be in contact with concrete shall not be painted. Unless otherwise SHOWN ON THE DRAWINGS, the areas of steel surfaces to be in contact with wood shall receive either the full paint coats specified or three shop coats of the specified primer.

If the paint would be harmful to a welding operator or would be detrimental to the welding operation or the finished welds, the steel shall not be painted within a suitable distance from the edges to be welded.

Antiweld spatter coatings shall be removed before painting. Weld slag and flux shall be removed by methods at least as effective as those specified for the cleaning.

Machine-finished or similar surfaces that are not to be painted but require protection shall be protected with a coating of rust inhibitive petroleum, or other coatings that may be more suitable for special conditions.

Erection marks and weight marks shall be copied on areas that have been previously painted with the shop coat.

(5) Field Painting. Steel structures shall be painted as soon as practicable after erection.

Metal that has been shop coated shall be touched up with the same type and brand of paint as the shop coat. This touch-up shall include cleaning and painting of field connections, welds, and all damaged or defective paint and rusted areas. The contractor may elect the option to apply an overall coat of primer in place of touch-up or spot painting.

Surfaces (other than contact surfaces) which are accessible before erection but which will not be accessible after erection shall receive all field coats of paint before erection.

If possible, the final coat of paint shall not be applied until all concrete work is finished. If concreting or other operations damage any paint, the surface shall be cleaned and repainted. All cement or concrete spatter and drippings shall be removed before any paint is applied.

Wet paint shall be protected against damage from dust or other detrimental foreign matter.

(6) Drying of Painted Metal. The maximum time specified by the manufacturer shall be allowed for paint to dry before

recoating or exposure. No drier shall be added to paint on the job unless specifically called for in the specifications for the paint. No painted metal shall be subjected to immersion before the paint is dried through. Paint shall be protected from rain, condensation, contamination, snow, and freezing until dry.

(7) Handling of Painted Steel. Painted steel shall not be handled until the paint has dried, except for necessary handling in turning for painting or stacking for drying.

Painted surfaces that are damaged in handling shall be scraped off and touched up with the same number of coats and kinds of paint as were previously applied to the steel.

Painted steel shall not be loaded for shipment or shipped until it is dry.

(e) Measurement of Dry Film Thickness of Paints

(1) Instrumentation. Dry paint film thicknesses will be measured using pull-off (Type 1) or fixed-probe (Type 2) magnetic gauges. Type 1 gauges include Tinsley, Elecometer, Microtest, and Inspector models. Type 2 gauges include Elcometic, Minitector, General Electric, Verimeter, and Accuderm models. The contractor shall provide one gauge with instructions, in "as new" condition, to be operated under the observation of the Engineer. Operation and calibration shall be in accordance with manufacturer's instructions.

555.25
(Reserved)

## MEASUREMENT

555.26
Method

The method of measurement, as described in Section 106 will be DESIGNATED in the SCHEDULE OF ITEMS.

Components fabricated from metals listed in (a) below, such as castings, alloy steels, steel plates, anchor bolts and nuts, shoes, rockers, rollers, pins and nuts, expansion dams, roadway drains and scuppers, weld metal, bolts embedded in concrete, cradles and brackets, posts, conduits and ducts, and structural shapes for expansion joints and pier protection, will be considered as structural steel.

Unless otherwise provided, the weight of metal will be computed and based upon the following weights:

(a) Unit Weights, Pounds Per Cubic Foot

| | |
|---|---|
| Aluminum, cast or rolled | 173.0 |
| Bronze or copper alloy | 536.0 |
| Copper sheet | 558.0 |
| Iron, cast | 445.0 |
| Iron, malleable | 470.0 |
| Lead, sheet | 707.0 |
| Steel, cast or rolled, including alloy, copper bearing, and stainless | 490.0 |
| Zinc | 450.0 |

(b) Shapes, Plates, Railing, and Flooring. The weights of steel shapes and plates will be computed on the basis of their nominal weights and dimensions as SHOWN ON THE APPROVED SHOP DRAWINGS, without deducting for copes, cuts, and open holes. The weights of all plates shall be computed on the basis of nominal dimensions with no additions for overrun.

The weight of railing will be included as structural steel unless the SCHEDULE OF ITEMS contains a separate item for bridge railing under Section 556. The weight of steel grid flooring will be computed separately.

(c) Castings. The weight of castings will be computed from the dimensions SHOWN ON THE APPROVED SHOP DRAWINGS, deducting for open holes. To this weight will be added a 5-percent allowable for fillets and overruns.

Scale weights may be substituted for computed weights in the case of castings of small, complex parts for which accurate computations of weight would be difficult.

(d) Miscellaneous. The weight of the following will be excluded:

(1) Erection bolts placed for the convenience of the contractor.

(2) Shop and field paint.

(3) Galvanizing.

(4) Boxes, crates, and other containers used for shipping, together with sills, struts, and rods used for supporting members during transportation.

(5) High-strength steel bolts, nuts, and washers.

(6) Welds (shop and field).

**PAYMENT**

555.27 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 555(01) | Structural Steel, Furnished, Fabricated, and Erected . . . . . | LBS. |
| 555(02) | Structural Steel, _____ Furnished, Fabricated, and Erected . . . . . | LBS. |
| 555(03) | Structural Steel, Furnished and Fabricated . . . | LBS. |
| 555(04) | Structural Steel, _____ Furnished and Fabricated . . . . . | LBS. |
| 555(05) | Structural Steel, Erected . . . . . | LBS. |
| 555(06) | Structural Steel, _____ Erected. . . . . | LBS. |
| 555(07) | Structural Steel, Furnished, Fabricated and Erected . . . . . | L.S. |

# Section 556 - Bridge Railing

## DESCRIPTION

556.01 Work

This work shall consist of furnishing and installing bridge railing and bridge approach railing.

556.02 Classification

Bridge railings will be classified as Concrete Bridge Railing, Steel Bridge Railing, Steel Bridge Approach Railing, Aluminum Bridge Railing, or Timber Bridge Railing in accordance with the predominate material contained in each.

## MATERIALS

556.03 Requirements

Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Concrete | 552.03-04 |
| Joint Fillers | 705.01 |
| Paint | 708.03 |
| Reinforcing Steel | 709.01 |
| Beam-Type Steel Railing | 710.04 (606.02) |
| Timber | 710.05 (557.02) |
| Structural Steel | 717.01 |
| Hardware, Nuts, and Bolts | 717.02-03 |
| Aluminum Alloy | 717.15 |
| Aluminum Bolts and Nuts | 717.16 |
| Aluminum Welding Wire | 717.17 |

## CONSTRUCTION

556.04 Performance

Four sets of shop drawings or two sets and one reproducible set of same for steel or aluminum bridge railing, except beam-type steel railing, shall be submitted to the Engineer for review a minimum of 2 weeks prior to fabrication, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Inspection of the railing will be made after installation.

The railing shall be constructed so as not to reflect any uneveness in the structure or approach fills. Unless otherwise specified, all railing posts shall be vertical. Railing shall not be placed on a span until centering or falsework has been removed, rendering the span self-supporting.

556.05 Concrete Railing

All concrete shall be Class A and all concrete construction shall meet the requirements of Section 552.

556.06 Steel Railing

Erection of steel railing shall meet the applicable requirements of Sections 555 and 606.

556.07 Aluminum Railing

The fabrication and erection of aluminum railing shall meet the requirements of Section 555 subject to the following amendments and additions:

(a) Cutting. Material 1/2 inch thick or less may be cut by shearing, sawing, or milling. Material over 1/2 inch thick shall be sawed or milled.

Cut edges shall be true, smooth, and free from burns or ragged breaks. Reentrant cuts shall be filleted by drilling prior to cutting.

Flame cutting will not be permitted.

(b) Bending. Material may be heated to a temperature not exceeding 400 °F for a period not exceeding 30 minutes to facilitate bending, unless cold bending is required to retain the original mechanical properties of the material furnished.

(c) Bolt Holes. Bolt holes shall be drilled to finished size or subpunched smaller than the nominal diameter of the fastener and reamed to size. The amount by which the diameter of a subpunched hole is smaller than that of the finished hole shall be at least one-quarter the thickness of the piece. The finished diameter of holes shall be not more than 7 percent greater than the nominal diameter of the fastener except:

(1) Slotted bolt holes, to take care of expansion, shall be provided as SHOWN ON THE DRAWINGS.

(2) Anchor bolt holes may be up to 25 percent greater than the nominal bolt diameter with a maximum of 1/2 inch greater than the nominal bolt diameter, unless otherwise SHOWN ON THE DRAWINGS.

(d) Contact with Other Materials. Where aluminum alloys come in contact with other metals, the contacting surfaces shall be thoroughly coated with an aluminum-impregnated calking compound approved by the Engineer, or a synthetic rubber gasket meeting the requirements of the SPECIAL PROJECT SPECIFICATIONS may be placed between the two surfaces. Aluminum alloys shall not be placed between the two surfaces and shall not be placed in contact with copper, copper-base alloys, lead, or nickel.

Where aluminum alloys come in contact with concrete or stone, the contact surfaces shall be thoroughly coated with an aluminum-impregnated calking compound approved by the Engineer. When a bond between aluminum and concrete is desired, the aluminum shall be coated with zinc-chromate paint and allowed to dry before installation.

Where aluminum alloys come in contact with wood, the contacting aluminum surface shall be coated with an approved aluminum calking compound.

556.08 Timber Railing

Erection of timber railing shall meet the requirements of Section 557. Erection of the posts for bridge approach railing shall meet the applicable requirements of Section 606.

556.09 Painting

All steel railing, except beam-type railing, shall be cleaned and given one primer coat and two field coats of paint meeting the requirements of Subsections 555.22 and 555.24 when SHOWN ON THE DRAWINGS. Beam-type railing shall be painted to meet the requirements of Section 606. If galvanizing is SHOWN ON THE DRAWINGS instead of painting, the requirements of AASHTO M 111, ASTM A 123, or AASHTO M 180, as applicable, shall apply.

**MEASUREMENT**

556.10 Method

The method of measurement as described in Section 106 will be DESIGNATED in the SCHEDULE OF ITEMS.

The length of railing will be along the line and grade of the railing from end to end of the rail except when terminal sections are in the SCHEDULE OF ITEMS.

The following incidental items will be included in payment for railing, and separate measurement and payment will not be made:

(a) Fastenings, anchors, and posts.

(b) Sheets, pads, shims, plates, etc.

(c) Reinforcing steel and portions of reinforcing steel extending into curbs and parapets.

(d) Approach railing, end anchorages, and terminal sections unless separate pay items are included in the SCHEDULE OF ITEMS for approach railing, end anchorages, or terminal section.

**PAYMENT**

556.11
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 556(01) | Concrete Bridge Railing . . . . . | L.F. |
| 556(02) | Steel Bridge Railing . . . . . | L.F. |
| 556(03) | Aluminum Alloy Bridge Railing . . . . . | L.F. |
| 556(04) | Timber Bridge Railing . . . . . | L.F. |
| 556(05) | Bridge Railing . . . . . | L.S. |
| 556(06) | Bridge Approach Railing . . . . . | L.F. |
| 556(07) | End Anchorage . . . . . | EA. |
| 556(08) | Terminal Section, Class _____ . . . . | EA. |

# Section 557 - Timber Structures

## DESCRIPTION

557.01
Work

This work shall consist of construction of timber structures and timber portions of composite structures. It shall include furnishing and installing or installing only, all hardware, lumber, and timbers SHOWN ON THE DRAWINGS.

## MATERIALS

557.02
Requirements

Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Structural Timber and Lumber | 716.01 |
| Hardware and Structural Steel | 716.02 |
| Preservative Treatments | 716.03 |
| Structural Glued Laminated Timber | 716.04 |

Paint for timber structures shall be white and shall meet the requirements of AASHTO M 70, Type I, Class A. The paint, as specified, is intended for use in covering previously painted surfaces. When applied to unpainted timber, turpentine and linseed oil shall be added as required by the character of the surface in an amount not to exceed 1 pint each per gallon of the paint.

The contractor shall furnish the following compliance certificates to the Engineer upon delivery of the materials to the jobsite:

(a) Verification of compliance with grading rules and species of timber and lumber. Certification shall be by an agency accepted as competent by the American Lumber Standards Committee.

(b) Certification of preservative, penetration in inches, and retention in pounds per cubic foot (assay method) either by a qualified inspection and testing agency or by supplier certification if each piece is stamped or branded with the AWPB quality mark.

(c) Certification from a qualified inspection and testing agency indicating all glue-laminated members are in accordance with U.S. Department of Commerce Voluntary Standard PS 56, "Structural Glued Laminated Timber" (AITC A190) modified as SHOWN ON THE DRAWINGS.

(d) Such other certifications as SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS.

## CONSTRUCTION

557.03
Performance

Excavation, foundation, backfill, and embankments shall be in accordance with Section 206.

557.04
Storage & Handling of Material

All materials shall be so handled, stacked, and protected as to prevent scarring, breaking, warping, or weathering. Corners of heavy construction timbers and banded packages of lighter construction timber shall be protected when handled by slings.

All field cuts or abrasions made in fabricated timber after treatment shall be carefully trimmed and given three brush coats of the same type of preservative used in the original treatment unless otherwise SHOWN ON THE DRAWINGS. Field cuts shall be limited to holes and minor trimming, and cuts SHOWN ON THE DRAWINGS.

In addition to the requirement for field treatment, all field cut end grain of main stringers or timber members to be buried under ground shall be coated with an asphalt, coal tar, or creosote water proofing material meeting the requirements of AASHTO M115, 116, 118, or 121.

557.05 Workmanship

All lumber and construction timber shall be cut and framed so all joints will have even bearing over the entire contact surface. No shimming shall be done in making joints, and all joints shall be closed. Nails and spikes shall be driven to set the heads flush with the wood surface. All holes for smooth dowels, except for the dowels used to join glue-laminated deck panels, and drift pins shall be 1/16 inch less in diameter than the dowels or pins. Holes for bolts shall be bored with a bit of the same diameter as that of the bolt, except when galvanized hardware is specified, then all holes shall be drilled 1/16 inch greater than the bolt size. Holes for lag screws shall have the same diameter and depth as the shank of the screw, plus a lead hole for the threaded portion with the diameter approximately 75 percent of the shank diameter. Before driving bolts or pins, all holes bored after treatment shall be treated as specified in Subsection 557.04. Any holes drilled but not used after being treated shall be plugged with treated plugs.

557.06 Bolts & Washers

Washers of the size and type SHOWN ON THE DRAWINGS shall be placed under all bolt heads and nuts. All nuts shall be finally tightened to provide proper bearing and excess bolt lengths of more than 1 inch shall be cut off. After being finally tightened, all nuts shall be checked or burred effectively with a pointing tool to prevent loosening.

557.07 Framed Bents

Mud sills shall be firmly and evenly bedded to solid bearing and carefully tamped in place. Concrete pedestals for the support of framed bents shall be finished carefully so that sills or posts will bear evenly and uniformly over the entire bearing surface.

557.08 Pile Bents

Treatment, furnishing, and driving of construction piles shall be in accordance with Section 551.

557.09 Caps for All Bents

Timber caps shall be placed to obtain even and uniform bearing over the tops of all supporting construction posts or construction piles. Ends of caps shall be in true alinement.

557.10 Bracing

Bracing shall be bolted through at intersections with the construction piling and construction posts and shall be capped or sealed as SHOWN ON THE DRAWINGS.

557.11 Solid-Sawn Stringers

Stringers shall be size matched at bearings and shall be positioned so that the camber is up and if possible so that knots near the edge will be in the top portion of the stringers. Bridging between stringers shall be neatly and accurately framed and securely fastened.

557.12 Glue-Laminated Panel Decks

Panels shall not be dragged or skidded. When lifted, they shall be supported in the weak-moment plane at a sufficient number of points to avoid overstressing, and the edges shall be protected from damage.

When dowels are SHOWN ON THE DRAWINGS between deck panels, a template or drilling jig shall be used to ensure that dowel holes are accurately spaced. The holes shall be drilled to a depth 1/4 inch greater than one-half the dowel length and of the same diameter as the dowel unless otherwise SHOWN ON THE DRAWINGS. A temporary dowel shall be used as a check for snug fit prior to production drilling. The dowels shall be of the size SHOWN ON THE DRAWINGS with the tips slightly tapered or rounded. A lubricant may be used to facilitate the connection process.

The tips of all dowels shall be partially and equally started into the holes of the two panels being joined. The panels shall be drawn together keeping the edges parallel, until the panels abut tightly. Each panel shall be securely fastened to each stringer as SHOWN ON THE DRAWINGS.

## MEASUREMENT

557.13 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS. Lumber and timber used for falsework, bracing, or sheeting will not be included. Furnishing and installation of piling and guardrail will be in accordance with Sections 551 and 556, respectively. Structure excavation will be in accordance with Section 206.

## PAYMENT

557.14 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 557(01) | Treated Timber Structure . . . . . | L.S. |
| 577(02) | Treated Timber for Structure . . . . . | MFBM |

# Section 558 - Prefabricated Bridge Structures

## DESCRIPTION

558.01 Work

This work shall consist of furnishing and erecting the prefabricated superstructure portions of bridges and/or the erecting of Government-furnished prefabricated superstructure units. The length and width of the structure, including curbs and railings and the horizontal and vertical alignment will be as SHOWN ON THE DRAWINGS.

This work shall also include construction of bearing caps, bulkhead walls, and other supports, including excavation and backfill, when SHOWN ON THE DRAWINGS or on approved manufacturers' drawings. Unless furnished by the Government, prefabricated bridge units shall be furnished complete, in place, including deck, and railing when required, and all incidental materials connected therewith.

When there are specified limitations on acceptable girder, deck, and railing materials and type, they shall be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

## MATERIALS

558.02 Requirements

Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Concrete | 552.03-04 |
| Prestressed Concrete | 553.04-07 |
| Precast Concrete | 553A.02 |
| Structural Steel Components | 555.02 |
| Railing | 556.03 |
| Timber and Hardware | 557.02 |
| Reinforcing Steel | 709.01 |

Concrete compressive strength, structural steel ultimate strength and designation, timber species, grade, and treatment, and other material specifications shall be designated on the manufacturer's drawings and will be subject to approval by the Engineer prior to fabrication.

558.03 Design Requirements

Prefabricated bridges shall be designed in accordance with the AASHTO Standard Specifications for Highway Bridges, latest edition and addendums, for the HS20-44 loading, including impact, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

558.04 Design Drawings & Calculations

The contractor shall submit to the Engineer for approval four copies of the design drawings, calculations, and shop drawings. They shall include any manufacturer's installation special handling specifications. The drawings shall be certified and bear the stamp of a registered professional engineer. Drawings shall be submitted sufficiently in advance of the start of the work to allow time for review by the Engineer and correction of any changes by the contractor. Such time shall be proportional to the complexity of the work, but not less than 21 days.

When Government-furnished units are specified, erection drawings and manufacturer's handling specifications will be furnished to the contractor by the Government.

## CONSTRUCTION

558.05 Performance

The work shall conform to the applicable construction provisions of the following Subsections:

| | |
|---|---|
| Concrete Structures | 552.05-14 |
| Prestressed Concrete Structures | 553.06-16 |
| Precast Concrete Structures | 553A.03-04 |

| | | |
|---|---|---|
| Steel Structures | . . . . . | 555.03-25 |
| Timber Structures | . . . . . | 557.03-12 |
| Structure Excavation and Backfill | . . . . . | 206.02-07 |
| Reinforcing Steel | . . . . . | 554.03-06 |
| Bridge Railing | . . . . . | 556.04-09 |

558.06 Government-Furnished Bridges

When Government-furnished prefabricated bridge units are specified, the contractor shall transport the units from the storage site designated in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS to the bridge site, and shall erect the units complete in place, including connection of all girders, diaphragms, railings, and other elements.

Upon taking possession of the Government-furnished units at the storage site, the contractor shall assume all liability for damage from his operations, including handling, transporting, and erecting the units in place, until final acceptance of the project by the Contracting Officer.

558.07 Manufacturer's Requirements

The contractor shall furnish all tools, devices, special equipment, and incidentals, and comply with all manufacturer's erection requirements. This manufacturer's requirement also applies to the movement and erection of Government-furnished units.

**MEASUREMENT**

558.08 Method

The method of measurement, as described in Section 106, will be designated in the SCHEDULE OF ITEMS.

**PAYMENT**

558.09 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 558(01) | Prefabricated Bridge . . . . . | EA. |
| 558(02) | Install Government-furnished Prefabricated Bridge . . . . . | EA. |

# Section 559 - Log Structures

## DESCRIPTION

559.01 Work

This work shall consist of cutting, hauling, and installing the timber for constructing log bridges, including abutments, piers, and superstructure.

This work shall also include structure excavation and backfill for abutments and piers and furnishing and installing all hardware.

## MATERIALS

559.02 Requirements

The Government will provide trees from which the contractor can cut the required logs. The Government will mark trees for cutting or identify the general area from which trees shall be cut at locations SHOWN ON THE DRAWINGS. Trees to be cut for stringers shall be approved by the Engineer. The contractor shall dispose of all debris resulting from this operation in accordance with Section 201.

559.03 Lumber

Lumber shall be in accordance with the species, grades, and dimensions SHOWN ON THE DRAWINGS.

559.04 Aggregate

Aggregate, when shown for decking/surfacing, shall meet the requirements SHOWN ON THE DRAWINGS.

559.05 Hardware

All hardware shall be of the sizes, shapes, types, and finishes for specific uses as SHOWN ON THE DRAWINGS.

559.06 Matting

Fabric mat as SHOWN ON THE DRAWINGS shall meet the requirements of Section 720.

## CONSTRUCTION

559.07 Performance

Excavation, foundation, backfill, and embankment work shall be in accordance with Section 206.

Timber caps shall be placed to obtain even and uniform bearing over the tops of supporting posts or piles and with post and pile ends in true alignment. All caps shall be secured as SHOWN ON THE DRAWINGS.

Stringers shall be size matched at bearings and shall be placed in position so that the crown is up and, if possible, so that knots that may affect the strength of the member will be in the top portion of the stringer.

Stringers shall be cut to the exact length with a square cut. A sufficient depth of material shall be removed from the top surface of the stringer to provide a bearing area for the decking as SHOWN ON THE DRAWINGS. Hewing shall not exceed 3/4 inch depth at the small end of the log. Hewing of the top of the butt end shall not exceed 3 inches in depth for a distance not to exceed one-fourth span length.

Bottom surface of the small end of the logs shall be cut or hewed only to the depth necessary to achieve the required bearing area. Tip ends smaller than the largest tip shall be blocked or shimmed. Butt ends may be cut or dapped to the depth of the largest top end. The maximum slope of any tip shall be 1 to 10. Top and bottom cuts shall be parallel. Where shims or blocks are used under small ends, the shims should cover the entire bearing area.

All logs, including face logs, tie logs, mud sills, and anchor logs, shall be notched together as SHOWN ON THE DRAWINGS and shall be tied or drift pinned together.

All necessary clearing, grubbing, and excavation shall be completed and approved prior to starting the bridge erection. Wood chinking or rock may be hand placed for backing behind minor open spacing between logs, provided that their least dimension is greater than the minimum opening between logs. When rock is used, the larger rocks shall be placed against the logs and backed up with smaller rocks in such a manner that no materials can escape or be washed out.

## MEASUREMENT

559.08 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Excavation and Backfill are included in the measurement for the item for Log Structure and no separate measurement and payment will be made.

## PAYMENT

559.09 Basis

The accepted quantities will be paid for at the contract unit price for the pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 559(01) | Log Structure . . . . . | EA. |